EUROPEAN UNION

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Module 1

Objective Type

Each question carries **One** mark

1. The energy sources, that are either found or stored in nature are
   a) Secondary Energy Sources b) Primary Energy Sources
   c) both (a) and (b) d) none of the above

2. Natural Gas contains ?
   a) 95-99% methane b) 95-99% Ethane c) 95-99% methane & ethane mix
   d) None

3. Inexhaustible energy sources are known as
   a) commercial Energy b) renewable Energy
   c) primary energy d) secondary energy

4. Bangladesh primary energy consumption in 2017 is _____ of the world's consumption
   a) 1% b) 2% c) 0.2% d)0.1%

5. There are ___ gas fields discovered in Bangladesh
   a) 22 b) 25
   c) 26 d) 16

6. Bangladesh natural gas reserves are estimated to last over
   a) 6.7 years b) 5.6 years c) 4.5 years d) 7.6 years

7. Bangladesh coal is generally characterized as
   a) low ash and high sulfur b) low ash and low sulfur c) high ash and high sulfur
   d) high ash and low sulfur

8. The installed capacity of renewable energy in Bangladesh is _____ % of the total country share.
   a) 3.89 b) 2.98 c) 2.89 d) 3.98

9. Which fuel dominates the energy mix in Bangladesh energy scenario?
   a) Oil b) Natural gas c) Coal d) Nuclear

10. The expected energy efficiency improvement by 2030 by Energy Efficiency and Conservation Program of Bangladesh is
    a) 22% b) 25% c) 20% d) 30%

11. "The judicious and effective use of energy to maximise profits and enhance competitive positions". This can be the definition of:

a) Energy conservation

b) Energy management

c) Energy policy

d) Energy Audit

12. The energy management function is generally vested in –

(a) Senior Management

(b) One energy manager or co-ordinator

(c) Distributed among number of middle manager

(d) (b) & (c) together

13. The objective of energy management includes

a) Minimising energy costs

b) Minimising waste

c) Minimising environmental degradation

d) All the above

14. The ratio of current year's production to the reference year's production is called as

a) Demand factor

b) Production factor

c) Utilisation factor

d) Load factor

15. Replacement of steam based hot water generation by solar system is an example of

a) Matching energy usage to the requirement

b) Maximising system efficiency

c) Energy substitution

d) Performance improvement

16. One unit of electricity is equivalent to_kcal heat units.

a) 800
b) 860
c) 400
e) 680

17. The benchmarking parameter for air conditioning equipment is

a) kW/Ton of Refrigeration

b) kW/ kg of refrigerant handled

c) kcal/m3 of chilled water

d) Differential temperature across chiller

18. The percentage of energy saved at the current rate of use, compared to the reference year rate of use, is called

a) Energy Utilization

b) Energy Performance

c) Energy Efficiency

d) None

19. Which instrument is used to monitor O_2, CO in flue gas? (EA)

a) Combustion analyzer

b) Power analyzer

c) Pyrometer

d) Fyrite

20. Lux meter is used to measure……

a) Illumination level

b) Sound intensity and illumination level

c) Harmonics
d) Speed

21. For a cement plant the parameter, "kWh/MT of clinker "indicates

a) Energy Index parameter

b) Utility factor

c) Production factor

d) Load factor

22. Energy manger should be well versed with

a) Manufacturing and processing skills

b) Managerial and technical skills

c) Technical and marketing skills

d) Managerial and commercial skills

23. An energy policy does not include

a) Target energy consumption reduction

b) Time period for reduction

c) Declaration of top management commitment

d) Future production projection

24. CO_2 measurement of Fyrite kit is based on

a) Weight basis (dry)

b) Volume basis (dry)

c) Weight basis (wet)

d) Volume basis (wet)

25. Non-contact speed measurements can be carried out by

a) Tachometer

b) Stroboscope

c) Oscilloscope

d) Speedometer

26. The tool used for performance assessment and logical evaluation of avenues for improvement in Energy management and audit is

a) Fuel substitution
b) Monitoring and verification
c) Energy pricing
d) Bench marking

27. Infrared thermometer is used to measure

a) Surface temperature

b) Flame temperature

c) Flue gas temperature

d) Hot water temperature

28. Find out the 'odd' among the following choices for fuel substitution for industrial sector of India.

a) LDO with LSHS

b) Coal with rice husk

c) Natural gas for fertilizer plant

d) LPG for soft coke

29. The various types of the instruments, which requires during audit need to be

a) Easy to carry

b) Easy to operate

c) Inexpensive

d) All (a) to (c)

30. Air velocity in ducts can be measured by using___and manometer

a) Orifice meter

b) Borden gauge

c) Pitot tube

d) Anemometer

31. An energy audit team is formed during

a) post audit phase

b) audit phase

c) pre-audit phase

d) the time of study

32. Which of the following is not part of energy monitoring

a) data recording

b) data analysis

c) data reporting

d) energy efficiency equipment financing

33. The energy sources that are either found or stored in nature are

a) Secondary Energy Sources

b) Primary Energy Sources

c) both (a) and (b)

d) none of the above

34. Which of the following is commercial energy source?

a) Electricity

b) Coal

c) Oil

d) All the above

35. Inexhaustible energy sources are known as

a) commercial Energy

b) renewable Energy

c) primary energy

d) secondary energy

36. Energy consumption per unit of GDP is called as:

a) Energy Ratio

b) Energy intensity

c) Per capita consumption

d) None

Short Answer Questions

Each question carries **Five** marks

1. List any four important factors involved in deciding final cost of purchased electricity.
2. What are the principles of energy management?
3. What is the need for managerial skills in energy management?
4. What do you mean by energy audit?
5. Explain how matching energy usage to requirement can enhance energy efficiency
6. Give any four bench marking parameters followed in equipment/utility related in Industries.
7. List any one energy audit instrument used for power measurement and one for flue gas measurement along with parameters to be measured?
8. What is the significance of an energy policy?
9. How do you classify energy conservation measures?

10. Define ‘energy management’.

11. List steps involved in pre-audit phase.

12. What are the factors to be considered before procuring fuels for energy efficiency and economics?

13. What are the few comparative factors need to be looked in to for external benchmarking used for inter-unit comparison and group of similar units?

14. What is the objective of energy management?

15. What are the few important technical feasibility parameters that one should consider during analysis of energy conservation opportunities?

16. What do you understand by ‘plant energy performance’ (PEP)?

17. What are fuel substitution and list one example of fuel substitution?

18. What are the base line data that an audit team should collect while conducting detailed energy audit?

19. List at least four examples falling under “optimising the input energy requirements” while maximizing system efficiency.

20. Which set of standard equipment does the energy auditor need to establish the operational efficiency of an Induced draft fan? Assume that the operational efficiency of the motor can be known from the performance chart of the motor

21. Classify the types of the energy available on the earth?

22. Briefly mention about primary sources of energy?

23. What is renewable energy and list at least three renewable energy sources?

24. Define Reserve to ‘Production Ratio’?

25. How do you define ‘Final Energy Consumption’ and which sector dominate in Bangladesh ?

26. What is Energy intensity and what it indicates?

27. Differentiate between Energy Conservation and Energy Efficiency?

28. Explain PDCA approach to EnMS?

29. What are the benefits of implementing ISO 50001?

Long Answer Questions

Each question carries **Ten** marks

1. Briefly describe the Energy Efficiency & Conservation programs, target and methodology in the Bangladesh energy action plans?
2. Briefly explain with examples on fuel and energy substitution?
3. Distinguish between ‘preliminary energy audit’ and ‘detailed energy audit’?
4. Give a typical energy audit reporting format.
5. Write down the steps involved in ‘Energy management Strategy’?
6. List steps involved in ‘detailed energy audit’.

Module 2

Objective Type

Each question carries **One** mark

1.	Specific heat in kCal/kg -^{0}C of fuel oil is in the range of a) 0.15 – 0.20 b) 0.22 – 0.28 c) 0.29 – 0.32 d) none of the above
2.	Grade B Indian coal has a energy content range (in kcal/kg) of a) 3360-4200 b) 4200-4900 c) 4940-5600 d) 5600-6200
3.	Which of the following fuel requires maximum air for stochiometric combustion? a) Butane b) Propane c) Hydrogen d) Coal
4.	Stochiometric air required for combustion of Bagasse is about a) 13.7 b) 3.2 c) 6 d) 18
5.	Which fuel releases the most energy per kg on complete combustion a) Carbon b) Sulphur c) Nitrogen d) Hydrogen
6.	How many kg of CO_2 are produced in complete combustion of 16 kg of Methane? a) 42 b) 44 c) 16 d) none of the above
7.	In flue gas the theoretical CO_2 is 15.5% and measured CO_2 is 11% by volume. The percentage of excess air will be

	a) 40.9% b) 38.7 % c) 240.9 % d) 140.9 %
8.	The lowest excess air is required in a a) coal burner b) low pressure oil burner c) high pressure gas burner d) high pressure oil burner
9.	Which of the following is not measured in ultimate analysis? a) carbon b) sulphur c) hydrogen d) ash
10.	With increase in the percentage of excess air for combustion of coal, percentage of CO_2 in flue gas. a) increases b) decreases c) remains same d) none of the above
11.	Which of the following requires the least amount of oxygen /kg for complete combustion a) Carbon b) Sulphur c) Hydrogen d) Methane
12.	Which of these fuels has the highest heating value? a) Methane b) Hydrogen c) Diesel d) LPG
13.	LPG is predominantly the mixture of Propane and ___ a) Methane b) Ethane c) Butane d) Isopropane
14.	Natural gas consists of mainly the following a) Ethane b) Methane c) Propane d) Butane

15.	_____is required for the simple estimation of flame temperature of the fuel. **a)** Ultimate analysis **b)** Proximate analysis **c)** Size of the coal **d)** All of the above
16.	The large difference between GCV and NCV of gaseous fuels is due to their a) large moisture content b) negligible moisture content c) low hydrogen content d) large hydrogen content
17.	Which of the following contributes to spluttering of flame at burner tip during combustion of fuel oil? a) ash content b) water content c) sulphur content d) humidity of air
18.	For coal fired system the flame length is dictated by a) moisture b) volatile matter c) ash content d) fixed carbon
19.	Which one of the following is not true with respect to the role of nitrogen in the combustion of any fuel a) produces oxides of nitrogen b) reduces the volume of combustion by-products c) dilutes the flue gases d) carries useful heat in flue gases
20.	Which one of the following fuel has the highest hydrogen content and lowest sulphur content

	a) coal b) fuel oil c) natural gas d) LSHS
21.	For stoichiometric combustion of 1 kg of carbon, the required amount of air will be about a) 31 kg b) 21 kg c) 11.6 kg d) 2.67 kg
22.	The stoichiometric air to natural gas ratio by volume for complete combustion is a) 14-15 b) 7-8 c) 9.5-10.5 d) none of the above
23.	How much kg of SO2 is produced in complete combustion of 32 kg of sulphur? a) 16 b) 32 c) 64 d) 128
24.	100 kg of a fuel contains 3% sulphur. For complete combustion of sulphur in the fuel it will require _____kg of oxygen a) 3 b) 6 c) 30 d) 103
25.	Which property indicates the lowest temperature at which fuel oil is readily pumpable? a) flash point b) pour point c) specific heat d) specific volume
26.	The factor that influences atomisation of fuel oil is a) viscosity b) density c) flash point d) pour point
27.	Which of the following is not measured in ultimate analysis? a) carbon b) sulphur c) hydrogen d)moisture
28.	The unit of specific gravity in SI system is a) kg/ m^3 b) m^3/kg c) gm/cc d) none of the above
29.	The density of a substance relative to water is called

	a) viscosity b) specific gravity c) dew point d) pour point
30.	Liquid fuel density is measured by an instrument called a) tachometer b) hydrometer c) anemometer d) none of the above
31.	The material used to control SO_x in the FBC boiler is a) lime b) alumina c) silica d) limestone
32.	The low combustion temperature in FBC boilers results in minimal formation of a) CO b) SO_x c) NO_x d) CO_2
33.	Demineralisation of water is the process to remove a) dissolved oxygen b) dissolved salts c) carbon-dioxide d) chlorine
34.	Good opportunity for energy savings from continuous blow down of boiler is by a) recovery of flash steam for use in deaerator b) using the blow down steam to run steam turbine c) reusing the hot water so formed as make-up water d) none of the above
35.	Which of the following benefits is not achieved by maximizing condensate recovery? a) minimization of boiler exit flue gas temperature b) maximization of boiler output c) reduction in water treatment costs d) reduction in energy input costs

36.	Which data is not required to calculate the efficiency of boiler by indirect method? a) flue gas temperature b) ambient temperature c) calorific value of fuel d) <u>blow down rate</u>
37.	Radiation losses from a boiler practically a) increase with increase in its % loading b) <u>decrease with increase in its % loading</u> c) are independent of its % loading d) none of the above.
38.	The efficiency of a typical FBC boiler is of the order of a) <u>80%</u> b) 30% c) 40% d) 70%
39.	Fluidized bed combustion takes place in the temperature range of a) above 1000^0C b) below 500^0C c) 600-700^0C d) <u>800-900^0C</u>
40.	An oil fired boiler is operating at 5% O_2 in the flue gas. The percentage excess air supplied to the boiler is approximately a) 15 % b) 25 % c) <u>31 %</u> d) 42 %
41.	Pick the boiler, which can be considered as most combustion efficient? a) <u>fluidized bed combustion boiler</u> b) lancashire boiler c) stoker fired boiler d) chain grate boiler
42.	The type of firing used for a pulverized coal fired boiler is

	a) over firing b) tangential firing c) vertical firing d) mixed firing for effective heat transfer
43.	The percentage raise in boiler efficiency by a 20°C raise in combustion air temperature is a) 0.1% b) 0.2% c) 10% d) 1%
44.	In FBC boiler the combustion is carried out at a temperature a) closer to steam temperature b) at adiabatic combustion temperature c) at and above ash fusion temperature d) below ash fusion temperature of fuel used
45.	Reverse osmosis for water treatment involves a) removal of total salts b) removal of only hardness causing salts c) removal of alkali salts d) removal of non-hardness salts
46.	Which of the following is not required in the boiler efficiency evaluation by direct method a) steam flow b) fuel flow c) feed water temperature d) O_2 % in flue gas
47.	Which data is not required to calculate the efficiency of boiler by indirect method? a) flue gas temperature b) ambient temperature c) calorific value of fuel **d)** blow down rate

48.	The efficiency of a boiler was improved from 70% to 80%. The % fuel savings achieved are a) 12.5% b) 18% c) 25% d) none of the above
49.	Which of the following is the best way to assess boiler losses? a) benchmarking evaporation ratio b) indirect efficiency evaluation c) direct efficiency evaluation d) none of the above
50.	What is the appropriate fuel size in a coal fired FBC boiler? a) 25-50 mm b) 50-75 mm c) 6-10 mm d) less than 5 mm
51.	The waste heat boiler application is not suitable for which of the following? a) gas turbine b) diesel engine c) furnaces d) dryers
52.	Removal of dissolved gases from the boiler feed water is called a) descaling b) deaeration c) deoxidation d) none of the above
53.	Which of the following boiler type has the lowest permissible boiler drum TDS concentration? a) low pressure water tube boiler b) fire tube boiler c) Lancashire boiler d) all of the above
54.	In a CFBC boiler, the capture and recycling of bed materials is accomplished by a) bag filters b) settling chamber c) cyclone d) scrubber system
55.	The limit to reduction of stack temperature in an oil fired boiler is influenced by

	a) oil temperature b) air temperature c) % carbon in oil d) % sulphur in oil
56.	The type of boiler in which water passes through the tubes and hot gases pass outside the tubes is known as; a) water tube b) fire tube c) packaged boiler d) none of the above
57.	F & A (from and at) rating of the boiler is the amount of steam generated from; a) water at 0 ºC to saturated steam at 100 ºC b) water at feed water temperature to saturated steam at 100 ºC c) water at 100 ºC to saturated steam at 100 ºC d) water at ambient temperature to saturated steam at 100 ºC
58.	A supercritical boiler has parameters beyond critical point which refers to; a) 221.2 bar (a) pressure and 374.18 ^{0}C temperature b) 246 bar (a) pressure and 538 ^{0}C temperature c) 306 bar (a) pressure and 598 ^{0}C temperature d) 170 bar (a) pressure and 538 ^{0}C temperature
59.	A rise in conductivity of boiler feed water indicates a) drop in the total dissolved solids in boiler water b) more steam generation c) rise in the total dissolved solids in boiler water d) greater purity of feed water

60.	A coal fired FBC boiler can operate at ___ excess air a) 3 – 4 % b) <u>20 -25 %</u> c) 30 – 40 % d) 10 – 15 %
61.	_____ is predominantly used as a medium for soot blowing in boilers a) compressed air b) <u>steam</u> c) high pressure water d) all of the above
62.	The recommended TDS level for package fire tube boilers is a) 10,000 ppm b) 5,000 ppm c) 2,000 ppm d) <u>3,000 ppm</u>
63.	In an oil fired steam boiler the air to fuel ratio is 15:1 & evaporation ratio is 14:1. The flue gas to fuel ratio will be a) 29:1 b) <u>16:1</u> c) 14:1 d) 15:1
64.	A boiler generates 5 TPH of steam at an efficiency of 78 %. The enthalpy added to steam in the boiler is 580 kcal/kg. The fuel consumption with a GCV of 4200 kcal/kg is a) <u>885 kg/hr</u> b) 985 kg/hr c) 1038 kg/hr d) 1200kg/hr
65.	Automatic blow down controls for boilers work by sensing a) dissolved gases b) dissolved solids c) pH d) <u>conductivity and pH</u>
66.	Dissolved CO_2 in boiler feed water when left untreated would result in occurrence of _____in boiler tubes a) creep b) <u>water side corrosion</u> c) scale d) water hammer
67.	Recommended boiler feed water pH value at 25^{o}C is ---------

	a) 8.0 - 9.0 b) 5.2 - 6.2 c) 9.8-10.2 d) 10-10.5
68.	Which of the following is not applicable in the preservation of boiler by dry method? a) un-slacked lime b) activated alumina c) anhydrous calcium chloride d) hydrazine
69.	Which one of the following is true of a water softening process? a) It reduces hardness but not TDS b) It reduces both hardness and TDS c) It reduces TDS but not hardness d) None of the above
70.	Soot deposit in boiler tubes is predominantly due to a) poor water treatment b) low steam pressure c) incomplete combustion d) high excess air
71.	Which of the following fuel fired steam boiler will have the least evaporation ratio? a) coconut shell b) natural gas c) oil d) rice husk
72.	The largest heat loss in the heat balance of a coal fired boiler is due to a) dry flue gas loss b) loss due to hydrogen in the fuel c) radiation losses d) moisture in the air
73.	Water treatment for steam boilers is generally required to a) remove hydrogen b) prevent scale formation c) help improve combustion efficiency d) reduce stack temperature
74.	Which of the following salt causes temporary hardness in water? a) calcium sulphate b) calcium bicarbonate c) calcium chloride d) calcium nitrate
75.	Which of the following can be used as desiccant in boiler preservation?

	a) silica gel b) activated carbon c) un-slaked lime d) all of the above
76.	Which of the following boiler water treatment ensures complete removal of salts? a) demineralization b) softening c) de-aeration d) all of the above
77.	Which of the following boiler utilizes the combination of suspension firing and grate firing? a) traveling grate stoker boiler b) packaged boiler c) spreader stoker boiler d) pulverized fuel boiler
78.	Which of the component is common to supercritical boiler and sub critical boiler for power generation? a) economizer b) water walls c) re-heaters d) all of the above
79.	Chemical used for dozing in boiler drum to reduce dissolved gases is a) hydrazine b) chlorine c) alum d) all of the above
80.	In a boiler Air preheater is installed a) Before the economizer b) after economizer c) after ESP d) Before superheater
81.	The steam pressure drop in a steam pipe is inversely proportional to the _____ of pipe diameter a) 4^{th} power b) 6^{th} power c) 5^{th} power d) none of above
82.	In a Mollier diagram, the point at which the saturated liquid and saturated vapour lines meet is known as the; a) vapour point b) liquid point c) critical point d) sub-critical point
83.	The best quality of steam for indirect process heating is; a) dry saturated steam b) super-heated steam c) wet steam d) super critical steam
84.	In a steam system, the purpose of venting air is because air is a; a) good conductor b) inert substance c) dilutant d) insulator
85.	Latent heat at the critical point of a steam phase diagram is; a) 640 kCal/kg b) zero c) 540 kCal/kg d) 584 kCal/kg
86.	Velocity of steam in steam pipe is directly proportional to;

	a) number of bends in pipe b) specific volume of steam c) length of pipe d) <u>diameter of the pipe</u>
87.	As the pressure of steam increases from 4 kg/cm^2 to 8 kg/cm^2, the value of total enthalpy and latent heat of steam respectively; a) increases & remains the same b) <u>increases & decreases</u> c) decreases & increases d) decreases & remains the same
88.	The difference in temperature between steam and condensate refers to the principle of operation of a; a) thermodynamic trap b) <u>thermostatic trap</u> c) orifice type trap d) float trap
89.	The working media in a thermocompressor is a) electricity b) compressed air c) high temperature oil d) <u>steam</u>
90.	Which of the following does not contribute to steam savings a) insulation of steam pipe lines b) <u>superheated steam for indirect process heating</u> c) providing dry steam for process d) none of the above
91.	Flash steam can be recovered from a) superheated steam b) saturated steam c) <u>high pressure condensate</u> d) condensate at atmospheric pressure
92.	Which of these is not true of 'critical point' of steam/water mixture? a) the temperature at critical point is 374.15^{o}C b) the pressure at critical point is 221.2 bar c) saturated liquid and saturated vapour lines meet at critical point d) <u>enthalpy of evaporation is maximum at critical point</u>
93.	The head loss due to friction in a pipe is a) directly proportional to the diameter b) directly proportional to the gravitational constant c) inversely proportional to the velocity d) <u>directly proportional to the square of velocity</u>
94.	Select the wrong statement with respect to steam traps a) discharges condensate as soon as it is formed b) does not allow steam to escape c) capable of discharging air and other incondensable gases d) <u>does not allow condensate to escape</u>
95.	An increase in the steam pressure from 3 bar to 10 bar, will result in a decrease of a) sensible heat b) enthalpy of steam c) saturation temperature d) <u>specific volume</u>
96.	Saturated steam when throttled to a lower pressure results in a) wet steam b) <u>super-heated steam</u> c) super critical steam d) same state of steam
97.	Steam mains are run with a slope primarily to a) <u>avoid water hammer</u> b) increase the velocity of steam c) avoid condensation of steam d) reduce radiation and convection losses

98.	If 10% air is entrained in a steam system at 3 kg/cm^2 g then the saturation temperature of steam will be a) <u>less than the saturation temperature at 3 kg/cm^2 g</u> b) more than the saturation temperature at 3 kg/cm^2 g c) equal to the saturation temperature at 3 kg/cm^2 g d) equal to the saturation temperature at 3.3 kg/cm^2 g
99.	Select the incorrect statement with respect to steam a) evaporation is a constant temperature process b) higher the pressure higher is the steam saturation temperature c) <u>higher the pressure higher is the latent heat</u> d) latent heat at critical point is zero
100.	The working fluid for thermo compressor is a) <u>low pressure steam</u> b) high pressure steam c) compressed air d) waste heat from chimney
101.	Steam at 4 bar has sensible heat of 144 kcal/kg and latent heat of 510 kcal/kg. If the steam is 90% dry than the total enthalpy of steam in kcal/kg is a) 588 b) 654 c) <u>603</u> d) 459
102.	For transporting steam to a long distance, the most suitable among the following will be a) <u>slightly superheated steam</u> b) dry saturated steam c) mildly wet steam d) high pressure steam
103.	In a steam system, the purpose of air venting is because air a) is a good conductor b) <u>acts as insulator</u> c) is inert d) is diluent
104.	The inverted bucket trap operates on the principle of _____ difference between water and steam a) pressure b) <u>density</u> c) temperature d) velocity
105.	In a pressure reduction valve, which of these does not change? a) Temperature b) Pressure c) <u>Enthalpy</u> d) None of above
106.	Which trap is preferred in discharge of condensate recovery from process equipment? a) <u>Float trap</u> b) Thermodynamic trap c) Thermostatic trap d) All of the above
107.	In industrial applications the commonly used trap for main steam lines is a) thermostatic trap b) inverted bucket trap c) <u>thermodynamic trap</u> d) open bucket trap
108.	Steam mains should be run with a falling slope of … in the direction of steam flow for effective line condensate drainage a) 50 mm in 30 meters b) <u>125 mm in 30 meters</u>

	c) 250 mm in 30 meters d) 350 mm in 30 meters
109.	Heat loss through furnace openings is directly proportional to; a) fourth power of furnace temperature b) fourth power of absolute furnace temperature c) absolute furnace temperature d) square of absolute furnace temperature
110.	What is the most effective way to avoid ambient air infiltration into a fuel fired furnace; a) slight negative pressure should be maintained b) operate at about 90% capacity c) increase the chimney height d) slight positive furnace pressure should be maintained
111.	Which loss is the highest in a typical forging furnace operating at 1300 ^{o}C? a) flue gas loss b) wall loss c) cooling water loss d) unavoidable opening loss
112.	Scale losses in a reheating furnace will; a) increase with CO in combustion gases b) increase with excess air c) have no relation with excess air d) decrease with excess air
113.	Which of the following is not a property of ceramic fibre insulation? a) low thermal conductivity b) light weight c) high heat capacity d) thermal shock resistant
114.	In a reheating furnace, soaking time of a cycle depends typically on; a) excess air level b) preheat temperature of charge c) thickness of the charged material d) furnace atmosphere
115.	Heat transfer in a furnace is effected by a) radiation from flame b) radiation from furnace walls c) convection due to movement of hot gases over the stock d) all of the above
116.	In an oil fired heat treatment furnace which of the following is not required to determine its efficiency by direct method a) weight of input material b) oxygen percentage in flue gas c) fuel consumption d) calorific value of fuel
117.	Which of the following may not help in energy efficient furnace operation? a) maintaining a positive draft inside the furnace b) minimizing refractory losses c) complete combustion with maximum excess air d) use of ceramic fibre in batch type furnace
118.	Select the wrong statement with respect to furnace operations

	a) the burner flame should not touch the stock b) air infiltration leads to oxidation of billets c) ceramic fibre linings are used in the exterior of the furnace d) heat loss through openings is proportional to T^4
119.	The balance draft furnace is one using a) induced draft fan and chimney b) induced draft fan and forced draft fan c) forced draft fan and chimney d) without induced and forced draft fans
120.	Tuyeres is a terminology associated with a) induction furnace b) pusher type furnace c) arc furnace d) cupola
121.	Instrument used for measuring billet temperature in a reheating furnace is ___. a) thermograph b) infrared pyrometer c) Pt/Pt-Rh thermocouple with indicator d) chrome alumel thermocouple with indicator
122.	Heat transfer in a reheating furnace is achieved by a) Conduction b) Convection c) Radiation d) All of the above
123.	The storage heat losses in a batch type furnace can be best reduced by a) insulating brick b) ceramic fibre c) cold face insulation d) fire brick
124.	Ideal furnace for melting & alloying is a) induction furnace b) cupola furnace c) rotary hearth d) recirculating bogie furnace
125.	Commonly used flux medium in a cupola furnace a) calcium carbide b) fluorspar c) calcium carbonate d) sodium carbonate
126.	Which property of ceramic coating influences energy savings in furnaces? a) emissivity b) coating thickness c) conductivity d) convective heat transfer coefficient
127.	What is the predominant mode of heat transfer in reheating furnaces? a) convection b) radiation c) conduction d) pulsation
128.	Furnace wall heat loss does not depend on _____ a) temperatures of external wall surfaces b) velocity of air around the furnace c) thermal conductivity of wall brick d) material of stock to be heated.
129.	Scale losses in reheating furnaces will

	a) increase with excess air b) decrease with excess air c) have no relation with excess air d) increase with CO in combustion gases
130.	In which zone of cupola furnace does the conversion of CO2 to CO take place? a) combustion zone b) melting zone c) reduction zone d) preheating zone
131.	Furnace wall heat loss depends on a) temperatures of external wall surfaces b) velocity of air around the furnace c) thermal conductivity of wall brick d) all of the above
132.	Ceramic fibre gives the maximum energy savings when used in a) continuous furnace b) batch furnace c) arc furnace d) induction furnace
133.	Furnace wall heat loss does not depend on a) temperature of external surface b) temperature of air around the furnace c) emissivity of external wall surface d) stock to be heated
134.	Which of the energy saving measures will not be applicable for a heat treatment furnace a) complete combustion with minimum excess air b) waste heat recovery from the flue gases c) optimum capacity utilization d) **heat recovery from furnace openings**
135.	In a Heat exchanger with a high LMTD results in a) higher heat transfer area **b) lower heat transfer area** c) higher u-factor d) none of the above
136.	In a counter-flow heat exchanger, cold fluid enters at 30°C and leaves at 50°C, whereas the hot fluid enters at 150°C and leaves at 130°C. The LMTD is **a) 100°C** b) 280°C c) 0°C d) 20°C

137.	In a heat exchanger, for the same heat duty, higher the heat transfer coefficient; a) higher will be the heat transfer area needed b) higher will be the LMTD **c) lower will be the heat transfer area needed** d) lower will be the LMTD
138.	The parameter assumed to remain constant during LMTD calculation of a Heat exchanger is a) temperature drop b) heat transfer area **c) specific heat of fluids** d) none of the above
139.	Deaerator is a_____Heat exchanger. a) Shell and tube type b) Plate type **c) Direct contact type** d) Run Around Coil type
140.	A shell and tube heat exchanger is most suitable if **a) a liquid is heating another liquid** b) a gas is heating another gas c) a gas is heating a liquid d) the hot gas is loaded with dust
141.	Economizer in boiler is used to extract heat from flue gases for pre-heating a) blow down b) fuel oil c) air for combustion of fuel **d) feed water**
142.	Which of the following depends on physical properties of fluids as well as geometry of the heat exchanger? **a) Overall heat transfer coefficient** b) Fouling coefficient c) LMTD (Log Mean Temperature Difference) d) Effectiveness

143.	A waste heat recovery system (Shell and Tube heat exchanger) receives hot fluid at 200°C and leaves at 70°C, cold medium enters at 30°C and leaves at 90°C, the type of flow involved in this is a) cross-flow b) co- current flow **c) counter-current flow** d) none of the above
144.	Corrosion in stack, Air Pre-Heater, Economizer is mainly influenced by _ **a) Sulphur content in fuel** b) Ash content in fuel c) Moisture content in fuel d) All of the above
145.	Which of the following waste heat recovery systems is of thermal storage type? a) ceramic recuperator b) metallic recuperator **c) regenerative burner** d) waste heat boiler
146.	Radiation recuperators are used when the furnace flue gas temperature is more than a) 200ºC **b) 800ºC** c) 600ºC d) 400ºC
147.	Regenerator is used mainly along with a a) boiler **b) high temperature furnace** c) compressor d) gas turbine
148.	Which of the following heat recovery equipment works on a vapour compression cycle? a) thermo-compressor b) heat wheel **c) heat pump** d) heat pipe
149.	In a heat pump **a) work is added to improve quality of waste heat** b) heat is added to improve quality of waste heat c) steam is added to improve quality of waste heat d) air is added to improve quality of waste heat

150.	Heat wheels are mostly used in a situation of…. a) high temperature exhaust gases b) **heat exchange between large masses of air having small temperature differences** c) heat transfer between a liquid and gas d) corrosive gases
151.	If the volatile matter in coal is low, which of the following equipment is the best waste heat recovery option in a boiler a) economiser **b) air preheater** c) deaerator d) heat pipe
152.	The major limitation of metallic recuperator is ------- a) limitation of handling CO_x, NO_x etc. **b) limitation of reduced life for handling temperature more than 1000^{o}C** c) manufacturing difficulty of the required design d) none of the above
153.	The heat recovery device in which high conductivity bricks are used for storing heat is a) heat pipe b) heat pump c) thermo compressor **d) regenerator**
154.	Bottoming cycle cogeneration is characterised by **a) Heat first power later** **b)** Only Heat **c)** Power First and Heat Later **d)** Only Power
155.	The efficiency of which of the following turbine systems is the highest a) condensing **b) back pressure** c) double extraction condensing d) extraction condensing

156.	A waste heat recovery steam generator is used with a) steam turbines b) back pressure turbines **c) gas turbines** d) condensing turbines
157.	Combined cycle is a combination of a) conventional boiler first followed by cogeneration system **b) Brayton cycle first followed by a standard Rankine cycle** c) Rankine cycle first followed by a Brayton cycle d) extraction in the first portion and then a condensing cycle
158.	The efficiency of a stand-alone gas turbine without any heat recovery system will be in the range of a) 10 –15 % b) 15 –20 % c) 20 – 25 % **d) 35 – 40 %**
159.	A chemical plant needs steam at 3 bar and 10 bar in addition to electric power. The most suitable co-generation choice among the following will be a) extraction cum condensing b) condensing turbine c) back pressure turbine d) **extraction cum back pressure turbine**
160.	Power is to be generated from a cement kiln exhaust gas. The applicable type of cogeneration is called a) topping cycle b) Carnot cycle **c) bottoming cycle** d) Brayton cycle
161.	The Brayton cycle is a characteristic of a) steam turbine b) petrol engine c) **gas turbine** d) none of the above
162.	Recuperator as a waste heat recovery system is used mainly in a a) boiler b) **reheating furnace** c) compressor d) gas turbine

163.	The device used for recovering waste heat from the textile drier exhaust a) **heat wheel** b) recuperator c) economizer d) regenerator
164.	In the context of cogeneration turbine, the thermodynamic process taking place is a) **expansion** b) condensation c) contraction d) both (a) & (c)
165.	Which of the following works on a refrigeration cycle? a) heat pipe b) heat wheel c) **heat pump** d) thermo compressor
166.	Wick in heat pipe is provided to facilitate a) forward movement of hot vapors b) forward movement of hot liquid **c) return of condensed liquid** d) return of hot vapors
167.	Which of the following requires electrical energy for equipment operation? a) thermo compressor b) **heat pump** c) heat pipe d) economizer
168.	Ceramic recuperators can withstand gas side temperature up to a) 400^{o}C **b) 1300°C** c) 1000^{o}C d) 1700^{o} C
169.	The waste heat recovery equipment in a combustion system will be more economical when the exit flue gases are at a temperature of a) 200^{o}C b) 400^{o}C c) 600^{o}C **d) 800°C**
170.	Which among the following uses a sealed working fluid for heat recovery **a) heat pipe** b) recuperator c) heat wheel d) thermocompressor

171.	The device that upgrades a low temperature heat source to a higher temperature sink is called a) heat pipe **b) heat pump** c) plate heat exchanger d) economizer
172.	A heat pipe can transfer up to ____ times more thermal energy than copper a) 10 b) 20 c) 50 **d) 100**
173.	In an industry, exhaust gas from the furnace is used for power generation by installing waste heat recovery steam boiler and a steam turbine. This type of co- generation is termed as a) combined cycle b) Brayton cycle c) topping cycle **d) bottoming cycle**
174.	A power plant which uses first a gas turbine followed by a steam turbine for power generation is called a) topping cycle **b) combined cycle** c) Brayton cycle d) bottoming cycle
175.	A cycle which generates electricity or mechanical power first is called a) bottoming cycle **b) topping cycle** c) combined cycle d) cogeneration
176.	The effectiveness of a heat exchanger does not depend on a) specific heat of hot fluid b) specific heat of cold fluid c) inlet temperature of hot fluid d) **LMTD**
177.	The exhaust from which of the following is not suitable for waste heat boiler application? a) gas turbine **b) hot air dryer** c) diesel engine d) furnace
178.	Maximum heat transfer to the stock in a reheating furnace is by a) **radiation** b) conduction c) convection d) none of these

179.	Example for basic type of refractory is a) chrome **b) chrome magnesite** c) alumina d) all the above
180.	The most common refractory used in furnaces is a) zirconia brick b) magnesite brick **c) fire brick** d) silica brick
181.	The most economic insulation is the thickness where ….. a) depreciation costs of insulation and energy cost due to losses are the same **b) the sum of energy cost due to losses and insulation depreciation cost is minimum** c) energy losses are minimized d) energy cost due to losses are minimized.
182.	Which of the four refractories has the highest melting point temperature? **a) Lime (CaO)** b) Silica (SiO_2) c) Titania (TiO_2) d) Alumina (Al_2O_3)
183.	Insulating material made by blending and melting of alumina and silica is known as **a) ceramic fibre** b) high alumina brick c) fire brick d) insulating brick
184.	High emissivity coatings are most effective on a)outer surface of furnace b)**inner surface of furnace** c)furnace charge d)none of the above
185.	As the furnace temperature increases, the emissivity of most refractory materials a) increases upto a certain level and then decreases b) increases **c) decreases** d) decreases upto a certain level and then increases

186.	What is the most effective way to avoid ambient air infiltration into a continuous furnace? a) close all openings b) increase the chimney height c) operate at about 90% capacity d) **maintain slightly positive pressure inside the furnace**
187.	The storage heat losses in a batch type furnace can be best reduced by use of a) hot face insulating bricks b) **hot face ceramic fibre** c) cold face insulating bricks d) cold face ceramic fibre
188.	Which of the following is the most important property of an insulating brick with respect to energy savings? **a) porosity** b) mechanical strength c) colour d) compactness
189.	Which of the following is a synthetic refractory? a) MgO b) Al2O3 **c) SiC** d) SiO2
190.	Alumina is a_____type of refractory a) basic b) acidic **c) neutral** d) none of the above
191.	Dolomite is a_____type of refractory a) acidic **b) basic** c) neutral d) none of the above
192.	An increase in bulk density of a refractory increases its a) volume stability b) heat capacity c) resistance to slag penetration d) **all of the above**

193.	Pick the wrong statement. The thermal efficiency of a furnace increases by a) reducing surface heat loss b)preheating Combustion air. c) **maintaining high levels of excess air** d)minimising unburnt losses
194.	The heat loss in a furnace depends on a) Emissivity of walls b) Conductivity of refractory c) Wall thickness d) **All of the above**
195.	Ceramic coating is used in furnaces because it enhances a) conductivity b) convective heat transfer coefficient **c) emissivity** d) radiation factor
196.	Ceramic fibre gives the maximum savings when used in a) continuous furnace b) **batch furnace** c) arc furnace d) induction furnace
197.	Which of the following is not a property of ceramic fibre? a) low thermal conductivity b) light weight **c) high heat capacity** d) thermal shock resistant
198.	In determining the optimal economic insulation thickness for a steam pipeline, thickness which of the following factors need not be considered a) annual hours of operation b) calorific value c) **pipe material** d) cost of fuel
199.	Which of the following is an example of a basic refractory a) Alumino-silicate b) chrome b) **Magnesite** d)pure alumina

200.	The thermal resistance of an insulation **a) decreases with increased thermal conductivity** b) increases with increased thermal conductivity c) decreases with decreased thermal conductivity d) has no relation with thermal conductivity
201.	Which property of the refractory determines the deformation under stress? a) **creep** b) refractoriness under load (rul) c) porosity d) pyrometric cone equivalent (PCE)
202.	The insulation used for temperatures more than 350^{o}C a) Polyurethane b) polystyrene **c) Calcium silicate** d) magnesia
203.	Glass mineral wool can be applied for temperature range application upto a) 950 ^{o}C b) **500 ^{o}C** c) 1200 ^{o}C d) 750 ^{o}C
204.	The insulation material suitable for low temperature application to prevent heat gain is a) mineral fiber b) fiber glass c) silica **d) polyurethane**
205.	The effectiveness of insulation with ingress of moisture would a) increase **b) decrease** c) may increase or decrease depending on temperature and thickness of insulation d) remain unaffected
206.	Magnesite, chrome-magnesite, dolomite are examples of --------- type of refractory a) acid b**) basic** c) neutral d) none of the above

207.	In determining the economic thickness of steam pipe insulation which of the following is not required? a) cost of fuel b) boiler efficiency c) **steam pressure** d) heat content of fuel
208.	The softening temperature of a refractory is indicated by **a) Pyrometric cone equivalent (PCE)** b) refractoriness under load (RUL) c) creep d) cold crushing strength
209.	Co-generation is also known as a)Re-generation system b)Brayton system **c)Combined heat and power system** d)Reversible system
210.	The unit for heat-to-power ratio of a CHP plant is **a) kW_{th} / kW_e** b) BTU / kW c) kCal / kW d) kWh_{th} / kW_e
211.	The cogeneration system which has high overall system efficiency is a) **back pressure steam turbine** b) combined cycle c) extraction condensing steam turbine d) reciprocating engine
212.	Which CHP system has the smallest heat to power ratio with the least flexibility to increase or reduce the ratio? a) back pressure turbine **b) combined cycle** c) extraction condensing steam turbine d) reciprocating engine
213.	The working media in a thermo-compressor is a) electricity b) compressed air c) high temperature oil **d) steam**
214.	Which of the following factor is critical for FBC boilers? a) Pressure of Fluidisation air b) Critical fluidisation Velocity c) Size of fuel particles d) **All of the above**

215.	Auxiliary power consumption for coal preparation will be highest in a; a) stoker fired boiler b) AFBC boiler c) CFBC boiler **d) pulverized coal fired boiler**
216.	In FBC boiler, the combustion is carried out at a temperature a) closer to steam temperature. b) adiabatic combustion temperature **c) below ash fusion temperature** d) above ash fusion temperature
217.	The difference between mean velocity of solid and gas in a FBC boiler is called a) fluidization factor **b) slip velocity** c) settling velocity d) none of the above
218.	For efficient sulphur retention in the bed, temperature of a fluidized bed boiler should be a) 700°C b) 1100°C **c) 850°C** d) 1000°C
219.	For even distribution of fluidized air in AFBC boilers, which one of the following is used? **a) perforated metal distributor plate** b) secondary air from sides c) compressed air through nozzles d) none of the above
220.	The efficiency of a typical FBC boiler would be around a) 90% **b) 80%** c) 70% d) 40%
221.	The major advantage of the PFBC boilers are a) low excess air b) low radiation loss c) low hydrogen loss **d) compactness in size**
222.	Fluidized bed combustion takes place in the temperature range of a) above 1000^0C b) below 500^0C c) 600-700^0C **d) 800-900^0C**

223.	In FBC boilers fluidization depends largely on --------- i) Particle size ii) Air velocity iii) Bed Material iv) Size of Boiler a) i & iii b) ii & iii **c) i & ii** d) i,ii,iii,iv
224.	NOx formation in FBC boilers is minimised because of a) higher velocity of flue gas in combustion chamber b) higher pressure of the air supplied **c) lower temperatures in the bed and combustion chamber** d) higher contact of solid particles in the flue gas
225.	A major advantage of PFBC boilers compared to conventional pulverised coal fired boiler is a) less ash removal b) low excess air c) low radiation loss **d) much smaller size**
226.	When the boiler bed temperature exceeds beyond 950°C, the result is: a) Low steam temperature **b) clinker formation** c) Melting of lime stones d) Ash carry over
227.	In a glass industry waste heat is used for power generation. This type of cogeneration is called a) topping cycle **b) bottoming cycle** c) combined cycle d) none of the above
228.	In circulating fluidized bed combustion boilers most of the heat transfer takes place… a) inside the combustion zone b) bed tubes **c) outside of the combustion zone** d) super heater tubes
229.	For equal capacity, the boiler size is the smallest for a) AFBC b)CFBC **c) PFBC** d) Pulverized coil fired boiler

230.	An axial compressor is used in conjunction with which of the following a) Back pressure steam turbine b) Condensing turbine **c) Gas turbine** d) none of the above
231.	Which is not a property of Ceramic fibre insulation a) low thermal conductivity b) light weight **c) high heat storage** d) thermal shock resistant
232.	Chances of NOx formation are least in a) Chain grate stoker boiler b) Spreader stoker boiler c) Pulverized coal fired boiler **d) FBC boilers**
233.	Quality of waste heat in flue gas refers to a) dust concentration in flue gas **b) temperature** c) moisture in flue gas d) corrosive gases in flue gas
234.	The material used to control SO_x in the FBC boiler is a) lime b) alumina c) silica **d) limestone**
235.	Mark the best choice of insulation material for electric heat treatment furnace among the following a) glass wool b) calcium silicate c) fire bricks **d) ceramic fibre**
236.	The low combustion temperature in FBC boilers results in minimal formation of a) CO b) SOx **c) NOx** d) CO_2
237.	Which of the following heat recovery equipment works on a vapour compression cycle? a) thermocompressor b) heat wheel **c) heat pump** d) heat pipe
238.	Which type of the following co-generation system has high heat-to-power ratio? a) gas turbine **b) back pressure turbine** c) extraction condensing turbine d) reciprocating engine

239.	Which of the following will be an ideal heating medium for heat transfer in a heat exchanger? a) hot water b) super heated steam **c) dry saturated steam** d) wet steam
240.	In a low temperature waste heat recovery system, which of the following device is the most suitable a) Economiser **b) heat wheels** c) regenerator d) ceramic recuperator
241.	The coefficient of thermal expansion of refractory material should be **a) low** b) high c) medium d) very high
242.	Pick the boiler, which can be considered as most combustion efficient? **a) fluidized bed combustion boiler** b) lancashire boiler c) stoker fired boiler d) chain grate boiler
243.	Recuperator will be more efficient if the flow path of hot and cold fluids is in: a) co-current mode **b) counter current mode** c) cross current mode d) none of the above
244.	The difference between mean solid and mean gas velocity in FBC boiler is called a) fluidization factor **b) slip velocity** c) settling velocity d) none of the above
245.	In a CFBC Boiler the capture and recycling of bed materials is accomplished by a) settling chamber **b) cyclone** c) back filter d) scrubber
246.	In FBC boiler the combustion is carried out at a temperature a) closer to steam temperature b) at adiabatic combustion temperature c) at and above ash fusion temperature **d) below ash fusion temperature of fuel used**
247.	Thermo-compressor is commonly used for a) compressing hot air **b) upgrading low pressure steam** c) distillation d) reverse compression of CO2
248.	Ceramic fibre gives the maximum savings when used in a) continuous furnace **b) batch furnace** c) arc furnace d) induction furnace

249.	The major limitation of metallic recuperator is a) handling COx, NOx etc. **b) reduced life for handling temperature more than 650°C** c) manufacturing difficulty of the required design d) none of the above
250.	Which of the following when added to alumino silicate helps to reduce the shrinkage level of ceramic fibre **a) ZrO_2** b) SiO_2 c) Al_2O_3 d) $CaSO_4$
251.	A thermal insulator has **a) low thermal conductivity** b) high thermal conductivity c) high convection coefficient d) low convection coefficient
252.	Emissivity is a measure of material's ability to a) only absorb heat b) only radiate heat **c) absorb and radiate heat** d) none of the above
253.	Fluidized bed combustion results in _____ SOx and NOx emissions a) increased **b) decreased** c) no effect on d) elimination of
254.	Furnace wall heat loss does not depend on a) temperature of external surface b) temperature of air around the furnace c) emissivity of external wall surface **d) stock to be heated**
255.	Insulating material made by blending and melting of alumina and silica is known as **a) ceramic fibre** b) high alumina brick c) fire brick d) insulating brick
256.	Regenerators are widely used in **a) glass melting furnace** b) reheating furnace c) baking ovens d) heat treatment furnace
257.	The furnace bed temperature of a fluidized bed boiler is about **a) 850°C** b) 1100°C c) 700°C d) 1000°C
258.	The waste heat boiler application is not suitable for which of the following? a) gas turbine b) diesel engine c) furnaces **d) dryers**
259.	What is the appropriate fuel size in a coal fired FBC boiler? a) 25-50 mm b) 50-75 mm **c) 6-10 mm** d) less than 5 mm

260.	Which property is most important for a fire brick? a) high porosity **b) thermal stability at high temperature** c) low bulk density d) chemical resistance
261.	In a cogeneration system, with extraction condensing turbine, the highest heat rate is recorded when; **a) maximum power output and maximum extraction to process** b) maximum power output and normal extraction to process c) maximum power output and minimum extraction to process d) none of the above
262.	A bottoming cycle is one in which fuel is used for producing a) power primarily followed by by-product heat output **b) heat primarily followed by by-product power output** c) power, heat and refrigeration simultaneously d) none of the above
263.	An increase in bulk density of a refractory increases its a) volume stability b) heat capacity c) resistance to slag penetration **d) all of the above**
264.	The insulation material used for medium temperature application is **a) calcium silicate** b) polyurethane c) wood d) mica
265.	A coal fired FBC boiler can operate at ___ excess air a) 3 – 4 % **b) 20 -25 %** c) 30 – 40 % d) 10 – 15 %
266.	Which of the following is most suitable for high temperature waste heat recovery ? a) heat wheel b) heat pump c) heat pipe **d) recuperator**

267.	Among the following, cogeneration concept is not applicable to which type of industry? a) sugar b) paper & pulp c) refinery **d) refractory**
268.	Which of the following influences energy savings when ceramic coating is applied on furnace hot side? a) Conductivity b) Convective heat transfer coefficient **c) Emissivity** d) Factor for total radiation
269.	The insulation thickness for which the total cost is minimum is called a) Minimum insulation thickness b) Cheapest insulation thickness **c) Economic thickness** d) None of the above
270.	Reduction of specific fuel consumption using ceramic fibre is ideally suited for: a) Tunnel kiln b) pusher type reheating furnace c) Glass furnace **d) Heat treatment furnace**
271.	The most common form of refractory material extensively used in the construction of small furnaces is… a) silica bricks **b) Fire brick** c) Chrome magnesite d) Calcium silicate blocks
272.	FBC boiler has an advantage of: a) Burning high quality coal b) Burning variety liquid fuels **c) Burning wide variety of coal** d) None of the above
273.	Recovery of heat from dryer exhaust air is a typical application of: a) Waste heat recovery boiler b) heat pump **c) Heat wheels** d) Economiser

274.	Heat exchanger will be more efficient if the flow path of hot and cold fluids is in: a) co-current mode **b) counter current mode** c) cross current mode d) none of the above

Short Answer Questions

Each question carries **Five** marks

S-1	To meet a process plant's heat and power requirements, high pressure steam at 70 MT/hr passes through a back pressure steam turbine, for power generation and the exhaust steam is sent for thermal process requirements in the plant. With the following operating data, calculate the heat to power ratio in kW/kW if the turbine and generator efficiencies are 90% and 92% respectively.
S-2	A steam pipe of 100mm diameter is insulated with mineral wool. As a part of energy saving measure, the insulation is upgraded with efficient Calcium silicate insulation. Calculate the percentage reduction in heat loss due to above measure with the following data, Boiler efficiency : 80% Surface temperature with mineral wool : 95°C Surface temperature with calcium silicate : 55°C Ambient temperature : 25°C
S-3	A cogeneration plant has an electrical output of 5 MW with a back pressure turbine which has a input steam conditions to the turbine as 32 TPH with Enthalpy of 3418 KJ/kg @ 64 ata and 500oC and the exit conditions of steam at the end of the back pressure turbine is 186oC, with enthalpy of 2835.8 KJ/kg. After the process heating, all the condensate @ 730C returns to the boiler. Calculate the Heat to power Ratio and Energy Utilization factor of the process. Fuel consumption of the boiler is 8.2 TPH Coal at 4800 GCV.
S-4	A gas turbine of 20 MW Capacity was running with Naphtha as its fuel. In order to reduce emissions, the firm has decided to replace Naphtha fuel with Natural Gas. The cost of power generation using Naphtha was Rs 9.2 per unit. If the efficiency of the Gas Turbine remains at 35%, calculate the percentage reduction in cost of generating electricity after switching to Natural gas. GCV of Natural gas = 10800 kCal/kg Cost of Natural Gas = Rs 36000/ton
S-5	In a paper industry, 1.5 Tons/hr of saturated steam at 8 bar is used for preheating 25 Tons/hr of Soda liquor in a heat exchanger. Soda liquor enters the heat exchanger at

<table>
<tr><td></td><td>55°C and the specific heat of the liquor is 0.38 Kcal/Kg°C. Calculate the exit temperature of the soda liquid leaving the heat exchanger & the LMTD of the exchanger with the following data from steam table
<table>
<tr><td rowspan="2">Pressure, bar</td><td rowspan="2">Temperature, °C</td><td colspan="3">Enthalpy kcal/kg</td></tr>
<tr><td>Water</td><td>Evaporation</td><td>Steam</td></tr>
<tr><td>8.0</td><td>165</td><td>165</td><td>490</td><td>660</td></tr>
</table></td></tr>
<tr><td>S-6</td><td>Milk is flowing in a pipe cooler at a rate of 0.95 kg/sec. Initial temperature of the milk is 55 °C and it is cooled to 18 °C using a stirred water bath with the constant temperature of 10°C around the pipe. Specific heat of milk is 3.86 KJ/kg°C. Calculate the heat transfer rate (kcal/hr) and also LMTD of the exchanger.</td></tr>
<tr><td>S-7</td><td>An economizer was installed in the furnace-oil fired boiler. The following are the data monitored after commissioning the economiser.
Air to fuel ratio = 20
Evaporation ratio of the boiler = 12
Specific heat of flue gas = 0.25 kcal/kg°C. Condensate recovery in the plant = Nil.

Calculate the rise in temperature of feed water in an economizer, which brings down the flue gas temperature from 280 ^{O}C to 180 ^{O}C.</td></tr>
<tr><td>S-8</td><td>Explain with sketch the working principle of a regenerator used for high temperature furnace.</td></tr>
<tr><td>S-9</td><td>Explain briefly the bottoming cycle cogeneration system and mention any two of its application in industry</td></tr>
<tr><td>S-10</td><td>Distinguish between plate heat exchanger and shell and tube heat exchanger?</td></tr>
<tr><td>S-11</td><td>List down five major advantages of waste heat recovery in rolling mill furnace</td></tr>
<tr><td>S-12</td><td>Write short notes on factors affecting wall losses in batch type reheating furnaces?</td></tr>
</table>

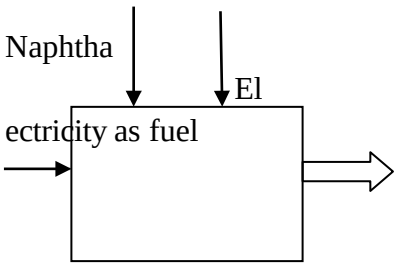
S-13	For a 5 TPH capacity boiler, estimate the rise in temperature of feed water in an economizer, when the flue gas temperature decreases from 310ºC to 180ºC. Air to fuel ratio and evaporation ratio of the boiler are 22 and 10 respectively. Assume condensate recovery and boiler blow down is nil. Specific heat of flue gas: 0.23 kCal/kg ºC
S-14	List some applications using ceramic fibre.
S-15	In selection of a refractory which physical, chemical and other properties of a refractory are important?
S-16	What are the important aspects to be considered for retrofitting a conventional boiler to FBC technology?
S-17	Explain what is meant by a combined cycle.
S-18	List at least five important parameters to be considered before installing a cogeneration system.
S-19	What is a 'heat pipe'? How does it work?
S-20	Briefly explain the principle of a 'thermocompressor'
S-21	What is the economic thickness of insulation?
S-22	Name any five parameters required to evaluate economic thickness of insulation
S-23	How does high emissivity coating in a furnace chamber helps in reducing energy consumption?
S-24	(i) Which sources of heat can be recovered from a 2 MW reciprocating engine cogeneration system? and (ii) What is roughly the temperature level of these waste streams?
S-25	(i) list prime movers for cogeneration, and (ii) State the one with the highest efficiency.
S-26	A firm wants to recover waste heat in a flue gas stream of 1800 kg/hour from a furnace. Specific heat of flue gas is 0.23 kCal/kg^0 C. (i) Calculate the heat recovered if the heat exchanger has an efficiency of 97% and temperature of flue gas drops from 900^0 C to 220^0 C across the heat exchanger. (ii) How many liters of water per hour can be heated by 40^0 C from this waste stream?

S-27	What is the principle of CFBC (circulating fluidized bed combustion) boiler?
S-28	How does a thermocompressor work? Explain briefly with a sketch
S-29	Match the following: Cogeneration system — Typical range of heat to power ratio a) Back pressure steam turbine — 1) 2.0 – 10.0 b) Extraction-condensing steam turbine — 2) 1.3 – 2.0 c) Gas turbine — 3) 1.1 – 2.5 d) Combined cycle — 4) 1.0 – 1.7 e) Reciprocating engine — 5) 4.0-14.3
S-30	In a re-rolling mill furnace the outlet flue gas temperature is 550^{o}C. The industry has installed a recuperator to preheat combustion air upto 300^{o}C and reduces fuel consumption by 15%. List down other three more advantages other than reduction in fuel consumption which would accrue to the industry.
S-31	Given the choice would you paint the outer surface of a reheating furnace black, or with a shiny glossy colour (such as silver colour)? Explain.
S-32	Write short notes on economic insulation thickness for energy efficiency.
S-33	List down five advantages of FBC boiler.

Long Answer Questions

Each question carries **Ten** marks

L-1	In a chlor-alkali plant, 100 TPD caustic solution at 30% concentration is dried to 55% concentration in a single effect evaporator, where the ratio of steam input to moisture removal is 1.0 kg/kg. It is proposed to be replaced by a triple effect evaporator at an investment cost of Rs. 5 crore, for which the ratio of steam input to moisture removal is 0.45 kg/kg. Steam for the evaporator is generated from an oil fired boiler at an evaporation ratio of 14. Calculate annual fuel savings in TPD.
L-2	Write short notes on following refractory properties and their significance. a) Porosity b) Bulk density c) Pyrometric cone equivalent d) Thermal conductivity
L-3	A heat exchanger is to be designed to condense the hydrocarbon vapor mixture from a distillation column at the rate of 11.0 kg/sec which is available at its saturation temperature of 120°C. The latent heat of condensation of the hydrocarbon vapor mixture is 450 kJ/kg. The cooling water at 32°C is used in counter-current direction at the rate of 58 kg/sec to condense the vapor mixture. The specific heat of cooling water is 4.18 kJ/kg ^{o}C. Determine LMTD and area of the heat exchanger surface if the overall heat transfer co-efficient is 600 J/m^{2}s°C.
L-4	A liquid waste stream has a flow rate of 3.5 kg/s and a temperature of 70^{o} C with a specific heat capacity of 4190 J/kgK. Heat recovered from the hot waste stream is used to pre-heat boiler make-up water. The flow rate of the make-up water is 2 kg/s, its temperature is 10^{o}C and its specific heat capacity is 4190 J/kg/K. The overall heat transfer coefficient of the heat exchanger is 800 W/m^{2}K. If a make-up water exit temperature of 50^{o}C is required, and assuming that there is no heat losses from the exchanger, determine 1) The heat transfer rate 2) The exit temperature of the effluent and

	3) The area of the heat exchanger required
L-5	A process industry is equipped with a steam power plant generating 1,00,000 units/day and a separate low-pressure boiler generating at an average steam production of 8.3 Tons of steam/hour at enthalpy of 630 kcal/kg for process heating. The feed water temperature to the boiler is 70^{o}C. The efficiencies of the steam power plant and boiler are 29% and 75% respectively. Coal is used in both cases and calorific value of coal is 3800 kcal/kg. The management proposes to commission a cogeneration plant retaining the coal as fuel. The expected energy utilization factor of the cogeneration plant is 75%. Calculate coal savings with the new cogeneration plant.
L-6	A counter-flow double pipe heat exchanger using hot process liquid is used to heat water, which flows at 10.5m^3/hr. The process liquid enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperature of water are 30°C and 90°C respectively. Specific heat of water is 4.18 kJ/kg°C. a) Calculate the heat transfer area, if overall heat transfer coefficient is 814 W/m^2°C.. b) What would be the percentage increase in area, if the fluid flows were parallel?
L-7	a) In a typical fertilizer manufacturing plant, the quantity of 133200 Ton of Ammonia is produced annually, using naphtha as fuel as well as raw material (feed) and electricity from captive power plant.  Naphtha as feed raw Ammonia production plant Ammonia Production

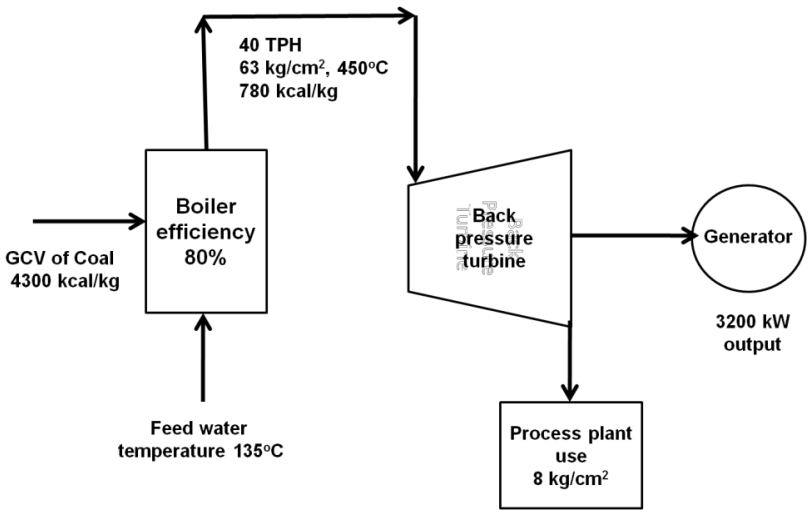
<table>
<tr><td></td><td>The quantity of annual raw material consumption and its heating values are given in table.

<table>
<tr><th>Raw material consumption</th><th>Quantity</th><th>Heating Value</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>1.Naphtha - feed</td><td>66800 Ton</td><td>10650 kCal / kg</td></tr>
<tr><td>2.Naphtha - fuel</td><td>31200 Ton</td><td>10650 kCal / kg</td></tr>
<tr><td>3.Electricity</td><td>1180 x Lakh kWh</td><td>2500 kCal/kWh</td></tr>
</table>

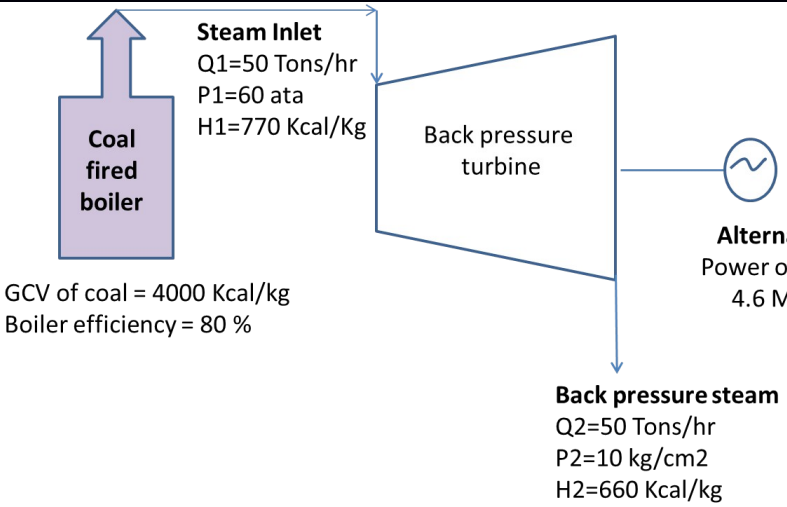
Calculate the specific energy consumption of ammonia production in Gcal / Ton.

b) Sketch the schematic diagram of “Back Pressure Turbine” and “Extraction Condensing Turbine” Cogeneration systems (Note: no explanation required).</td></tr>
<tr><td>L-8</td><td>a) List the advantages of CFBC boilers over AFBC boilers.

b) What are the advantages of plate heat exchanger over shell and tube heat exchanger?</td></tr>
<tr><td>L-9</td><td>The schematic of a back pressure steam turbine cogeneration system of process plant operating round the clock with operating data is depicted below.

 
</td></tr>
</table>

	If the steam requirement of the process is to be increased to 44TPH which can be met by the existing boiler through the back pressure turbine, a) find out the reduction in cost of electrical energy drawn from the grid per day due to additional power generation ,assuming the same steam to power recovery as in the existing case and at a grid electricity cost of Rs.7/kWh, Aux power remains the same b) also find out the additional coal requirement per day?
L-10	A steam pipeline of 250 mm outer diameter & 100 meters long is insulated with 150 mm Mineral wool insulation. As an energy conservation measure, the management has upgraded the existing Mineral wool insulation with efficient calcium silicate insulation. Calculate the economics in terms of payback if the insulation is upgraded at a cost of 20 lakhs. Given: Operating hours: 8000 Boiler efficiency: 87 % Fuel Oil Cost: Rs. 45,000 per ton GCV of the fuel: 10,200 kcal/kg Thickness of Mineral wool insulation: 150 mm Thickness of Calcium Silicate insulation: 100 mm Surface temperature with Mineral wool insulation: 70 °C Surface temperature with Calcium silicate insulation: 55 °C Ambient temperature: 30 °C
L-11	The energy flow diagram in a cogeneration plant in paper industry is given below.

	 Calculate the following i) Input coal consumption per hour if feed water temperature is 50^{o}C ii) Heat to power ratio of cogeneration plant iii) % turbine and generator losses
L-12	List down any ten points that need attention while selecting biomass fluidised bed combustion boiler
L-13	In a crude distillation unit of a refinery, furnace is operated to heat 500 m^3/hr of crude oil from 255°C to 360°C by firing 3.4 tons/hr of fuel oil having GCV of 9850 kcal/kg. As an energy conservation measure, the management has installed an air preheater (APH) to reduce the flue gas heat loss. The APH is designed to pre-heat 57 tonnes/hr of combustion air to 195°C. Calculate the efficiency of the furnace before & after the installation of APH. Consider the following data: • Specific heat of crude oil = 0.6 kcal/kg°C • Specific heat of air = 0.24 kcal/kg°C • Specific gravity of Crude oil = 0.85 Ambient temperature = 28°C.

L-14	The management of a foundry is considering retrofitting the existing heat treatment furnace with hot face insulation of 75 mm ceramic fibre. (Note: Hot face insulation is known as veneering: ie over the existing refractory lining, ceramic fibre modules are applied to reduce the heat loss during operation and heat storage loss in refractory structure). Furnace Operating data: Heat Treatment furnace : (Bogey Type) Batch Operation Furnace Capacity : 5 Ton (per batch) Fuel type : Furnace Oil Surface Area of Side walls : (1.4 x 4.5) x 2 = 12.6 m^2 Back Wall : 0.95 x 1.4 = 1.33 m^2 Roof : 0.95 x 4.5 = 4.3 m^2 Refractory Type : Fire Bricks Wall Thickness Side walls : 18 inches Arch : 13.5 inches Number of cold starts per month: 5 Nos. Number of batches per month: 15 Nos. Fuel Cost : Rs 48/ kg GCV of furnace oil : 10200 kCal/kg Heat Storage (kCal /m^2) for batch operation and cold start from walls and roof area are given below.

	For batch operation	Cold Start

		Existing(with only fire bricks)	75 mm Veneering+ fire bricks	Existing(with only fire bricks)	75 mm Veneering+ fire bricks
	Wall	79480	45350	116697	23,964
	Roof	74770	31,401	97,236	16,438

For batch operation furnace is heated from 300^{o}C to 850^{o}C

For cold start up furnace is heated from ambient 30 ^{o}C to 850^{o}C

Calculate the following due to veneering

a) Total heat loss reduction per month from wall and roof during batch operation.

Total heat loss reduction per month from wall and roof during cold starts.

L-15	Explain briefly <u>any two</u> of the following a) Heat Wheel b) Topping and bottoming cycles for cogeneration with examples c) Economic thickness of insulation
L-16	Describe any five properties of ceramic fibre from the point of view of their uses in furnace.
L-17	What is meant by heat- to power ratio in a cogeneration system? Show in a sketch three different modes in which a single steam turbine can be used for cogeneration.
L-18	Explain four types of topping cycle cogeneration systems?
L-19	What are waste heat recovery boilers? Explain the need and benefits?
L-20	(i) state two examples of heat pump applications (ii) in which situation are heat pumps most promising? (iii) draw the schematics of a heat pump system (iv) briefly discuss each process stage
L-21	On the topic of waste heat recovery boilers, explain the following:

	(i) Which are typical applications of waste heat boilers? (ii) How do they differ from ordinary steam boilers? (iii) In what temperature range do they operate? (iv) Is it more energy efficient to generate hot water of 80^0 C or saturated steam at 6 bar in a waste heat boiler? Explain
L-22	The insulation of a steam pipeline is to be upgraded. With the following data calculate the simple payback period for the insulation upgradation project.

Length of the steam pipeline	110 m
Bare pipe external diameter	100 mm
Heat loss from the pipe with existing 25 mm insulation thickness	2000 kcal/m^2hr
Thickness of insulation to be added	25 mm
Heat loss after insulation upgradation	400 Kcal/m^2/hr
Boiler efficiency	75%
GCV of coal	4000 kcal/kg
Annual operating hours	8000 hrs
Cost of coal	Rs. 2000/Ton
Investment for insulation upgradation	Rs. 4 lakhs

L-23

A steam pipeline of 100mm diameter is not insulated for 100 metre length, supplying steam at 10 kg/cm ^{2}.Find out the fuel savings if it is properly insulated with 50mm insulating material. Assume 8000 hours of operation per year.

Given:

Boiler efficiency :80%

Cost of fuel oil :Rs 20,000/tonne.

Gross Calorific value of fuel :10300k.cal/kg

Surface temperature without insulation :170^0C

Surface temperature after insulation :50^0C

Ambient temperature :30^0C

L-24	Explain briefly the principal of operation of a) Heat pipe b) Radiation Recuperator c) Plate Heat Exchanger
L-25	Explain the significance of heat to power ratio. Under what circumstances is cogeneration attractive?
L-26	(a) Explain the important properties of ceramic fibre. (b) Name five general requirements of refractory material.
L-27	A process industry needs saturated steam at 5 kg/cm^2(g) and 10 kg/cm^2(g) pressure level for process heating. A fluidized bed boiler generates steam at 22 kg/cm^2(g) pressure at the rate of 24 TPH. 4 TPH of steam is reduced through PRDS for meeting the 10 kg/cm^2(g) steam requirement. The balance steam is passed through a Back pressure steam turbine. The turbine back pressure steam at 5 kg/cm^2(g) is sent to a process in the plant. a) Mechanical Efficiency of steam turbine = 92 % b) Losses in gear transmission = 4% c) Efficiency of alternator = 96 % d) The total heat of steam at turbine inlet condition at 22 kg/cm^2 (g) = 708 kCal/kg e) The total heat of steam at turbine outlet condition at 5 kg/cm^2 (g) = 658 kCal/kg Calculate the total power output from the system.
L-28	Write short notes on any two of the following a) general requirements of refractory material for furnace application b) causes of boiler tube leakages c) thermocompressor d) heat pipe

Module 3

Objective Type

Each question carries **One** mark

1. If the voltage level of the electricity distribution system is raised from 11 kV to 33 kV for the same loading conditions, the distribution losses are reduced by a factor of

   a) 1/9 b) 1/3 c) 1/6 d) none of the above

2. In electricity distribution, if the voltage is raised from 11 kV to 33 kV for the same loading conditions, the voltage drop in the distribution system would be lower by a factor of

   a) 1/4 b) 1/2 c) 1/3 d) none of the above

3. If the reactive power drawn by a particular load is zero, it means the load is operating at

   a) lagging power factor b) leading power factor
   c) unity power factor d) none of the above

4. Select the location of installing capacitor bank, which will reduce the electricity distribution losses to the maximum extent

a) main sub-station bus bars b) motor terminals

c) motor control centre d) distribution board bus bars

5. A pure inductive load draws

a) leading reactive power b) active power

c) lagging reactive power d) none of the above

6. The nearest kVAr compensation required for improving the power factor of a 100 kW load from 0.8 lag to unity power factor is

a) 50 kVAr b) 75 kVAr c) 100 kVAr d) none of the above

7. The percentage increase in power consumption of a compressor with suction side air filter pressure drop of 250 mmWC is closest to

a) 0.5% b) 2% c) 3% d) 4%

8. A power factor capacitor designed for 10 kVAR at 415 V was found to be operating at 400 V. The effective capacity of the capacitor would be

a) 9.3 kVAR b) 10 kVAR c) 10.8 kVAR d) none of the above

9. A four pole induction motor operating at 50 Hz, with 1% slip will run at an actual speed of

a) 1500 RPM b) 1515 RPM c) 1485 RPM d) none of the above

10. With decrease in design speed of induction motors the required capacitive kVAr for reactive power compensation for the same capacity range will

a) increase b) decrease c) not change d) none of the above

11. kW rating indicated on the name plate of an induction motor indicates

a) rated input of the motor b) rated output of the motor
c) maximum input power which the motor can draw
d) maximum instantaneous input power of the motor

12. For every 4°C reduction in the air inlet temperature of an air compressor, the power consumption will normally decrease by….. percentage points for the same output.

a) 1 b) 2 c) 3 d) 4

13. The acceptable pressure drop in mains header at the farthest point of an industrial compressed air network is

a) 0.3 bar b) 0.5 bar c) 1.0 bar d) 2 bar

14. PF capacitor installed at the motor starter location will improve

a) motor design power factor

b) motor operating power factor from the starter to the power supply side

c) motor operating power factor from the starter to the motor terminals side

d) all of the above.

15. A 200 cfm compressor has a loading and unloading period of 10 seconds and 20 seconds respectively during a compressed air leakage test. The air leakage in the compressed air system would be

a) 20.3 cfm b) 42.1 cfm c) 66.6 cfm d) 132.8 cfm

16. Higher chiller COP can be achieved with

a) lower evaporator temperature and higher condensing temperature

b) lower evaporator temperature and lower condensing temperature

c) higher evaporator temperature and higher condensing temperature

d) none of the above

17. Vertical type reciprocating compressors are used in the capacity range of

a) 50 – 150 cfm b) 200 – 500 cfm

c) 500 - 1000 cfm d) above 1000 cfm

18. One ton of refrigeration (TR) is equal to

a) 3.51 kW b) 3024 kcal/hr c) 12,000 BTU/hr d) all of the above

19. Approximate percentage reduction in power consumption with 1 °C rise in evaporator temperature in refrigerating systems is

a) 1% b) 2% c) 3% d) 4%

20. The refrigerant used in vapour absorption systems is

a) steam b) pure water c) freon d) lithium bromide

21. Li – Br water absorption refrigeration systems have a COP in the range of

a) 0.4 – 0.5 b) 0.65 – 0.70 c) 0.75 – 0.80 d) none of the above

22. Slip ring induction motors, in general, have a …… design efficiency in comparison with the squirrel cage induction motors for similar ratings

a) lower b) higher c) same d) none of the above

23. System resistance in water pumping system varies with

a) square of flow rate b) cube of flow rate

c) square root of flow rate d) none of the above

24. The outer tube connection of the pitot tube is used to measure …… in the fan system

a) static pressure b) velocity pressure
c) total pressure d) dynamic pressure

25. If the speed of a pump is doubled, pump shaft power goes up by

a) 2 times b) 6 times c) 8 times d) 4 times

26. If the speed of a pump is doubled, the pump head goes up by

a) 4 times b) 2 times c) 8 times d) 16 times

27. Friction loss in a piping system carrying fluid is proportional to

a) fluid flow b) $(\text{fluid flow})^2$ c) $\frac{1}{\text{fluid flow}}$ d) $\frac{1}{(\text{fluid flow})^2}$

28. Shaft power of the motor driving a pump is 30 kW. The motor efficiency is 0.9 and pump efficiency is 0.6. The power transmitted to the water is

a) 16.2 kW b) 18.0 kW c) 27.0 kW d) none of the above

29. For fans, the relation between flow discharge Q and speed N is

a) $\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$ b) $\frac{Q_1}{Q_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{Q_1}{Q_2} = \frac{N_1^3}{N_2^3}$ d) none of the above

30. If inlet and outlet water temperatures of a cooling tower are 40°C and 32°C respectively and atmospheric DBT and WBT are 35 °C and 28 °C respectively then the approach of cooling tower is

a) 3°C b) 4°C c) 5°C d) 7°C

31. Cooling tower effectiveness is

a) approach / (range + approach) b) range/ (range + approach)

c) approach / range d) none of the above

32. The lowest theoretical temperature to which water can be cooled in a cooling tower is

a) DBT of the atmospheric air b) WBT of the atmospheric air

c) average DBT and WBT of the atmospheric air

d) difference between DBT and WBT of the atmospheric air

33. Which of the following ambient conditions will evaporate maximum amount of water in a cooling tower

a) 35 °C DBT and 25 °C WBT b) 40°C DBT and 38°C WBT

c) 35 °C DBT and 28 °C WBT d) 38 °C DBT and 37 °C WBT

34. In general, design chilled water temperature drop across chillers is approximately

a) 5 °C b) 1 °C c) 10 °C d) 15 °C

35. Normally a manufacturer's guaranteed best approach of a cooling tower is

a) 5 °C b) 12 °C c) 8 °C d) 2.8 °C

36. GLS lamp is

a) general lighting service lamp b) general lighting source lamp
c) glow light source lamp d) glow light service lamp

37. The unit of illuminance is

a) lux b) luminaire c) lumens d) none of the above

38. Luminous efficacy of which of the following is the highest?

a) CFL b) HPMV c) HPSV d) LPSV

39. If voltage is reduced from 230 V to 200 V for a fluorescent tube light, it will result in

a) reduced power consumption b) increased power consumption
c) increased light levels d) no change in power consumption and light levels

40. What is the typical frequency of a high frequency electronic ballast?

a) 50 Hz b) 10 kHz c) 30 kHz d) 50 kHz

41. The compression ratio in diesel engines is in the range of

a) 5:1 to 10:1 b) 10:1 to 13:1 c) 14:1 to 25:1 d) none of the above

42. The rated efficiency of a diesel generator captive power plant has a range of

a) 43% – 45% b) 50% – 60% c) 60% – 70% d) above 70%

43. The maximum unbalanced load between phases should not exceed …… % of the capacity of the DG set

a) 1 b) 5 c) 10 d) none of the above

44. The exhaust gas waste heat recovery potential of a turbo charged genset at 500 kW loading and 480°C exhaust gas is closest to ……

(Assume exit gas temperature of 180°C and 8 kg gas/ kWh generated)

a) 1.6 lakh kCal/hr b) 2.2 lakh kCal/hr c) 3.0 lakh kCal/hr d) 3.5 lakh kCal/hr

45. The operating efficiency of a DG set also depends on

a) turbo charger performance b) inlet air temperature

c) % loading d) all of the above

46. The core losses of a transformer are the least if the core is made up of

a) silicon alloyed iron (grain oriented) b) copper
c) amorphous core – metallic glass alloy d) none of the above

47. The basic functions of an electronic ballast fitted to a fluorescent tube light exclude one of the following

a) to ignite the lamp b) to stabilize the gas discharge
c) to supply power to the lamp at supply frequency
d) to supply power to the lamp at very high frequency

48. Modern electronic soft starters are used for motors to

a) achieve variable speed b) provide smooth start and stop
c) improve the loading d) none of the above

49. The nearest kVA rating required for a DG set with 1000 kW connected load, with diversity factor of 1.5 and 84% loading and 0.8 power factor is

a) 500 kVA b) 1000 kVA
c) 1500 kVA d) 2000 kVA

50. Maximum demand controller is used to

a) switch off non-essential loads in a logical sequence

b) switch off essential loads in a logical sequence

c) controls the power factor of the plant

d) all of the above.

51. The voltage drops in transmission / distribution line depends on ____.

a) reactance and resistance of the line
b) current in the line
c) length of the line
d) all of the above

52. Power factor is the ratio of

a) kW/kVA
b) kVA/kW
c) kVAr/kW
d) kVAr/kVA

53. If the reactive power drawn by a particular load is zero, it means the load is operating at

a) lagging power factor
b) leading power factor
c) unity power factor
d) none of the above

54. Select the ideal location of installing capacitor banks, which will reduce the distribution loss to the maximum extent.

a) main sub-station bus bars
b) motor terminals
c) motor control centre
d) distribution transformers

55. A 10 HP/7.5 kW, 415 V, 14.5 A, 1460 RPM, 3 phase rated induction motor, after decoupling from the driven equipment, was found to be drawing 3 A at no load. The current drawn by the motor at no load is high because of

a) faulty ammeter reading
b) very high supply frequency at the time of no load test

c) lose motor terminal connections

d) very poor power factor as the load is almost reactive

56. If voltage applied to a 415 V rated capacitors drops by 5 %, its VAr output drops by about____.

a) 5% b) 10% c) 19% d) none of the above

57. Which of the following is not a positive displacement compressor

a) Roots blower b) Screw Compressor
c) Centrifugal Compressor d) Reciprocating Compressor

58. Which of the factors will indicate the performance of a rewound induction motor?

a) no load current b) stator winding resistance
c) air gap d) all the above

59. A six pole induction motor operating at 50 Hz, with 1% slip will run at an actual speed of

a) 1000 RPM b) 1010 RPM c) 990 RPM d) none of the above

60. With decrease in design speed of squirrel cage induction motors the required capacitive kVAr for reactive power compensation for the same capacity range will

a) increase b) decrease c) not change d) none of the above

61. The ratio of current drawn by the induction motor to its rated current does not reflect true loading of the motor at partial loads mainly due to

a) increased motor slip b) decreased operating power factor
c) decreased motor efficiency d) none of the above

62. For every 4°C rise in the air inlet temperature of an air compressor, the power consumption will normally increase by___ percentage points for the same output.

a) 1 b) 2 c) 3 d) 4

63. Typical acceptable pressure drop in mains header at the farthest point of an industrial compressed air network is

a) 0.3 bar b) 0.5 bar c) 0.7bar d) 1.0 bar

64. Vertical type reciprocating compressor are used in the cfm capacity range of

a) 50-150 b) 200-500 c) 500-1000 d) 1000 and above

65. A battery of two reciprocating 250 cfm belt driven compressors installed in a centralized station, were found to be operating at the same loading period of 60% and unloading period of 40%. The least cost solution to reduce wastage of energy in this case would be

a) switching off one compressor

b) reducing appropriately the motors pulley sizes

c) reducing appropriately the compressors pulley sizes

d) none of the above

66. With increase in condensing temperature in a vapor compression refrigeration system, the specific power consumption of the compressor for a constant evaporator temperature will

a) increases
b) decreases
c) sometime increases and sometime decreases
d) remains the same

67. With increase in evaporator temperature in a vapor compression refrigeration system, while maintaining a constant condenser temperature, the specific power consumption of the compressor will

a) increase
b) decrease
c) sometime increase and sometime decrease
d) remains the same

68. The refrigeration load in TR when 15 m^3/hr of water is cooled from 21^o C to 15 ^{o} C is about

a) 7.5 b) 32 c) 29.8 d) none of the above

69. Coefficient of Performance (COP) for a refrigeration compressor is given by

a) Cooling effect (kW) / Power input to compressor (kW)
b) Power input to compressor (kW) / cooling effect (kW)
c) Q x C_P x (Ti – To) / 3024
d) none of the above

70. The efficiency of backward-inclined fans compared to forward curved fans is__

a) higher b) lower c) same d) none of the above

71. _____ fans are known as “non-overloading“ because change in static pressure do not overload the motor

a) radial b) forward- curved c) backward-inclined d) tube- axial

72. A 100 cfm reciprocating compressor was observed to be operating at load - unload pressure setting of 6.0 kg/cm^{2}g and 7.5 kg/cm^{2}g respectively. This situation will result in

a) increased leakage loss in air distribution system
b) increased loading timings of the compressor
c) increased energy consumption of the compressor d) all the above

73. The specific ratio as defined by ASME and used in differentiating fans, blowers and compressors, is given by

a) suction pressure/discharge pressure b) discharge pressure/suction pressure
c) suction pressure/ (suction pressure + discharge pressure)
d) discharge pressure/ (suction pressure + discharge pressure)

74. In centrifugal fans, airflow changes direction

a) once b) twice
c) thrice d) none of the above

75. Reducing the fan RPM by 10% decreases the fan power requirement by

a) 10% b) 27% c) 33% d) none of the above

76. It is possible to run pumps in parallel provided their_____ are similar

a) suction head b) discharge heads
c) closed valve heads d) none of the above

77. The operating point in a pumping system is identified by

a) point of intersection of system curve and efficiency curve
b) point of intersection of pump curve and theoretical power curve
c) point of intersection of pump curve and system curve
d) none of the above

78. Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9 and pump efficiency is 0.6. The power transmitted to the water is

a) 16.2 kW b) 18.0 kW c) 27.0 kW d) none of the above

79. The static pressure of a fan running at 500 RPM is 200 mm wc. If it has to be increased to 250 mmwc then the new speed of the fan would be

a) 625 RPM b) 400 RPM c) 1250 RPM d) 750 RPM

(One mark to be awrded to all)

80. If inlet and outlet water temperatures of a cooling tower are 42°C and 34°C respectively and atmospheric DBT and WBT are 39 ° C and 30 ° C respectively, then the approach of cooling tower is

a) 3° C b) 4° C c) 5° C d) 8° C

81. Which one from the following types of cooling towers consumes less power?

a) Cross-flow splash fill cooling tower b) Counter flow splash fill cooling tower
c) Counter flow film fill cooling tower d) None of the above

82. Which one of the following is true to estimate the range of cooling tower?

a) Range = Cooling water inlet temperature – Wet bulb temperature
b) Range = Cooling water outlet temperature – Wet bulb temperature

c) Range = $\frac{\text{Heat load in kCal/ h}}{\text{Water circulation in liters/ h}}$ d) None of the above

83. Which of the following ambient conditions will evaporate minimum amount of water in a cooling tower

a) 35 °C DBT and 25 °C WBT b) 40°C DBT and 36°C WBT

c) 35 °C DBT and 28 °C WBT d) 38 °C DBT and 37 °C WBT

84. Small by-pass lines are installed in pumps some times to _____.

a) save energy b) control pump delivery head
c) prevent pump running at zero flow d) reduce pump power consumption

85. Cycles of concentration in circulating water (C.O.C) is the ratio of

a) dissolved solids in circulating water to the dissolved solids in make up water

b) dissolved solids in make up water to the dissolved solids in circulating water

c) dissolved solids in evaporated water to the dissolved solids in make up water

d) none of the above

86. One lux is equal to ___.

a) one lumen per ft^2 b) one lumen per m^2

c) one lumen per m^3 d) none of the above

87. Color rendering index of Halogen lamps compared to low pressure sodium vapor lamps is

a) poor b) excellent c) average d) very poor

88. Which of the following options reduces the electricity consumption in lighting system in a wide spread plant?

a) replacing 150 W HPSV lamps with 250 W HPMV lamps

b) maintaining 260 V for the lighting circuit with 220 V rated lamps

c) installing separate lighting transformer and maintaining optimum voltage

d) none of the above

89. If voltage is reduced from 230 V to 190 V for a fluorescent tube light, it will result in

a) increased power consumption b) reduced power consumption

c) increased light levels d) no change in power consumption

90. What is the typical frequency of a high frequency electronic ballast?

a) 50 Hz b) 50kHz c) 30 kHz d) 60 Hz

91. Which combination of readings as indicated by the panel mounted instruments of a DG Set would give the indications of proper capacity utilisation of diesel engine and generator

a) kW & Voltage b) kVA & kVAr c) kW & KVA d) none of the above

92. Lower power factor of a DG set demands_____

a) lower excitation currents b) higher excitation currents

c) no change in excitation currents d) none of the above

93. The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is:

a) temperature rise b) back pressure

c) over loading of waste heat recovery tubes d) turbulence of exhaust gases

94. In a DG set, the generator is generating 1000 kVA, at 0.7 PF. If the specific fuel consumption of this DG set is 0.25 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour.

a) 230 litre b) 250 litre c) 175 litre d) none of the above

95. Which of the following losses is the least in DG sets:

a) cooling water loss b) exhaust loss

c) frictional loss d) alternator loss

96. Slip power recovery system is used in

a) DC motor b) synchronous motor

c) squirrel cage induction motor d) slipring induction motor

97. The basic functions of an electronic ballast fitted to a fluorescent tube light exclude one of the following

a) to stabilize the gas discharge b) to ignite the tube light

c) to supply power to the lamp at very high frequency
d) to supply power to the lamp at supply frequency

98. Select the feature which does not apply to energy efficient motors by design:

a) energy efficient motors last longer
b) starting torque for efficient motors may be lower than for standard motors

c) energy efficient motors have high slips which results in speeds about 1% lower than standard motors

d) energy efficient motors have low slips which results in speeds about 1% higher than standard motors

99. Energy savings potential of variable torque applications compared to constant torque application is:

a) higher b) lower c) equal d) none of the above

100. Maximum demand controllers are used to

a) control the power factor of the plant
b) switch off essential loads in a logical sequence

c) switch off non-essential loads in a logical sequence

d) none of the above

101 Select the incorrect statement:

In system distribution loss optimization, the various options available include

a) re-routing and re-conducting such feeders and lines where the voltage drops are higher

b) power factor improvement

c) optimum loading of transformers in the system

d) selection of Aluminium Cored Steel Reinforced (ACSR) lines instead of All Aluminium Alloy Conductors (AAAC)

102 A pure capacitive load in an alternating current (AC) circuit draws

a) lagging reactive power b) active power

c) leading reactive power d) none of the above

103 Select the incorrect statement:

a) harmonics occur as spikes at intervals which are multiples of the supply frequency

b) harmonics are multiples of the fundamental frequency

c) devices that draw sinusoidal currents when a sinusoidal voltage is applied create harmonics

d) transformers operating near saturation level create harmonics

104 In a 11 kV feeder, if the voltage is raised from 11 kV to 22 kV for the same loading conditions, the voltage drop in the same feeder system would be lower by a factor of

a) 1/4 b) 1/2 c) 1/3 d) none of the above

105 A 10 kVAr, 415 V rated power factor capacitor was found to be having terminal supply voltage of 370 V. The capacity of the power factor capacitor at the operating supply voltage would be approximately

a) 10 kVAr b) 9 kVAr c) 8 kVAr d) none of the above

106 The actual speed of a 2 pole induction motor operating at 49.8 Hz and at a slip of 1.5 % is given by

a) 2955 RPM b) 2980 RPM c) 2943 RPM d) none of the above

107 Power factor is the ratio of

a) $kW/ (kW^2+kVAr^2)^{1/2}$ b) $(kW^2+kVAr^2)^{1/2}/kW$
c) kVAr/kW d) $kVAr/ (kW^2+kVAr^2)^{1/2}$

108 The nearest kVAr compensation required for improving the power factor of a 1000 kW load from 0.8 lagging power factor to unity power factor is

a) 500 kVAr b) 750 kVAr c) 1000 kVAr d) none of the above

109 The approximate size of the capacitor selected for the PF improvement and its installation at the induction motor terminals may be equal to

a) No-load kVAr of motor b) 90% of no-load kVAr of motor

c) full load kVAr of motor d) none of the above

110 A 7.5 kW, 415 V, 14.5 A, 1460 RPM, 3 phase rated induction motor with full load efficiency of 88% draws 10.1 A and 5.1 kW of input power. The percentage loading of the motor is about

a) 60 % b) 70 % c) 50% d) none of the above

111 Select the wrong statement:

a) for every 4°C rise in the air inlet temperature of an air compressor, the power consumption will normally increase by one percentage points for the same output.

b) after-coolers remove the moisture in the air before it enters the next stage of compressor to reduce the work of compression

c) for every 250 mm WC pressure drop increase across the suction path due to choked filters etc., the compressor power consumption increases by about 2 percent for the same output

d) centrifugal compressors are better suited for applications requiring very high capacities, typically above 12,000 cfm

112 The reciprocating air compressor efficiency does not depend on

a) discharge pressure b) flow rate
c) suction pressure d) system air leakages

113 The leak test results show load time of 10 seconds and unload time of 20 seconds in a load-unload reciprocating compressor. If the compressor capacity is 256 cfm, then the approximate leakage would be

a) 85 cfm b) 170 cfm c) 256 cfm d) 128 cfm

114 Dynamic air compressors are mainly of the following type

a) two stage reciprocating compressors b) centrifugal compressors
c) two stage screw compressors d) none of the above

115 The flow output of which of the following changes with the discharge pressure

a) screw compressor b) centrifugal compressor
c) reciprocating compressor d) none of the above

116 Higher chiller COP can be achieved with

a) higher evaporator temperature and lower condensing temperature
b) lower evaporator temperature and higher condensing temperature
c) lower evaporator temperature and lower condensing temperature
d) none of the above

117 In water cooled refrigeration systems, condenser cooling water temperature should be closest to

a) ambient dry bulb temperature b) ambient wet bulb temperature

c) dew-point temperature d) none of the above

118 The refrigeration load in TR when 20 m^3/hr of water is cooled from a 13 ^{o} C to 8 ^{o} C is about

a) 33 b) 80.3 c) 39.6 d) none of the above

119 One ton of refrigeration (TR) is equal to

a) 50.4 kcal/min b) 3516 W c) 200 BTU/min d) all of the above

120 In a vapour compression refrigeration system, the component where the refrigerant fluid experiences no heat loss or gain is

a) compressor b) condenser c) expansion valve d) evaporator

121 A fan with 25 cm pulley diameter is driven by a 1470 rpm motor through a v-belt system. If the motor pulley is reduced from 20 cm to 15 cm at the same motor rpm and fan pulley diameter, the fan speed will reduce by

a) 1176 rpm b) 882 rpm c) 294 rpm d) none of the above

122 For centrifugal fans, the relation between Power (kW) and Speed (N) is given by

a) $\frac{kW_1}{kW_2} = \frac{N_1}{N_2}$ b) $\frac{kW_1}{kW_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{kW_1}{kW_2} = \frac{N_1^3}{N_2^3}$ d) none of the above

123 The pressure flow characteristic curve of a centrifugal fan changes with the following flow control method

a) inlet guide vane b) inlet damper c) outlet damper d) none of the above

124 The hydraulic power of a motor pump set is 6.9 kW. If the power drawn by the motor is 14.0 kW at a 88% efficiency, the pump efficiency is given by

a) 43.4% b) 49.3% c) 56% d) none of the above

125 Which of the following is not true of air receivers?

a) smoothen pulsating air output
b) storage of large volumes of air
c) a source for draining of moisture
d) increases the pressure of air

126 If inlet and outlet water temperatures of a cooling tower are 42°C and 36°C respectively and atmospheric DBT and WBT are 39 °C and 32 °C respectively, then the effectiveness of cooling tower is

a) 85.7% b) 60% c) 75% d) none of the above

127 The efficiency of forward curved fans compared to backward-inclined fans is__

a) higher
b) lower
c) same
d) none of the above

128 The motor efficiency is 0.9 and pump efficiency is 0.6. The power transmitted to the water is 15.11 kW. The input power to the motor driving the pump is about

a) 28.0 kW b) 16.8 kW c) 25.2 kW d) none of the above

129 What is the impact on flow and head when the impeller of a pump is trimmed?

a) both flow and pump head increases b) both head and flow decreases

c) flow decreases and pump head increases d) none of the above

130 In a pumping system the static head is 10 m and the dynamic head is 15 m. If the pump speed is doubled, then the total head will be

a) 50 m b) 70 m c) 40 m d) none of the above

131 Lowering the Cycles of Concentration (C.O.C) in circulating water in a cooling tower, the blow down quantity will

a) increase b) decrease c) not change d) none of the above

132 A water pump is delivering 200 cubic metres per hour at ambient conditions. The impeller diameter is trimmed by 10%. The water flow at the changed condition is given by

a) 180 m^3/hr b) 160 m^3/hr c) 140 m^3/hr d) none of the above

133 Which of the following ambient conditions will evaporate maximum amount of water in a cooling tower

a) 40°C DBT and 37°C WBT

b) 38 °C DBT and 37 °C WBT

c) 35 °C DBT and 29 °C WBT

d) 35 °C DBT and 30 °C WBT

134 The L/G ratio of a cooling tower does not depend on

a) range

b) enthalpy of inlet air

c) outlet wet bulb temperature

d) dry bulb temperature

135 The lowest theoretical temperature to which water can be cooled in a cooling tower is

a) average DBT and WBT of the atmospheric air
b) WBT of the atmospheric air
c) DBT of the atmospheric air
d) difference between DBT and WBT of the atmospheric air

136 The unit of lux is

a) 1000 lumens per square feet

b) 10 lumen per square metre

c) one lumen per square metre

d) one lumen per square feet

137 If voltage is reduced for gas discharge lamps to its optimum value, it will result in

a) reduced power consumption

b) increased power consumption

c) increased light levels

d) no change in power consumption

138 Which is the most energy efficient lamp?

a) LPSV b) HPMV c) FTL d) GLS

139 The ratio of luminous flux emitted by a lamp to the power consumed by the lamp is ___.

a) Illuminance b) Lux

c) Luminous Efficacy d) Colour Rendering Index

140 Which of the following is the best definition of illuminance?

a) time rate of flow of light energy

b) luminous flux incident on an object per unit area

c) flux density emitted from an object without regard for direction

d) flux density emitted from an object in a given direction

141 Typical exit flue gas temperature of a 5 MW DG set operating above 80% load is in the range of

a) 340 to 370 deg C b) 250 to 280 deg C

c) 200 to 230 deg C d) none of the above

142 In a DG set, the generator is consuming 150 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.25 litres/ kWh at that load, then what is the kVA loading of the set at 0.6 PF?

a) 300 kVA b) 600 kVA c) 1000 kVA d) none of the above

143 The factors affecting Waste Heat Recovery from exhaust flue gases of DG set are:

a) DG set loading

b) Temperature of exhaust flue gases after turbo charger

c) Back pressure on the DG set d) all of the above

144 The jacket cooling water in a diesel engine flows at 12.9 m^3/hr with a range of 10°C and accounts for 30% of the engine input energy. The power output of the engine will be

a) 430 kW b) 500 kW c) 387 kW d) none of the above

145 The maximum back pressure drop (mmWC) allowed in a DG set is

a) 100-150 b) 150-200 c) 250-300 d) none of the above

146 The electronic ballast in lighting application does not have one of the following characteristics

a) lower operational losses than conventional ballasts

b) tuned circuit to deliver power at 28-32 KHz

c) requiring a mechanical switch (starter)

d) low temperature rise

147 Energy savings potential of variable torque applications in comparison to constant torque application is:

a) higher b) lower c) equal d) none of the above

148 The function of soft starter includes

a) delivers a controlled release of power to the motor

b) provides smooth, stepless acceleration and deceleration.

c) extension of motor life

d) all of the above

149 The occupancy sensors in a lighting installation are best suited for

a) large production shops/hangars

b) conference halls

c) street lighting

d) entrances of offices/buildings

150 The blowdown quantity required in cooling towers is given by

a) evaporation loss/ (cycle of concentration –1)

b) (cycle of concentration –1)/ evaporation loss

c) evaporation loss/ (1 - cycle of concentration)

d) evaporation loss/ (cycle of concentration +1)

151 For the same quantity of power handled by a distribution line, lower the voltage

a) lower the current drawn and lower the distribution loss
b) lower the voltage drop and lower the distribution loss
c) higher the current drawn and higher the distribution loss
d) higher the voltage drop and lower the distribution loss

152 If the efficiencies of a power plant, transmission and distribution systems are 30%, 95% & 85% respectively, the cascade efficiency of transmission and distribution system is given by

a) 24.23% b) 80.75% c) 95% d) 85%

153 kVAr of PF capacitors required to reduce Maximum Demand of electrical system should be based on

e) PF indicated in the utility bill
f) PF worked out based on MD in kW and MD in kVA
g) highest instantaneous PF shown on the meter
h) lowest instantaneous PF shown on the meter

154 If the apparent power drawn over a recording cycle of 30 minutes is 200kVA for 10 minutes, 3000kVA for 15 minutes and 2000 for 5 minutes. The MD recorder will commute MD as

a) 3000 kVA b) 2000 kVA c) 3200 kVA d) 1900 kVA

155 Select the wrong Statement: Heat Rate of a Thermal Power Station

i) is the heat input in kCal for generating one kWh of electrical output
j) is the heat input in kCal for generating one kW of electrical output
k) is inverse of the efficiency of power generation
l) normally becomes better with increase in power generating capacity of power plant

156 Select the correct Statement: Power factor

m) is the ratio of Apparent power and Reactive Power
n) is the ratio of Reactive power and Apparent Power
o) of the lower speed induction motor is generally higher than that of the high speed motor of the same capacity
p) <u>of a pure inductive and capacitive load is zero</u>

157 In a brewery, the loading on transformer was 1200 kVA with the power factor of 0.86. The plant improved the power factor to 0.98 by adding capacitors. What is the reduction in kVA?

a) 144 <u>b) 147</u> c) 171 d) 163.3

Ans: 1200 – (1200 x 0.86 /.98) =147

158 Select the wrong Statement:

q) Squirrel cage induction motors are normally more efficient than Slip ring induction motors
r) Higher speed induction motors are normally more efficient than lower speed induction motors
s) <u>Totally Enclosed Fan Cooled (TEFC) motors are less efficient than Screen Protected Drip Proof (SPDP) motors</u>
t) Motor efficiency increases with increase in rated capacity of motor

159 Slip of an induction motor

a) increases with increase in speed b) <u>decreases with increase in speed</u> c) is independent of speed d) none of the above

160 The power factor of an induction motor

u) <u>increases with increase in motor loading</u>
v) decreases with increase in motor loading
w) is independent of motor loading
x) decreases with decrease in motor loading

161 Stator phase resistance at 30°C is 0.264 ohms. At 120°C, its value will be

a) 0.264 ohms <u>b) 0.354 ohms</u>

c) 0.237 ohms d) none of the above

162 An induction motor rated for 7.5 kW and 90 % efficiency, operating at full load, will

a) deliver 8.33 kW <u>b) deliver 7.5 kW</u> c) draw 7.5 kW d) draw 6.75 kW

163 The efficiency of compressed air system is around

a) 80% b) 50% <u>c) 10%</u> d) none of the above

164 Which of the following pipe fittings used in compressed air pipe line offers maximum resistance

a) Gate Valve b) Tee 90 deg long bend c) Elbow <u>d) Return bend</u>

165 Leakage test was conducted on a compressor having rated FAD of 600 cfm. (Prior to this leakage test FAD test was carried and found that the actual FAD of compressor which is 90% of the rated FAD). The leakage test reveals that the compressor is loaded for 16 sec and unloaded for 66 sec. then what is quantum of leakage?

a) 100 cfm b) 105 cfm c) 117 cfm d) 120 cfm

166 A battery of two reciprocating 250 cfm belt driven compressors installed in a centralized station, were found to be operating at the same loading period of 60% and unloading period of 40%. The least cost solution to reduce wastage of energy in this case would be

y) reducing appropriately the motors pulley sizes
z) reducing appropriately the compressors pulley sizes
aa) switching off one compressor
bb) none of the above

167 Coefficient of Performance (COP) for a refrigeration compressor is given by

cc) power input to compressor (kW) / cooling effect (kW)
dd) cooling effect (kW) / Power input to compressor (kW)
ee) $Q \times C_P \times (Ti - To) / 3024$
ff) none of the above

168 With decrease in evaporator temperature in a vapor compression refrigeration system, while maintaining a constant condenser temperature, the specific power consumption of the compressor will

a) increase b) decrease

c) sometime increase and sometime decrease d) remains the same

169 The refrigeration load in TR when 20 m^3/hr of water is cooled from 17° C to 10° C is about

a) 46.3 b) 41.6 c) 116.6 d) none of the above

170 The essential parameters to estimate cooling load from airside across air handling unit (AHU) or a fan coil unit (FCU) is

a) air flow rate b) dry bulb temperature

c) RH% or wet bulb temperature d) all of the above

171 In water cooled refrigeration systems, for efficient performance, condenser cooling water temperature should be closest to

a) dew-point temperature b) ambient wet bulb temperature

c) ambient dry bulb temperature d) none of the above

172 A fan with 30 cm pulley diameter is driven by a 1480 rpm motor through a v-belt system. If the motor pulley is reduced from 20 cm to 15 cm at the same motor rpm and fan pulley diameter, the fan speed will reduced by

a) 247 rpm b) 740 rpm c) 294 rpm d) none of the above

173 The specific ratio as defined by ASME and used in differentiating fans, blowers and compressors, is given by

a) discharge pressure/suction pressure
b) suction pressure/discharge pressure
c) suction pressure/ (suction pressure + discharge pressure)
d) discharge pressure/ (suction pressure + discharge pressure)

174 Reducing the fan RPM by 20% decreases the fan power requirement approximately by

a) 20% b) 48.8% c) 51.2% d) none of the above

175 The inner tube connection of the pitot tube is used to measure …… in the fan system

a) static pressure b) velocity pressure
c) total pressure d) dynamic pressure

176 Shaft power of the motor driving a pump is 20 kW. The motor efficiency is 0.9 and pump efficiency is 0.55 at that operating load. The power transmitted to the water is

a) 11 kW b) 9.9 kW c) 12.2 kW d) none of the above

177 It is possible to run pumps in parallel provided their_____ are similar

a) suction head b) discharge heads
c) closed valve heads d) none of the above

178 The efficiency of a centrifugal pump with a Best Efficiency Point of 65 %, at its shut off head will be

a) marginally more than 65% b) 65 % c) marginally less than 65 % d) 0 %

179 There are four pumps with the same friction head. For different static heads as shown below, the variable speed drive will be most economical for which of the application

a) 0 metre b) 20 metre c) 30 metre d) none of the above

180 A pump with 200 mm impeller is delivering a flow of 120 m^3/hr. If the flow is to be reduced to 100 m3/hr by trimming the impeller, what should be the impeller size?

a) 167mm b) 240mm
c) 60mm d) none of the above

181 If flow rate is 10m^3/hr and the range is 10^oC for a cooling tower, then its Heat load in kCal will be.

a) 100 b) 1000 c) 10000 d) 100000

182 A cooling tower is said to be performing well when:

a) Range is closer to zero b) Approach is close to zero

c) Approach is more than design d) Range is equal to approach

183 Which one of the following is true to estimate the range of cooling tower?

a) Range = Cooling water inlet temperature – Wet bulb temperature
b) Range = Cooling water outlet temperature – Wet bulb temperature

c) Range = $\frac{\text{Heat load in kCal/ h}}{\text{Water circulation in liters/ h}}$ d) None of the above

184 The lowest theoretical temperature to which water can be cooled in a cooling tower is

a) DBT of the atmospheric air
b) WBT of the atmospheric air
c) Average DBT and WBT of the atmospheric air
d) Difference between DBT and WBT of the atmospheric air

185 For the same dew point, choose the energy efficient compressed air dryers from the following

a) Desiccant regenerative dryer using heated low pressure air for purging
b) Desiccant regenerative type dryer using by compressed air for purging
c) Desiccant regenerative type dryer having external or internal heating with electricity or steam heater in addition to reduced or no compressed air purging
d) Refrigerated dryer

186 Ratio of luminous flux (lumen) emitted by a lamp to the power consumed (watt) by the lamp is called

a) Luminous intensity b) Luminous efficacy c) Reflectance d) Luminance

187 If voltage is reduced from 230 V to 200 V for a fluorescent tube light, it will result in

a) increased light levels
b) increased power consumption
c) reduced power consumption
d) no change in power consumption and light levels

188 Which of the following does not pertain to the family of variable speed drives?

a) Variable frequency drive b) Hydraulic coupling c) Eddy current drive d) Soft starter

189 If condenser temperature is 30°C and evaporator temperature is 25°C then COP cornot cycle of the refrigeration system is

a) 0.2 b) 0.6 c) 5 d) none of the above

190 A fluorescent tube light fitted with an electronic choke will

a) operate at 25 kHz b) not need a starter

c) increase light output d) all of the above

191 Which of the following is used as an absorbent in a vapour absorption system?

a) water
b) lithium
c) bromine
d) lithium bromide

192 The unit of one lux is

a) 1000 lumen per square feet b) 10 lumen per square metre

c) 1 lumen per square metre d) 1 lumen per square feet

193 Which of the following is not a gas discharge lamp

a) Fluorescent tube lamp b) Mercury vapour lamp
c) Metal halide lamp d) Incandescent lamp

194 The component responsible for maximum loss in a DG Set is

a) alternator losses
b) stack loss through flue gases
c) coolant losses
d) radiation losses

195 The DG set rating for a plant with connected load of 800 kW, diversity factor 0.6, and 0.8 PF at average loading of 60% will be

a) 480 kVA
b) 600 kVA
c) 800 kVA
d) 1000 kVA

196 When compared to standard motors, energy efficient motors have

a) lower slip b) lower shaft speed c) higher starting torque d) all of the above

197 The maximum unbalanced load between phases should not exceed ------% of capacity of DG sets.

a) 10%
b) 15%
c) 20%
d) 25%

198 A DC excitation is sued to vary the speed in a

a) Variable frequency drive
b) Eddy current drive
c) Slip ring motor
d) Fluid coupling

199 Select the Correct statement: Operating power factor of a DG set running in isolation from the grid supply

a) shall always be maintained at 0.8 at all the load
b) shall always be maintained at 1.0 at all the load
c) shall always be the same as maintained for the grid supply

d) shall be decided based on the engine shaft power (kW), alternator losses (kW), and load on the alternator (kVA)

200 A 4-pole squirrel cage induction motor operates with 1% slip at full load. What is the approximate full load RPM of motor you may expect at a grid frequency of 49.5 Hz?

a) 1485 b) 1470 c) 1500 d) none of the above

201 Heat Rate of a thermal power plant is expressed in

a) kCal/kWh b) kWh/kCal c) kWh/kJ d) kCal/kVAh

202 A 5 kVAr, 415 V rated power factor capacitor was found to be having terminal supply voltage of 430 V. The capacity of the power factor capacitor at the operating supply voltage would be approximately

a) 4.65 kVAr b) 5.5 kVAr c) 5 kVAr d) none of the above

203 Identify the location of installing capacitor banks, which will result in less reduction in the distribution losses in a factory

a) main sub-station bus bars b) motor terminals

c) motor control centres d) distribution panel boards

204 The nearest kVAr compensation required for changing the power factor of a 1000 kW load from 0.9 lead to unity power factor is

a) 900 kVAr b) 485 kVAr c) 1000 kVAr d) none of the above

205 Improving power factor at motor terminals in a factory will

a) increase active power b) release distribution transformer capacity c) reduce contract demand d) increase motor efficiency

206 What should be the maximum capacitor size to be installed at induction motor terminals for power factor improvement?

a) 70% of No load kVAr of the motor b) 80% of No load kVAr of the motor

c) 90% of No load kVAr of the motor d)100% of No load kVAr of the motor

207 The transformer capacity is rated in terms of

a) kW b) kVA c) kVAr d) HP

208 Which of the following is not likely to create harmonics in an electrical system

a) soft starters b) variable frequency drives c) UPS d) induction motors

209 For a four pole induction motor operating at 50 Hz, the slip at a shaft speed of 1450 RPM will be

a) 3.33 % b) 0 % c) 0.33 % d) none of the above

210 A three phase induction motor loaded at less than 50 %,if operated in star mode, will result in

a) reduced operating voltage b) electrical downsizing of the motor

c) improved efficiency and power factor d) all of the above

211 The performance of rewinding of an induction motor can be assessed by which of the following factors

a) no load current b) stator resistance

c) both no load current and stator resistance d) none of the above

212 An induction motor rated for 75 kW and 90 % efficiency, operating at full load, will

a) deliver 83.3 kW b) deliver 75 kW c) draw 75 kW d) draw 67.5 kW

213 With increase in design speed of induction motors the required capacitive kVAr for reactive power compensation for the same capacity range will

a) increase b) decrease c) not change d) none of the above

214 The flow rate of a reciprocating air compressor can be decreased by

a) inlet throttling b) outlet throttling c) decreasing speed d) all of the above

215 Which of the following delivers a pulsating output

a) roots blower b) centrifugal compressor

c) screw compressor d) reciprocating compressor

216 Use of hard water for inter cooler of a two stage reciprocating air compressor will

a) reduce work done for compression b) increase pressure drop in water side

c) decrease compressor speed d) reduce air inlet temperature to second stage

217 A 500 cfm reciprocating compressor has a loading and unloading period of 5 seconds and 20 seconds respectively during a compressed air leakage test. The air leakage in the compressed air system would be

a) 125 cfm b) 100 cfm c) 200 cfm d) none of the above

218 A 1000 cfm reciprocating compressor is operating to meet a constant demand of 500 cfm. The least cost energy efficient solution will be

a) load and unload b) multi step control

c) variable frequency drive d) pulley change

219 An air dryer in a compressed air system

a) reduces dew point of air b) increases dew point of air c) reduces work of compression d) none of the above

220 Which of the following can be used as refrigeration both in vapour compressor and vapour absorption system

a) ammonia b) R – 11 c) water d) lithium bromide

221 A 2 ton air conditioner installed in a room and working continuously for two hours will remove heat of

a) 3024 kCals b) 6048 kCals c) 12096 kCals d) 4000 kCals

222 Which of the following refrigeration systems uses vacuum for operation

a) vapour compression system using R-11
b) vapour compression system using HFC 134A
c) vapour absorption system using lithium bromide –water
d) vapour absorption system using ammonia –water

223 The refrigeration load in TR when 100 m3/hr of water is cooled from 12^{O}C to 7^{o}C is

a) 500 b) 165 c) 20 d) 50,000

224 Which of the following can also act as a heat pump

a) centrifugal pump b) centrifugal compressor c) air conditioner d) none of the above

225 Integrated Part Load Value (IPLV) in a vapour compression refrigeration refers to average of ____with partial loads

a) cooling effect b) TR/kW c) kW/TR d) kW

226 Partially closing the outlet damper in a fan system will

a) reduce flow b) increase power consumption c) reduce fan static pressure d) all of the above

227 Which of the following flow controls in the fan system will change the system resistance curve

a) inlet guide vane b) speed change with variable frequency drive

c)speed change with hydraulic coupling d) discharge damper

228 Parallel operation of two identical fans in a ducted system

a) will double the flow b) will double the fan static pressure

c) will not double the flow d) will increase flow by more than two times

229 A fan handling air in a ducted system is an example of

a) pure friction head b) pure static head

c) combination of static and friction head d) none of the above

230 A Pitot tube measures------- of the fluid

a) velocity b) flow

c) the difference between total and static pressures d) static pressure

231 In a centrifugal pump the velocity energy is converted to pressure energy by

a) impeller b) suction duct c) discharge duct d) volute

232 The hydraulic power in a pumping system depends on

a) pump efficiency b) motor efficiency

c) both motor and pump efficiency d) none of the above

233 The friction loss in a pipe carrying a fluid is proportional to the

a) fluid flow b) square of the pipe diameter

c) fluid velocity d) fifth power of pipe diameter

234 The efficiency of a pump does not depend on

a) suction head b) discharge head c) density of fluid d) motor efficiency

235 When the flow rate increases

a) NPSH available increases b) NPSH required increases

c) NPSH required decreases d) both NPSH available and NPSH required increases

236 NPSH available depends on

a) pump type b) inlet pipe diameter c) discharge head d) power drawn

237 If the wet bulb temperature is 28 ^{o}C and cooling water of 28 ^{o}C is required, then the most appropriate cooling tower would be

a) hyperbolic tower b) cross flow tower

c) induced draft counter flow tower with fills d) none of the above

238 Higher the COC in a cooling tower, the blow down quantity will

a) increase b) decrease c) no change d) it may increase or decrease

239 The most appropriate type of fan used for induced draft cooling tower, among the following is

a) centrifugal fan with FRP blades b) axial fan with aluminium blades

c) centrifugal fan with aluminum blades d) axial fan with mild steel blades

240 The blowdown loss in a cooling tower depends on

a) TDS in circulating water b) TDS in make up water

c) evaporation loss d) all of the above

241 FRP fans consume less energy than aluminium fans because

a) they are lighter b) they have better efficiencies c) they have less system resistance d) they deliver less air flow

242 Sodium vapour lamps are not used in indoor applications because they

a) have poor colour rendering index b) have poor energy efficiency

c) have low lumens output d) occupy a plenty of space

243 Which of the following is not a gas discharge lamp

a) fluorescent tube lamp b) mercury vapour lamp

c) metal halide lamp d) incandescent lamp

244 Luminous efficacy of a lamp is given by

a) Lux/W b) lumens/W c) W/Lux d) W/lumens

245 A 1100 kVA DG set is delivering 800 kW output. If the flue gas generated is 8 kgs/kWh then the total flue gas flow rate in kg/hr is

a) 8800 b) 6400 c) 100 d) 137

246 When compared to standard motors, energy efficient motors have

a) lower slip b) higher shaft speed c) lower starting torque d) all of the above

247 Use of soft starters for induction motors results in?

a) lower mechanical stress b) lower power factor

c) higher maximum demand d) all of the above

248 Which of the following is a variable torque load?

a) crusher b) machine tool c) centrifugal pump d) vibrating conveyors

249 Maximum demand controller installed in a factory will be beneficial only if

a) it is synchronized with the utility meter

b) maximum demand is more than 5000 kVA

c) maximum demand is less than 5000 kVA

d) the MD charges are for 100 % of the contract demand

250 A fluorescent tube light fitted with an electronic choke will

a) operate at 25 kHz b) do not need a starter c) increase light output d) all of the above

251 "HEAT RATE" is the heat input in kilo Calories or kilo Joules, for generating

a) one kWh of electrical output

b) one kW of electrical output

c) one kVAh of electrical output

d) one kVA of electrical output

252 Select the wrong Statement: The advantage of PF improvement by capacitor addition in an electric network is

a) reactive power component of the network is reduced

b) active power component of the network is reduced
c) I^2R power losses are reduced in the system
d) voltage level of the electric network is improved

253 The power factor indicated in the monthly electricity bill is

a) peak day power factor b) peak power factor during night

c) average power factor during the month

d) instantaneous peak power factor during the month

254 In the city electrical distribution scheme, a proposal is being prepared to upgrade 11 kV network to 33 kV. The reduction in distribution loss, corresponding to the same quantum of load in the proposed upgraded system will be

a) 11%

b) 33%

c) 3 times from its original loss value

d) none of the above

255 For the electricity consumers paying electricity bill on two part tariff, maximum demand recorded is the

a) instantaneous maximum demand drawn over the predefined recording cycle

b) time integrated demand over the predefined recording cycle

c) instantaneous maximum demand drawn within the whole billing period

d) none of the above

256 Busbar Voltages at the main electrical panel of a plant were balanced but at the Motor Control Circuit (MCC),receiving three phase power from busbars, the line voltages were found to be unbalanced. The plant had earlier installed three phase shunt capacitors to improve power factor at MCC. The main reason for this unbalance voltage at MCC among the following was

a)PF capacitors were switched off

b)PF capacitors were operating at higher voltage then their rated values

c) PF capacitors were operating at lower voltage then their rated values

d) It was result of blown fuse in one phase of the 3 phase PF capacitors

257 In case of a Synchronous motor, which is not true

a) AC power is fed to the stator

b) the speed of the rotor is a function of the supply frequency and the number of magnetic poles in the stator

c) synchronous motor rotates with some slip

d) D.C. excitation power is fed to the rotor.

258 The power factor of an induction motor

a) increases with decrease in percentage motor loading

b) decreases with increase in percentage motor loading

c) remains constant at all the percentage motor loading

d) none of the above

259 An induction motor installed with static PF correction capacitors across the motor terminals got damaged along with capacitors once it was disconnected from the supply. The possible reason among the following was

a) motor PF was over corrected or critically corrected (unity power factor)

b) charging current of the capacitor was only 80% of the motor magnitising current

c) motor was oversized

d) motor was undersized

260 A 22 kW rated 3 phase induction motor operating at 405 V and drawing 18 kW, 32 amperes will be operating at a power factor of

a) 0.98 b) 0.86 c) 0.8 d) none of the above

261 The FAD capacity of a reciprocating compressor is directly proportional to

a) speed b) pressure c) volume d) all of the above

262 The purpose of an inter cooler in a reciprocating compressor is to

a) remove the moisture in the air

b) reduce the temperature of the air before it enters the next stage

c) separate moisture and oil vapour

d) none of the above

263 Identify the correct statement for air compressors:

a. For every 4 °C drop in the inlet air temperature, the decrease in energy consumption is by 2%.

b. For every 4 °C rise in the inlet air temperature, the decrease in energy consumption is by 2%

c. For every 4 °C rise in the inlet air temperature, the increase in energy consumption is by 1%

d. The energy consumption remains same irrespective of inlet air temperature

264 Increase in the delivery pressure of a compressor by 1 bar would reduce the power consumption by

a) 2 to 3 % b) 6 to 8 % c) 12 to 14 % d) none of the above

265 As the 'approach' increases while other parameters remaining constant, the effectiveness of a cooling tower

a) increases b) remains unchanged c) decreases d) none of the above

266 The correction factor for actual free air discharge in a compressor capacity test will be ----------, when the compressed air discharge temperature is 15^0 C higher than ambient air of 40^0 C.

a) 0.727 b) 1.0479 c) 0.954 d) none of the above

267 power consumed by a refrigeration compressor is 2 kW per ton of refrigeration, then its energy efficiency ratio (Watt/Watt) is given by

a) 6 b) 1.76 c) 1.51 d) none of the above

268 If 30,000 kCal of heat is removed from a room every hour then the refrigeration tonnage will be nearly equal to

a) 30 TR b) 15 TR c) 10 TR d) 5 TR

269 Higher chiller COP can be achieved with

a) higher evaporator temperature and higher condensing temperature

b) lower evaporator temperature and higher condensing temperature

c) lower evaporator temperature and lower condensing temperature

d) higher evaporator temperature and lower condensing temperature

270 Chilled water enters evaporator at 12^0C and leaves at 7^0C . The flow rate of chilled water was measured as 5 m^3/min. The tons of refrigeration capacity will be

a) 0.827 b)8.27 c) 496 d) none of the above

271 The COP of a vapour compression system is 3.5. If the motor draws power of 10.8 kW at 90% motor efficiency, the cooling effect of vapour compression system will be

a) 34 kW b) 37.8 kW

c) 0.36 kW d) none of the above

272 A centrifugal pump is delivering 200 m^3/hr. The impeller diameter is trimmed by 10%. The new flow (m^3/hr.) will be

a)222 b) 200 c) 180 d)162

273 A centrifugal pump is operating at 1440 RPM. If the power is to be reduced to 75 % of the existing power , the speed of the pump as per affinity law will be

a) 1308 RPM b) 1080 RPM c) 360 RPM d) none of the above

274 If the delivery valve of the pump is throttled such that it delivers 60% of the rated flow always, one of the best options for improved energy efficiency pump operation would be

a) trimming of the impeller b) replacing the motor

c) replacing the existing pump with a smaller sized pump d) variable speed drive

275 Inclined manometer connected to a pitot tube is sensing ---------- pressure in a gas stream

tic pressure b) velocity pressure

c) total pressure d) atmospheric pressure

276 In case of parallel operation of pumps, select the wrong statement:

a)The system curve is usually not affected by the number of pumps that are running in parallel.

b)For a system with a combination of static and friction head loss,

the operating point of the pumps on their performance curves moves to a higher head

c) For a system with a combination of static and friction head loss, the flow rate with two pumps running is double that of a single pump.

d) If the system head were only static, then flow rate would be proportional to the number of pumps operating.

277 If two similar pumps are operating in series, the

a) flow is halved b) flow is doubled c) head is doubled d) head is halved

278 Changes in impeller diameter in a centrifugal pumps are limited to reducing its diameter to about--- of its maximum size

a) 75% b) 60% c) 50% d) 40%

279 The refrigerant used in vapour absorption systems is

a) freon b) steam c) pure water d) lithium bromide

280 Which of the following is incorrect statement in the case of cooling towers:

a)"Range" is the difference between the cooling tower water inlet and outlet temperature.
b) "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature.
c)'Range' is the only indicator of cooling tower performance.
d) Cooling tower capacity is expressed as heat rejected in TR

281 If flow rate is $10m^3/hr$ and the range is 10^oC for a cooling tower, then its heat load in kCal/hr will be.

a) 100 b) 1,000 c) 10,000 d) 1,00,000

282 Is there a conceptual difference between COP and EER?

e) There is a conceptual difference between COP and EER
f) There is no conceptual difference between COP and EER as both the parameters are calculated with different units in the ratio “refrigeration effect/ power input”
g) The relation between COP and EER is COP = 0.50 EER and hence there is no conceptual difference.
h) None of the above

283 For a cooling tower, the following two statements are made. What is your judgment ?

Statement A: Surface of heat exchange is the surface area of the water droplets, which is in contact with air.

Statement B: Area of heat exchange is the surface area of the fill sheets, which is in contact with air.

a) Statement A & B are false

b) Statement A is True & B is false

c) Statement A & B are True

d) Statement A is false & B is True

284 Forward curved centrifugal fans are best suited for

a) high pressure, medium flow b) medium pressure, high flow

c) high pressure, high flow d) none of the above

285 Squirrel cage induction motors, in general, have a …… design efficiency in comparison with the Slip ring induction motors for similar ratings

a) lower b) higher c) same d) none of the above

286 Ratio of luminous flux(lumen) emitted by a lamp to the power consumed(watt) by the lamp is called

a) Luminous intensity b) Luminous efficacy c) Reflectance d) Luminance

287 A power factor capacitor designed for 10 kVAR at 415 V was found to be operating at 439 V. The effective capacity of the capacitor would be

a) 9.3 kVAR b) 10 kVAR c) 11.2 kVAR d) none of the above

288 A centrifugal fan is operating at 700 RPM developing a flow of 2000 Nm^3/hr. at a static pressure of 600 mmWC. If the fan speed is reduced to 600 RPM, the static pressure will become:

a)441 mmWC b) 817 mmWC c)514 mmWC d) none of the above

289 The ratio between heat extracted and work done in a refrigeration system is called as

a)Efficiency b) COP c) Refrigeration effect d)none of the above

290 The fo Following function cannot be achieved with automatic power factor controllers

a) Voltage control b) KILOVAR control c) kW control d) PF control

291 The following electrical equipment has the highest efficiency

a) synchronous motor b) dc shunt motor c) induction motor d) transformer

292 The electronic ballast in lighting application does not have one of the following characteristics

a) requiring a starter

b) tuned circuit to deliver power at 28-32 KHz

c) lower operational losses than magnetic ballast

d) low temperature rise

d) None of the above

293 Which method uses infrared, acoustic, ultrasonic or microwave sensors for lighting control?

a) Time-based control

b) Daylight-linked control

c) Occupancy-linked control

d) Localized switching

294 In a DG set, the generator is consuming 90 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.25 litres/ kWh at that load, then what is the kVA loading of the set at 0.72 PF?

a) 360 kVA b) 500 kVA c) 1000 kVA d) none of the above

295 For assembly line, inspection areas, painting shops, where colour critical applications and higher illumination levels are required, the following type of lamps will be most suitable

a) mercury vapour lamps b) sodium vapour lamps

c) CFLs d) Metal halide lamps

296 When compared to standard motors, energy efficient motors have

a) lower slip b) lower shaft speed c) higher starting torque d) all of the above

297 If a 100 W,230 Volt rated incandescent lamp is operated at 200 Volt, the power drawn by the lamp will be (assume lamp filament resistance remains same)

a) 75W b) 87W c) 100W d)none of the above

298 Select the Correct statement: Operating power factor of a DG set running in isolation from the grid supply

a) shall always be maintained at 0.8 at all the load

b) shall always be maintained at unity at all the load

c) shall always be the same as maintained for the grid supply

d) shall be decided based on the engine shaft power(kW), alternator losses(kW), exciter power requiremetns and load on the alternator(kVA)

299 In a driven equipment connected with motor through a variable speed fluid coupling

a) motor speed can be changed b) driven equipment speed can be changed c) both motor and driven equipment speeds can be changed d) none of the above

300 Which of the following is WRONG

a) The luminous efficacy is the ratio of light output in lumens to power input to lamp in watts.

b) The minimum illuminance for all non-working interiors, has been mentioned as 20 Lux (as per IS 3646).

c) The efficacy of Halogen lamps and incandescent lamps is almost same

d) One lux is equal to one lumen per square feet.

301 Select the wrong statement:

a) 'Heat Rate' reflects the efficiency of generation.

b) 'Heat Rate' is the heat input in kilo Calories or kilo Joules, for generating 'one' kilo Watt of electrical output.

c) 'Heat Rate' is inverse of the efficiency of power generation.

d) design 'Heat Rate' of a 500MW thermal generating unit is lower than that of a 110 MW thermal generating unit.

302 In an industry, if the drawl over a recording cycle of 30 minutes is :

2500 kVA for 10 minutes

3600 kVA for 6 minutes

4100 kVA for 12 minutes

3800 kVA for 2 minutes

The MD recorder will be computing MD as

a) 3446 b) 3600 c) 3800 d) 4100

303 A bulk power factor correction system which is left connected to an installation where the load has reduced considerably may result in

a) leading power factor at input electric supply

b) damage to the installation cables

c) considerable reduction in maximum demand

d) a reduced supply tariff

304 The total loss for a transformer loading at 60% and with no load and full load losses of 3 kW and 25 kW respectively, is

a) 3 kW b) 12 kW c) 18 kW d) 25 kW

305 A pure resistive load in an alternating current (AC) circuit draws only

a) lagging reactive power b) active power

c) leading reactive power d) active apparent power

306 The nearest kVAr compensation required for improving the power factor of a 1000 kW load from 0.95 leading power factor to unity power factor is

a) 328 kVAr b) 750 kVAr c) 1000 kVAr d) none of the above

307 The ratings of the PF correction capacitors at motor terminals for a 37 kW induction motor at 3000 rpm synchronous speed will be----------in comparison to the same sized induction motor at 1500 rpm synchronous speed

a) more b) less c) same d) dependant on the connected load

308 The largest potential for electricity savings with variable speed drives is generally in

a) variable torque applications b) constant torque applications

c) conveyor belt applications d) balance torque applications

309 A 7.5 kW, 415 V, 15 A, 970 RPM, 3 phase rated induction motor with full load efficiency of 86% draws 7.5 A and 3.23 kW of input power. The percentage loading of the motor is about

a) 37 % b) 43 % c) 50% d) none of the above

310 Select the correct statement?

a) efficiency of an induction motor remains same at all the loading
b) squirrel cage induction motors are comparatively more efficient than Slip ring induction motors of the same ratings.
c) power factor of an induction motor remains constant during 50 -100% loading conditions
d) slip of the induction motor is more at the full load than at the part load

311 A two pole induction motor operating at 50 Hz, with 1% slip will run at an actual speed of

a) 3000 RPM b) 3030 RPM c) 2970 RPM d) none of the above

312 A super thermal power station of 2500 MW installed capacity generated

14,000 million units in a year. Its annual Plant Load Factor (PLF) is:

a) 60% b) 79% c) 64% d) none of the above

313 Select the incorrect statement

a) low speed Squirrel cage induction motors are normally less efficient than high speed Squirrel cage induction motors

b) the capacitor requirement for PF improvement at induction motor terminals decreases with decrease in rated speed of the induction motors of the same sizes

c) induction motor efficiency increases with increase in its rated capacity

d) totally-enclosed, fan cooled (TEFC) motors are more efficient than Screen–protected, drip-proof (SPDP) induction motors

314 The efficiency of compressed air system is around

a) 10% b) 50% c) 60% d) 90%

315 FAD refers to the compressed air at

a) at ISO stated conditions b) Inlet conditions c) at outlet conditions d) at STP

316 Select the incorrect statement:

a) compressor efficiency will be reduced by about 2 percent for every 250 mm WC pressure drop across the air inlet filters.

b) every 4^0C rise in inlet air temperature results in a higher energy consumption by 1 % to achieve equivalent output

c) an increase of 5.5^0C in the inlet air temperature to the second stage results in a 2 % increase in the specific energy consumption.

d) compressed air receiver volume should be 100% of the rated hourly free air output

317 Which of the following is not a part of the vapour compression refrigeration system

a) compressor b) evaporator c) condenser d) absorber

318 The refrigerant used in vapour absorption systems is

a) steam b) pure water c) freon d) lithium bromide

319 The COP of a vapour compression refrigeration system is 3.0. If the power input to compressor is 100 kW , the tonnage of refrigeration system is given by

a) 85.3 b) 9.48 c) 300 d) none of the above

320 The refrigeration load in TR when 30 m^3/hr of water is cooled from a 14 ^{o} C to 6.5 ^{o} C is about

a) 74.4 b) 64.5 c) 261.6 d) none of the above

321 The term Refrigeration means

a) addition of cooling b) removal of heat

c) removal and relocation of heat d) replacement of heat

322 For fans, the relation between power P and speed N is

a) $\frac{P_1}{P_2} = \frac{N_1}{N_2}$ b) $\frac{P_1}{P_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{P_1}{P_2} = \frac{N_1^3}{N_2^3}$ d) none of the above

323 Friction loss in a piping system carrying fluid is proportional to

a) fluid flow b) (fluid flow)^2 c) $\frac{1}{\text{fluid flow}}$ d) $\frac{1}{(\text{fluid flow})^2}$

324 _____ fans are known as “non-overloading“ because change in static pressure do not overload the motor

a) radial b) forward- curved c) backward-inclined d) tube- axial

325 Ammonia can be used as a refrigerant in

a) vapour compression chiller
b) vapour absorption chiller
c) both vapour compression and absorption chillers
d) none of them

326 The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as

a) net positive suction head available
b) static head
c) dynamic head
d) suction head

327 When the local static pressure in a fluid reaches a level below the vapor pressure of the liquid at the actual temperature, _____ may occur in a pump.

a) water hammering b) water chilling c) cavitation d) none of the above

328 Installation of "exclusive" transformer for lighting has following advantage

a) "Voltage" fluctuations in lighting circuit can be minimized by isolating from the power feeders.
b) This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.
c) With proper control device “over voltage” that might occur during lean load or off-peak can be avoided, in turn excess energy consumption and improved lamp life
d) all the above

329 Parallel operation of two identical fans in a ducted system

a) will double the flow b) will double the fan static pressure

c) <u>will not double the flow</u> d) will increase flow by more than two times

330 Normally the guaranteed best approach a cooling tower can achieve is

a) 5°C b) 8°C c) 12°C d) <u>2.8 °C</u>

331 Select the wrong statement ---

a) for a given heat rejection duty, a higher range will reduce the circulating water flow rate

b) when the cycle of concentration is left at one, all water left in the cooling tower after evaporation needs to be removed as blowdown.

c) a <u>better indicators for cooling tower performance is Range</u>

d) a cooling tower size will be greater for 20°C Wet bulb temperature (WBT) than for a 30°C WBT, for the same circulation, range and approach

332 Which of the following ambient conditions will evaporate minimum amount of water in a cooling tower

a) 35°C DBT and 30°C WBT b) 38°C DBT and 31°C WBT

c) <u>38°C DBT and 37°C WBT</u> d) 35°C DBT and 29°C WBT

333 Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9. The power transmitted to the water is 16.2 kW. The pump efficiency is

<u>a) 60%</u> b) 90% c) 54% d) none of the above

334 A 500 cfm reciprocating compressor is operating to meet a constant demand of 300 cfm. The least cost energy efficient solution will be

a) load and unload

b) reducing the speed of compressor by increasing the compressor pulley size appropriately

c) variable frequency drive

d) reducing the speed of compressor by reducing the motor pulley size appropriately

335 Which of the following lamp has the highest efficacy?

a) metal halide b) halogen lamps c) HPMV d) HPSV

336 Harmonics are generated by

a) variable frequency drive b) fluid coupling

c) eddy current drive d) energy efficient motor

337 The inputs required for an automatic power factor controller using kVAR control

a) current b) voltage c) capacitance d) both a and b

338 The unit of one lux is

a) 1000 lumen per square feet b) 10 lumen per square meter

c) 1 lumen per square meter d) 1 lumen per square feet

339 The efficiency of a pump does not depend on

a) suction head b) discharge head c) density of fluid d) motor efficiency

340 The flow output of which of the following changes with the discharge pressure

a) reciprocating compressor b) centrifugal compressor
c) screw compressor d) none of the above

341 A fan is operating at 970 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be

a) 244.3 b) 388.5 c) 469 d) none of the above

342 Luminous efficacy of a lamp is given by

a) Lux/Watt b) lumens/Watt c) Watt/Lux d) Watt/lumens

343 A fluorescent tube light fitted with an electronic choke will

a) operate at 50 Hz b) not need a starter
c) operate at 0.5 power factor d) none of the above

344 An engineering industry which was operating with a maximum demand of 500 kVA at 0.9 power factor improved its power factor to 0.99 by installing power factor correction capacitors near the load centres. The percentage reduction in distribution losses within the plant will be

a) 17.35% b) 1.21% c) 86.75% d) none of the above

345 Lower load side power factor for a DG Set:

a) demands higher excitation currents and results in increased losses
b) results in higher kVA loading of generator
c) results in lower operating efficiency and higher specific fuel consumption of DG set
d) all the above

346 The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is:

a) voltage unbalance on generator b) back pressure on engine

c) excessive steam generation d) turbulence in exhaust gases

347 Use of soft starters for induction motors results in

a) lower mechanical stress b) lower power factor

c) higher maximum demand d) all the above

348 Which of the following refrigeration systems uses vacuum for operation ?

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349 Which of the following electrical equipment has the highest efficiency ?

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c) induction motor d) transformer

350 Select the incorrect statement:

a) transformers operating near saturation level create harmonics

b) devices that draw sinusoidal currents when a sinusoidal voltage is applied create harmonics

c) harmonics are multiples of the supply frequency

d) harmonics occur as spikes at intervals which are multiples of the supply frequency

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b) 'Heat Rate' is the heat input in kilo Calories or kilo Joules, for generating 'one' kilo Watt of electrical output.

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b) squirrel cage induction motors are comparatively more efficient than Slip ring induction motors of the same ratings.
c) power factor of an induction motor remains constant during 50 -100% loading conditions
d) slip of the induction motor is more at the full load than at the part load

361 A two pole induction motor operating at 50 Hz, with 1% slip will run at an actual speed of

a) 3000 RPM b) 3030 RPM c) 2970 RPM d) none of the above

362 A super thermal power station of 2500 MW installed capacity generated

14,000 million units in a year. Its annual Plant Load Factor (PLF) is:

a) 60% b) 79% c) 64% d) none of the above

363 Select the incorrect statement

a) low speed Squirrel cage induction motors are normally less efficient than high speed Squirrel cage induction motors

b) the capacitor requirement for PF improvement at induction motor terminals decreases with decrease in rated speed of the induction motors of the same sizes

c) induction motor efficiency increases with increase in its rated capacity

d) totally-enclosed, fan cooled (TEFC) motors are more efficient than Screen–protected, drip-proof (SPDP) induction motors

364 The efficiency of compressed air system is around

a) 10% b) 50% c) 60% d) 90%

365 FAD refers to the compressed air at

a) at ISO stated conditions b) Inlet conditions c) at outlet conditions d) at STP

366 Select the incorrect statement:

a) compressor efficiency will be reduced by about 2 percent for every 250 mm WC pressure drop across the air inlet filters.

b) every 4^0C rise in inlet air temperature results in a higher energy consumption by 1 % to achieve equivalent output

c) an increase of 5.5^0C in the inlet air temperature to the second stage results in a 2 % increase in the specific energy consumption.

d) compressed air receiver volume should be 100% of the rated hourly free air output

367 Which of the following is not a part of the vapour compression refrigeration system

a) compressor b) evaporator c) condenser d) absorber

368 The refrigerant used in vapour absorption systems is

a) steam b) pure water c) freon d) lithium bromide

369 The COP of a vapour compression refrigeration system is 3.0. If the power input to compressor is 100 kW , the tonnage of refrigeration system is given by

a) 85.3 b) 9.48 c) 300 d) none of the above

370 The refrigeration load in TR when 30 m^3/hr of water is cooled from a 14 ^{o} C to 6.5 ^{o} C is about

a) 74.4 b) 64.5 c) 261.6 d) none of the above

371 The term Refrigeration means

a) addition of cooling b) removal of heat

c) removal and relocation of heat d) replacement of heat

372 For fans, the relation between power P and speed N is

a) $\frac{P_1}{P_2} = \frac{N_1}{N_2}$ b) $\frac{P_1}{P_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{P_1}{P_2} = \frac{N_1^3}{N_2^3}$ d) none of the above

373 Friction loss in a piping system carrying fluid is proportional to

a) fluid flow b) (fluid flow)^2 c) $\frac{1}{\text{fluid flow}}$ d) $\frac{1}{(\text{fluid flow})^2}$

374 _____ fans are known as “non-overloading“ because change in static pressure do not overload the motor

a) radial b) forward- curved c) backward-inclined d) tube- axial

375 Ammonia can be used as a refrigerant in

a) vapour compression chiller b) vapour absorption chiller

c) both vapour compression and absorption chillers d) none of them

376 The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as

a) net positive suction head available b) static head

c) dynamic head d) suction head

377 When the local static pressure in a fluid reaches a level below the vapor pressure of the liquid at the actual temperature, _____ may occur in a pump.

a) water hammering b) water chilling c) cavitation d) none of the above

378 Installation of "exclusive" transformer for lighting has following advantage

e) "Voltage" fluctuations in lighting circuit can be minimized by isolating from the power feeders.
f) This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.
g) With proper control device “over voltage” that might occur during lean load or off-peak can be avoided, in turn excess energy consumption and improved lamp life
h) all the above

379 Parallel operation of two identical fans in a ducted system

a) will double the flow b) will double the fan static pressure

c) will not double the flow d) will increase flow by more than two times

380 Normally the guaranteed best approach a cooling tower can achieve is

a) 5°C b) 8°C c) 12°C d) 2.8 °C

381 Select the wrong statement ---

a) for a given heat rejection duty, a higher range will reduce the circulating water flow rate

b) when the cycle of concentration is left at one, all water left in the cooling tower after evaporation needs to be removed as blowdown.

c) a better indicators for cooling tower performance is Range

d) a cooling tower size will be greater for 20°C Wet bulb temperature (WBT) than for a 30°C WBT, for the same circulation, range and approach

382 Which of the following ambient conditions will evaporate minimum amount of water in a cooling tower

a) 35°C DBT and 30°C WBT b) 38°C DBT and 31°C WBT

c) 38°C DBT and 37°C WBT d) 35°C DBT and 29°C WBT

383 Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9. The power transmitted to the water is 16.2 kW. The pump efficiency is

a) 60% b) 90% c) 54% d) none of the above

384 A 500 cfm reciprocating compressor is operating to meet a constant demand of 300 cfm. The least cost energy efficient solution will be

a) load and unload

b) reducing the speed of compressor by increasing the compressor pulley size appropriately

c) variable frequency drive

d) reducing the speed of compressor by reducing the motor pulley size appropriately

385 Which of the following lamp has the highest efficacy?

a) metal halide b) halogen lamps c) HPMV d) HPSV

386 Harmonics are generated by

a) variable frequency drive b) fluid coupling

c) eddy current drive d) energy efficient motor

387 The inputs required for an automatic power factor controller using kVAR control

a) current b) voltage c) capacitance d) both a and b

388 The unit of one lux is

a) 1000 lumen per square feet b) 10 lumen per square meter

c) 1 lumen per square meter d) 1 lumen per square feet

389 The efficiency of a pump does not depend on

a) suction head b) discharge head c) density of fluid d) motor efficiency

390 The flow output of which of the following changes with the discharge pressure

a) reciprocating compressor b) centrifugal compressor
c) screw compressor d) none of the above

391 A fan is operating at 970 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be

a) 244.3 b) 388.5 c) 469 d) none of the above

392 Luminous efficacy of a lamp is given by

a) Lux/Watt b) lumens/Watt c) Watt/Lux d) Watt/lumens

393 A fluorescent tube light fitted with an electronic choke will

a) operate at 50 Hz b) not need a starter
c) operate at 0.5 power factor d) none of the above

394 An engineering industry which was operating with a maximum demand of 500 kVA at 0.9 power factor improved its power factor to 0.99 by installing power factor correction capacitors near the load centres. The percentage reduction in distribution losses within the plant will be

a) 17.35% b) 1.21% c) 86.75% d) none of the above

395 Lower load side power factor for a DG Set:

a) demands higher excitation currents and results in increased losses
b) results in higher kVA loading of generator
c) results in lower operating efficiency and higher specific fuel consumption of DG set
d) all the above

396 The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is:

a) voltage unbalance on generator b) back pressure on engine

c) excessive steam generation d) turbulence in exhaust gases

397 Use of soft starters for induction motors results in

a) lower mechanical stress b) lower power factor

c) higher maximum demand d) all the above

398 Which of the following refrigeration systems uses vacuum for operation ?

a) vapour compression system using R-11

b) vapour compression system using HFC 134A

c) vapour absorption system using lithium bromide –water

d) none of the above

399 Which of the following electrical equipment has the highest efficiency ?

a) synchronous motor b) dc shunt motor
c) induction motor d) transformer

400 Select the incorrect statement:

a) transformers operating near saturation level create harmonics

b) devices that draw sinusoidal currents when a sinusoidal voltage is applied create harmonics

c) harmonics are multiples of the supply frequency

d) harmonics occur as spikes at intervals which are multiples of the supply frequency

401 In the city electrical distribution scheme, a proposal is being prepared to upgrade 33 kV network to 66 kV. The distribution loss, corresponding to the same quantum of load in the proposed upgraded system will be

a) less by 25%

b) less by 33%

c) less by 75%

d) none of the above

402 Rating of power factor correction capacitors at induction motor terminals should be

a) 100% of no load magnetizing kVAr of induction motor

b) 90% of no load magnetizing kVAr of induction motor

c) 120% of no load magnetizing kVAr of induction motor

d) none of the above

403 Select the correct statement:

a) the advantage of PF improvement by capacitor addition in an electric network is that active power component of the network is reduced

b) the power factor indicated in the monthly electricity bill is the lowest power factor recorded at any time during the billing month

c) PF capacitors operating at lower voltage then their rated values have higher operating kVArs then their rated values

d) the power factor of an induction motor decreases with decrease in percentage motor loading

404 If the efficiencies of a power plant, transmission and distribution systems are 30%, 95% & 85% respectively, the cascade efficiency of power generation, and transmission system is given by

a) 24.23% b) 28.5 % c) 80.75% d) 95%

405 Which of the following is not likely to create harmonics in an electrical system?

a) soft starters b) variable frequency drives

c) uninterrupted power supply source (UPS) d) induction motors

406 What is the % slip of a 4 pole induction motor if the shaft speed at 49.5 Hz supply frequency is 1460 rpm?

a) 1.68 b) 2.66 c) 1.71 d) none of the above

407 During induction motor operation, magnetic field is established in

a) stator winding only b) rotor winding only

c) stator and rotor windings d) at carbon brushes

408 An induction motor rated for 7.5 kW and 90 % efficiency at full load, was drawing 5 kW. The percentage loading on the motor is

a) 60 % b) 66.66% c) 74% d) none of the above

409 If the apparent power drawn over a recording cycle of 30 minutes is 3000kVA for 10 minutes, 2400kVA for 15 minutes and 2900 for 5 minutes, the MD recorder will commute MD as

a) 3000 kVA b) 2400 kVA c) 2683 kVA d) none of the above

410 The performance of rewinding of an induction motor can be assessed by which of the following factors?

a) load current b) stator resistance

c) no load current d) both no load current and stator resistance

411 The pressure drop in mains header at the farthest point of an industrial compressed air network shall not exceed

d) 2 bar b) 0.3 bar c) 0.5 bar d) 1.0 bar

412 The Free Air Delivery capacity of a reciprocating compressor is directly proportional to

a) pressure b) volume c) speed d) all of the above

413 The inlet air temperature to a two stage reciprocating air compressor is 35°C. At which of the following 2nd stage inlet temperatures the compressor will consume least power?

a) 75°C b) 65 °C c) 60°C d) 50°C

414 At which of the following discharge pressures, the reciprocating air compressor will consume maximum power

a) 3 bar b) 3.5 kg/cm^2 c) 150 psi d) 6 kg/cm^2

415 Which of the following is not true of air receivers?

a) smoothens pulsating air output b) stores large volumes of air
c) a source for draining moisture d) increases the pressure of air

416 A 1.5 ton air conditioner installed in a room and working continuously for two hours will remove heat of

a) 3024 kCals b) 6048 kCals c) 9072 kCals d) none of the above

417 Which of the following can be used as refrigerant both in vapour compressor and vapour absorption systems

a) Ammonia b) R – 11 c) R-12 d) Lithium Bromide

418 Chilled water enters evaporator at 12°C and leaves at 6°C. The flow rate of chilled water was measured as 300 m^3/hr. The tons of refrigeration capacity is

a) 0.595 b) 595.24 c) 35.7 d) none of the above

419 Centrifugal compressors are most efficient when they are operating at_____.

a) 50% load b) full load c) 75% load d) all load conditions

420 The Coefficient of Performance (COP) of Vapour Absorption Refrigeration System (VAR)

a) is higher than that of Vapour Compression Refrigeration (VCR) System

b) is lower than that of Vapour Compression Refrigeration (VCR) System

c) is same as that of Vapour Compression Refrigeration (VCR) System

d) is normally 4 to 4.5

421 Backward-inclined fans are known as _____ because change in static pressure does not overload the motor

a) overloading b) non-overloading
c) radial d) axial

422 The fan characteristic curve is a plot of

a) static pressure vs flow b) dynamic pressure vs flow

c) total pressure vs flow d) suction pressure vs flow

423 A fan is drawing 16 kW at 800 RPM. If the speed is reduced to 600 RPM then the power drawn by the fan would be

a) 12 kW b) 9 kW c) 6.75 kW d) none of the above

424 The hydraulic power of a motor pump set is 8.5 kW. If the power drawn by the motor is 15.5 kW at a 89% efficiency, the pump efficiency is given by

a) 54.8% b) 61.6% c) 48.8% d) none of the above

425 For the same flow through which of the following diameter pipes, the pump will work with maximum pressure

a) 80 mm b) 100 mm c) 120 mm d) 1400 mm

426 If inlet and outlet water temperatures of a cooling tower are 44°C and 38°C respectively and atmospheric DBT and WBT are 40 °C and 35 °C respectively, then the effectiveness of cooling tower is

a)54.5 % b) 66.6% c) 75% d) none of the above

427 In which of the following fans air enters and leaves the fan with no change in direction

a) forward curved b) backward curved c) radial d) propeller

428 The motor efficiency is 0.9 and the pump efficiency is 0.6.The input power to the motor driving the pump is 28 kW. The power transmitted to the water is

a) 15.12 kW b) 28 kW c) 25.2 kW d) none of the above

429 A water pump is delivering 200 m^3/hr at ambient conditions. The impeller diameter is trimmed by 10%. The water flow at the changed conditions is

a) 220 m^3/hr b) <u>180 m^3/hr</u> c) 162 m^3/hr d) none of the above

430 The operating point in a pumping system is identified by

a) point of intersection of system curve and efficiency curve

b) point of intersection of pump curve and theoretical power curve

<u>c) point of intersection of pump curve and system curve</u>

d) point of intersection of NPSH curve and pump curve

431 Increasing the Cycles of Concentration (C.O.C) in circulating water in a cooling tower, the blow down quantity will

a) increase <u>b) decrease</u> c) not change d) none of the above

432 At which of the following condenser temperatures, the power consumption of a vapour compression refrigeration system will be the least

a) 26°C b) 28 °C c) 29 °C d) <u>25 °C</u>

433 Which of the following ambient conditions will not evaporate maximum amount of water in a cooling tower

a) 41°C DBT and 38°C WBT b) <u>38 °C DBT and 37 °C WBT</u>

c) 36 °C DBT and 30 °C WBT d) 36°C DBT and 31 °C WBT

434 If inlet and outlet water temperatures of a cooling tower are 39°C and 33°C respectively and atmospheric DBT and WBT are 35 °C and 28 °C respectively then the approach of cooling tower is

a) 3°C b) 4°C c) 5°C d) 6°C

435 If flow rate is 100m^3/hr and the range is 8°C for a cooling tower, then its heat load in kCal/hr will be.

a) 800 b) 8,000 c) 80,000 d) 800,000

436 Which method uses infrared, acoustic, ultrasonic or microwave sensors for lighting control?

a) time-based control b) daylight-linked control

c) occupancy-linked control d) localized switching

437 If voltage is increased from 230 V to 250 V for a fluorescent tube light, it will result in

a) reduced power consumption b) increased power consumption

c) decreased light levels d) no change in power consumption and light levels

438 The 5th and 7th harmonic in a 50 Hz power supply system will have:

a) voltage and current distortions with 55 Hz & 57 Hz

b) voltage and current distortions with 500 Hz & 700 Hz

c) voltage and current distortions with 250 Hz & 350 Hz

d) no voltage and current distortion at all

439 Automatic power factor controller using kVAr control, requires sensing of

a) current b) voltage c) capacitance d) both a and b

440 The COP of a vapour compression system is 3.0. If the motor draws power of 11 kW at 90% motor efficiency, the cooling effect of vapour compression system will be

a) 29.7 kW b) 37.8 kW

c) 0.36 kW d) none of the above as cooling effect is always measured in TR

441 Which of the following can also act as a heat pump?

a) centrifugal pump b) centrifugal compressor

c) air conditioner d) none of the above

442 valve is used for capacity control in which of the following refrigeration compressors?

a) reciprocating b) centrifugal c) screw d) scroll

443 In a DG set, a 3 phase alternator is supplying on an average 100 A at 420 V and 0.9 pf to a load. If the specific fuel consumption of this DG set is 0.30 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour?

a) 11.34 litre b) 19.64 litre c) 21.82 litre d) 218.23 litre

444 The largest potential for electricity savings with variable speed drives is generally for:

a) variable torque applications b) constant torque loads

c) constant power load d) combination of above

445 The electronic ballast fitted in a tube light fitting does not have one of the following characteristics

a) lower operational losses than conventional ballasts

b) tuned circuit to deliver power at 28-32 KHz

c) requiring a starter

d) low temperature rise

446 Maximum demand controller is used to

a) switch off non-essential loads in a logical sequence

b) switch off essential loads in a logical sequence

c) controls the reactive power of the plant

d) all the above.

447 In a fluid coupling, connecting an induction motor and a fan

a) motor speed can be changed by the fluid coupling

b) fan speed can be changed by the fluid coupling

c) both motor and fan speed can be changed by the fluid coupling

d) none of the above is possible

448 In a "V" belt coupled fan drive, the measured speed at motor end 6" diameter pulley is 1480 rpm and that at fan end 10" diameter pulley is 820 RPM. What is the slippage loss in %?

a) 7.66 b) 8.29 c) 6.67 d) insufficient data, cannot be worked out

449 Select the incorrect statement:

a) slip ring induction motors are normally less efficient than squirrel cage induction motors

b) high speed squirrel cage induction motors are normally less efficient than low speed Squirrel cage induction motors

c) the capacitor requirement for PF improvement at induction motor terminal increases with decrease in rated speed of the induction motor

d) induction motor efficiency increases with increase in its rated capacity

450 Coefficient of Performance (COP) for a refrigeration compressor is given by

a) kW/TR
b) power input to compressor (kW) / cooling effect (kW)
c) cooling effect (kW) / Power input to compressor (kW)
d) none of the above

451 For the same quantity of power handled by a distribution line, the lower the voltage

i) the higher the current drawn and higher the distribution loss
j) the lower the current drawn and lower the distribution loss
k) the lower the voltage drop and lower the distribution loss
l) the higher the voltage drop and lower the distribution loss

452 The ratio of overall maximum demand of the plant to the sum of individual maximum demand of various equipment is _____.

a) load factor b) diversity factor c) demand factor d) maximum demand

453 Maximum demand charges for a billing cycle is calculated by the Utility based on:

a) the instantaneous demand drawn
b) the time integrated demand over the predefined recording cycle
c) the kVARh drawn per demand cycle
d) the kWh drawn during peak load period .

454 The total amount of harmonics present in the system is expressed using ___.

a) Total Harmonic Factor b) Total Harmonic Ratio

c) Total Harmonic Distortion d) Crest Factor

455 The gross efficiency of a coal based power plant with an operating gross heat rate of 2450 kCal/kWh is

a) 28.48% b) 35.10% c) 30% d) none of the above

456 The efficiency at various stages from power plant to end-use is given below: Efficiency of power generation in a power plant is 30 %, T & D losses are 23 %, distribution loss within the factory is 6 %, and equipment end use efficiency is 65 %. The overall cascade system efficiency from fuel input in power generation to end-use in this case will be

a) 2.69% b) 14.11% c) 4.21 d) none of the above

457 A 3 phase, 7.5 kW, 415 V, 15 A, 1480 RPM rated induction motor with full load efficiency of 90% draws 5 A at rated voltage and 0.5 power factor. The percentage loading of the motor is about

a) 21.56% b) 23.96% c) 33.33% d) none of the above

458 An induction motor installed with static PF correction capacitors across the motor terminals got damaged along with capacitors once it was disconnected from the supply. The possible reason among the following was

a) charging current of the capacitor was only 80% of the motor magnitising current

b) motor PF was over corrected or critically corrected (unity power factor)

c) motor was oversized

d) motor was undersized

459 A 4-pole squirrel cage induction motor operates with 1% slip at full load. What is the approximate full load RPM of motor you may expect at a grid frequency of 49.5 Hz ?

a) 1485 b) 1470 c) 1500 d) none of the above

460 The power factor of an induction motor

a) increases with increase in motor loading b) decreases with increase in motor loading

c) is independent of motor loading d) increases with decrease in motor loading

461 Which of the following pipe fittings used in compressed air pipe line offers maximum resistance

a) Gate Valve in open condition b) Return bend c) Elbow d) Tee 90° long bend

462 An induction motor rated for 15 kW and 93% efficiency, operating at full load at the rated parameters condition, will

a) deliver 15 kW b) deliver 16.12 kW c) draw 15 kW d) draw 13.95 kW

463 Modest flow variation, from 100% to 80%, in a centrifugal fan is achieved more efficiently with which of the following flow control methods

a) inlet damper b) outlet damper c) inlet guide vanes d) none of the above

464 A 200 cfm compressor has a loading and unloading period of 10 seconds and 20 seconds respectively during a compressed air leakage test. The air leakage in the compressed air system would be

a) 20.3 cfm b) 42.1 cfm c) 66.6 cfm d) 132.8 cfm

465 Select the correct Statement: The advantage of PF improvement by capacitor addition in an electric network is

a) apparent power component of the network is reduced

b) active power component of the network is reduced

c) I^2R power losses are reduced in the system from the point of installation to the load end

d) voltage level at the load end is not improved

466 A 500 cfm reciprocating compressor was earlier operating at load - unload pressure setting of 6.0 kg/cm^{2}g and 7.5 kg/cm^{2}g which was changed to 6.0 to 6.5. kg/cm^{2}g respectively for the same end use conditions. This change with respect to previous situation will result in

a) decreased unloading cycle time of the compressor

b) increased loading cycle time of the compressor

c) increased energy consumption of the compressor

d) <u>decreased leakage loss in air distribution system</u>

467 If the energy efficiency ratio (Watt/Watt) of a split air conditioner is 2.3, then power consumed by it per ton of refrigeration will be

a) <u>1.53 kW</u> b) 0.66 kW c) 2.3 kW d) none of the above

468 With increase in the suction lift from open wells, the delivery flow rate

a) increases b) <u>decreases</u> c) remains same d) none of the above

469 The refrigeration load in TR when 84 litre/minute of water is cooled from 21^{o}C to 15 ^{o}C is about

a) 0.166 b) 1.66 c) 16.66d) <u>10</u>

470 The COP of a vapour compression refrigeration system is 3.5. If the motor delivers power of 10.8 kW at its shaft with a 90% motor efficiency, the cooling effect of vapour compression system will be

a) 34 kW b) <u>37.8 kW</u>

c) 0.36 kW d) none of the above as cooling effect is always measured in TR

471 In a variable speed drive using hydraulic coupling

a) motor speed changes b) driven equipment speed changes

c) both a & b d) neither a nor b

472 A fan with 30 cm pulley diameter is driven by a 1480 rpm motor through a v-belt system. If the motor pulley is reduced from 20 cm to 18 cm at the same motor rpm and fan pulley diameter, the fan speed will reduced by

a) 247 rpm b) 888 rpm c) 98 rpm d) none of the above

473 Which of the following is wrong?

a) Pump raises an incompressible fluid to a higher level of pressure or head.

b) Compressor raises a compressible fluid to a higher level of pressure.

c) Blower moves gas volumes with moderate increase of pressure.

d) Pump raises relatively compressible fluid to a higher level of pressure or head.

474 As per the fan laws, by reducing the fan RPM by 10% , the fan power requirement:

a) decreases by 27% b) decreases by 19% c) does not change d) decreases by 73%

475 A centrifugal fan is operating at 800 RPM developing a flow of 3000 Nm^3/hr at a static pressure of 600 mmWC. If the fan speed is reduced to 600 RPM, the static pressure will become:

a) 450 mmWC b) 519.6 mmWC c) 337.5 mmWC d) none of the above

476 The operating point in a pumping system is identified by

a) point of intersection of system curve and efficiency curve

b) point of intersection of pump curve and theoretical power curve

c) point of intersection of pump curve and system curve

d) none of the above

477 It is acceptable to run pumps in parallel provided their_____ are similar

a) suction heads b) discharge heads c) closed valve heads d) none of the above

478 Small diameter by-pass lines are installed in pumps some times to _____.

a) save energy b) control pump delivery head

c) prevent pump running at zero flow d) reduce pump power consumption

479 There are four pumps working against the same friction heads. For which of the following static heads, the variable speed drive will be most economical. (assume magnitude of flow variation and the number of time it varies is same for all the situations and VSD application can be considered)

a) Pump A - 0 m b) Pump B - 10 m c) Pump C - 20 m d) Pump D - 25 m

480 A pump with 200 mm impeller is delivering a flow of 120 m^3/hr. If the flow is to be reduced to 100 m^3/hr by trimming the impeller, what should be the approximate impeller size?

a) 167 mm b) 138mm c) 60mm d) none of the above

481 If flow rate is 10 m^3/hr and the range is 8 ^oC for a cooling tower, then its heat load in kCal/hr will be.

a) 80 b) 800 c) 8,000 d) 80,000

482 When you do a walk through energy audit of a cooling tower which salient parameter will you quickly spot check for its water cooling performance?

a) makeup water tap is on or off b) hot water entry temperature to the cooling tower

c) cooling tower fan is on or off d) cold well and ambient wet bulb temperature

483 Natural draft cooling towers are mainly used in ____.

a) steel industry b) automobile industry c) process industry d) power stations

484 Which of the following is correct statement in the case of cooling towers:

a)"Range" is the difference between the cooling tower water inlet and ambient wet bulb temperature.

b) "Approach" is the difference between the cooling tower outlet cold water temperature and hot inlet water temperature.

c) "Range" is the only indicator of cooling tower performance.

d) Cooling tower capacity is expressed as heat rejected in Ton of Refrigeration (TR)

485 Which of the following is incorrect statement?

a) Inadequate cooling in after-coolers causes more condensation in air receivers and distribution lines

b) Performance of inter-coolers have no effect on work of compression

c) In a battery of air compressors in operation, the compressor with lower part load power consumption should be modulated.

d) For the same capacity, a compressor consumes more power at higher delivery pressure

486 Name the fan which is more suitable for high pressure application

a) propeller type fan b) tube-axial fan

c) backward curved centrifugal fan d) forward curved centrifugal fan

487 The basic functions of an electronic ballast fitted to a fluorescent tube light exclude one of the following

a) to stabilize the gas discharge b) to supply power to the lamp at supply frequency

c) to ignite the tube light d) to supply power to the lamp at very high frequency

488 Energy savings potential of variable torque applications compared to constant torque application is:

a) higher b) lower c) equal d) none of the above

489 In a DG set, a 3 phase alternator is loaded at 450 A, at 415 volts and 0.85 PF. If the specific fuel consumption of this DG set is 0.25 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour.

a) 39.68 litre b) 80.86 litre c) 68.74 litre d) none of the above

490 Slip ring induction motors, in general, have a …… design efficiency in comparison with the squirrel cage induction motors for similar ratings

a) lower b) higher c) same d) none of the above

491 A power factor capacitor designed for 10 kVAr at 415 V was found to be operating at 405 V. The effective capacity of the capacitor would be

a) 9.75 kVAr b) 10 kVAr c) 9.52 kVAr d) none of the above

492 Which combination of readings as indicated by the panel mounted instruments of a DG set would give the indications of proper capacity utilisation of diesel engine and generator?

a) kW & Voltage b) kVA & kVAr c) kW & kVA d) none of the above

493 Among the following electrical equipment _____ has the highest design efficiency

a) synchronous motor b) DC shunt motor c) induction motor d) transformer

494 The surface area of heat exchange in a cooling tower is enhanced by

a) fill media b) louvers c) drift eliminator d) cold water basin

495 How many units per liter will be available from a DG set if the operating efficiency is 40%? The calorific value of diesel is 10,000 kCal per liter

a) 3.50 b) 6.98

c) cannot be worked out as DG set loading is not indicated d) 4.65

496 The 5^{th} and 7^{th} harmonic in a 50 Hz power environment will have:

a) voltage and current distortions with 55 Hz & 57 Hz

b) voltage and current distortions with 500 Hz & 700 Hz

c) voltage and current distortions with 250 Hz & 350 Hz

d) no voltage and current distortion at all

497 The source of maximum harmonics among the following in a plant power system could be:

a) 100 CFL lamps of 11 W to 25 W b) 500 kW, 3 Phase, 415 V, 50 Hz resistance furnace

c) 5 kVA UPS for computer system d) Variable Frequency Drive for 225 kW motive load

498 Which of the following are emerging technological solutions in electric power distribution system?

a) Intelligent meters for improved system operation and customer relationship management

b) Intelligent or "smart meters" to replace older systems to allow customers a clear picture of their energy use profile,

c) SCADA system to control and data acquisition for complete T&D system

d) all the above

499 Which of the following options reduces the electricity consumption in lighting system in a wide spread plant?

a) installing separate lighting transformer and maintaining optimum voltage

b) maintaining 260 V for the lighting circuit with 220 V rated lamps

c) replacing 150 W HPSV lamps with 250 W HPMV lamps

d) none of the above

500 Capacitors with automatic power factor controller when installed in a plant

a) reduces active power drawn from grid b) reduces the reactive power drawn from grid

c) reduces the voltage of the plant d) increases the load current of the plant

501 Select the wrong statement:

a) lower the heat rate of a power generating unit, higher is the generation efficiency.

b) one kilo Watt hour of electrical energy being equivalent to 3600 kilo Joules of thermal energy

c) 'Heat Rate' is directly proportional to the efficiency of power generation.

d) design 'Heat Rate' of a 210 MW thermal generating unit is higher than that of a 110 MW thermal generating unit.

502 If power factor is improved from PF1 to PF2 then the reduction in distribution losses in an electric network is proportional to :

a) ratio of PF1 to PF2 b) square root of (PF1/PF2)

c) square of (PF1/PF2) d) none of the above

503 In the BEE labeling programme for distribution transformers, the total transformer losses at

a) 50% and 100% loading have been defined.

b) only 50% loading have been defined.

c) only 100% loading have been defined.

d) 25%, 50% and 100% loading have been defined.

504 A 5 kVAr, 415 V rated power factor capacitor was found to be having 5.5 kVAr operating capacity. The operating supply voltage at the same supply frequency would approximately be

a) 400 V b) 415 V c) 435 V d) none of the above

505 Busbar Voltages at the main electrical panel were balanced but at the following Motor Control Circuit (MCC), fitted with PF Correction capacitors, the voltages were unbalanced by about 3%. The possible reason for this could be

a) motors connected to MCC were operating at partial loads

b) motors connected to MCC were overloaded

c) excessive kVAr of Capacitors than required at MCC

d) blown fuse in one phase of the 3 phase capacitor bank connected to the MCC.

506 The iron losses in a transformer are proportional to :

a) kVA load b) square of kVA load

c) cube of kVA load d) none of the above

507 The synchronous speed (rpm) of a 2 pole induction motor at 49.5 Hz supply frequency is :

a) 3000 b) 2970 c) 1500 d) none of the above

508 kW rating indicated on the name plate of an induction motor indicates

a) rated input of the motor b) maximum input power which the motor can draw

c) rated output of the motor d) maximum instantaneous input power of the motor

509 A 7.5 kW, 415 V, 14.0 A, 1480 RPM, three phase rated squirrel cage induction motor, after decoupling from the driven equipment, was found to be drawing 3.5 A at no load. The current drawn by the motor at no load is high because of

a) very high supply frequency at the time of no load test b) faulty ammeter reading

c) very poor power factor as the load is almost inductive d) loose motor terminal connections

510 A six pole induction motor operating at 49.6 Hz, with 980 RPM actual speed , will have operating % slip of

a) 1.21% b) 2% c) 0% d) none of the above

511 The total loss for a transformer loading at 60% and with no load and full load losses of 3 kW and 25 kW respectively, is

a) 3 kW b) 12 kW c) 18 kW d) 25 kW

512 Eff1 (as per IS 12615:2004) induction motor is

a) endorsed by BEE as high efficiency label b) having same efficiency as of Eff2

c) having less efficiency than Eff 2 motor d) not covered in BEE labeling scheme for motors

513 Select the incorrect statement

a) required PF capacitor kVAr at induction motor terminal increases with decrease in speed of the motor

b) PF capacitor improves power factor from the point of installation back to the load side.

c) induction motor efficiency increases with increase in its rated capacity

d) The largest potential for electricity savings with variable speed drives is generally in variable torque applications

514 The adsorption material used in an adsorption air dryer is

a) calcium chloride b) magnesium chloride

c) activated alumina and silica gel d) potassium chloride

515 In a textile mill, two 150 cfm belt driven reciprocating compressors are seen to be working constantly with a loading time of 20 seconds and unloading time of 30 seconds. The best economic option for energy savings would be:

a) switch off one compressor

b) switch off one compressor and reduce motor pulley size of the other compressor appropriately

c) adopt variable speed drive for one of the compressors

d) none of the above

516 Which of the following pipe fittings used in compressed air pipeline offers maximum resistance

a) Gate Valve b) Tee 90 deg long bend c) Elbow d) Return bend

517 A package air conditioner of 5 TR capacity delivers a cooling effect of 4 TR. If EER (W/W) is 2.90, the power in kW drawn by compressor would be:

a) 4.85 b) 1.38 c) 1.724 d) none of the above

518 In an air washer of textile humidification system airflow of 3000 m^3/h at 25 ^oC and 10% relative humidity is humidified to 60% relative humidity by adding water through spray nozzles. The specific humidity of air at inlet and outlet are 0.002 kg/kg and 0.0062 kg/kg respectively .The amount of water required in kg/hr is

a) 14.9 b) 6 c) 10 d) none of the above

519 In a vapour compression refrigeration system, the component where the refrigerant fluid experiences no heat loss or gain is

a) compressor b) condenser c) expansion valve d) evaporator

520 The refrigeration load in TR when 20 m^3/hr of water is cooled from 13 ^oC to 8 ^oC is about

a) 33 b) 80.3 c) 39.6 d) none of the above

521 In an engine room 15 m long, 10 m wide and 4 m high, ventilation requirement in m^3/hr for 20 air changes/hr is:

a) 6000 b) 9000 c) 12000 d) none of the above

522 The specific ratio as defined by ASME and used in differentiating fans, blowers and compressors, is given by

a) discharge pressure/suction pressure b) suction pressure/discharge pressure

c) discharge pressure/ (suction pressure + discharge pressure)

d) suction pressure/ (suction pressure + discharge pressure)

523 Friction loss in a piping system carrying fluid is proportional to

a) fluid flow b) $(\text{fluid flow})^2$ c) 1/fluid flow d) $1/(\text{fluid flow})^2$

524 The efficiency of backward-inclined fans compared to forward curved fans is__

a) lower b) higher c) same d) none of the above

525 For centrifugal fans, the relation between shaft input Power (kW) and Speed (N) is given by

a) $\frac{kW_1}{kW_2} = \frac{N_1}{N_2}$ b) $\frac{kW_1}{kW_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{kW_1}{kW_2} = \frac{N_1^3}{N_2^3}$ d) none of the above

526 The value, by which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as

a) static head b) dynamic head c)suction head d) net positive suction head available

527 In a pumping system the static head is 10 m and the dynamic head is 15 m. If the pump speed is doubled, then the total head will be

a) 50 m b) 70 m c) 40 m d) none of the above

528 The advantage of installing a dedicated servo transformer for lighting feeders is;

i) "Voltage" fluctuations in lighting circuit can be minimized by isolating from the power feeders.
j) reduction of voltage related problems, which in turn increases the efficiency of the lighting system.
k) with proper control device “over voltage” that might occur during lean load or off-peak can be avoided, in turn less energy consumption and improved lamp life can be achieved
l) all the above

529 Parallel operation of two identical fans in a ducted system

a) will double the flow b) will double the fan static pressure

c) will increase flow by more than two times d) will not double the flow

530 The COP of a vapour compression refrigeration system is 3.0. If the compressor motor output is 9.555 kW, the tonnage (TR) of the refrigeration system is

a) 8.15 b) 28.665 c) 3 d) none of the above

531 A cooling tower is said to be performing well when:

a) range is close to zero b) approach is close to zero

c) approach is more than design values d) range is equal to approach

532 A process fluid at 40 m^3/hr, with a density of 0.95, is flowing in a heat exchanger and is to be cooled from 35 °C to 29 °C. The fluid specific heat is 0.78 kCal/kg. If the chilled water range across the heat exchanger is 4 °C, the chilled water flow rate is

a) 44.46 m^3/hr b) 40 m^3/hr c) 35 m^3/hr d) none of the above

533 Input power to the motor driving a pump is 30 kW. The motor efficiency is 0.9. The power transmitted to the water is 16.2 kW. The pump efficiency is

a) 54% b) 60% c) 90% d) none of the above

534 The most energy intensive dryer among the following

a) refrigeration b) desiccant (heat of compression)

c) desiccant (heatless purge) d) desiccant (blower reactivated)

535 The illuminance is 10 lm/m² from a lamp at 1 meter distance. The illuminance at half the distance will be

a) 40 lm/m² b) 10 lm/m² c) 5 lm/m² d) none of the above

536 Harmonics are generated by

a) energy efficient motors b) transformers

c) eddy current drives d) variable frequency drives

537 The main precaution to be taken care by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is:

a) temperature rise b) back pressure

c) over loading of waste heat recovery tubes d) turbulence of exhaust gases

538 The lamp which gives 10% visible radiation is

a) CFL b) flourescent tube light c) HPSV d) incandescent lamp

539 The electronic ballast in lighting application does not have one of the following characteristics

a) lower operational losses than conventional ballasts

b) tuned circuit to deliver power at 28-32 kHz

c) requiring a starter

d) low temperature rise

540 The lumens output varies from _____ Lumens/Watt in case of White LED lamps.

a) 30-50 b) 75-125 c) 101-175 d) 67-121

541 A fan is operating at 970 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 650 mmWC. If the speed is reduced to 700 RPM, the static pressure (mmWC) developed will be

a) 388.5 b) 244.3 c) 469 d) none of the above

542 The blowdown quantity required in cooling towers is given by

a) evaporation loss/ (cycle of concentration –1)

b) (cycle of concentration –1)/ evaporation loss

c) evaporation loss/ (1 - cycle of concentration)

d) evaporation loss/ (cycle of concentration +1)

543 A hotel building has four floors each of 1000 m^2 area. If the Lighting Power Density (LPD) is 10.8 W/m^2, the interior lighting power allowance for the hotel building is

a)10800 W b) 21600 W c) 43200 W d) none of the above

544 A DG set is generating 900 kVA at 0.8 PF. If the specific fuel consumption of this DG set is 0.3 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour.

a) 270 litres b) 300 litres c) 216 litres d) none of the above

546 Energy Performance Index (EPI) kWh/m^2 /yr is calculated based on

a) total building annual electrical energy consumption/ built up area
b) total building annual electrical energy consumption/ carpet area
c) total building annual electrical energy consumption for HVAC & lighting/ built up area
d) none of the above

547 Two most important electrical parameters, which are to be monitored on generator panel, among the following, for safe operation of a Diesel generator set are:

a) voltage and ampere b) kVA and ampere c) power factor and voltage d) kW and kVA

548 Which of the following is not a climate zone as per ECBC classification?

a) hot-dry b) warm-humid c) cold d) cold-humid

549 The T2,T5,T8 and T12 fluorescent tube light are categorized based on

a) diameter of the tube b) length of the tube
c) both diameter and length of the tube d) none of the above

550 Select the feature which does not apply to energy efficient motors by design:

a) energy efficient motors last longer

b) starting torque for efficient motors may be lower than for standard motors

c) energy efficient motors have high slips which results in speeds about 1% lower than standard motors

d) energy efficient motors have low slips which results in speeds about 1% higher than standard motors

551 In a 22 kV feeder, if the voltage is raised from 22 kV to 66 kV for the same loading conditions, the voltage drop in the same feeder system would be lowered to

a) 1/2 b) 1/3 c) 1/9 d) unpredictable value

552 Normally, the efficiency of distribution transformer at full load varies anywhere between

a) 96 to 99 % b) 80 to 85 % c) 60 to 70% d) 50%- 60%

553 What is the reduction in distribution loss if the current flowing through the distribution line is reduced by 10%?

a)10% b) 90% c) 19% d) 81%

554 Power factor is the ratio of

a) kVAr/kW b) $(kW^2+kVAr^2)^{1/2}/kW$

c) $kW/ (kW^2+kVAr^2)^{1/2}$ d) $kVAr/ (kW^2+kVAr^2)^{1/2}$

555 The electricity bill shows an average power factor of 0.72 with an average kW demand of 627. How much kVAr is required to improve the power factor to 0.95? (Given Data: tan 01 = 0.964,tan 02 = 0.329)

a) 398 b) 144 c) 95 d) 627

556 Where transformer loading is known, the actual transformer loss at a given load can be computed as:

a) No Load Loss+ (Actual kVA Load/rated kVA) X Load Loss
b) No Load Loss+ (Actual kVA Load/rated kVA)^2 X Load Loss
c) No Load Loss+ (Actual kVA Load/rated kVA) X Load Loss^2
d) [No Load Loss+{ (Actual kVA Load/rated kVA) X Load Loss}]^2

557 Direct current motors are used in special applications where

a) high torque starting or where smooth acceleration over a broad speed range is required.
b) low torque starting or where steady acceleration over a narrow speed range is required.
c) normal torque starting or where high acceleration over a broad speed range is required.
d) low torque starting or where smooth acceleration over a broad speed range is required.

558 A 3-phase, 415 volts, 50 Hz, 100 kW, 6 pole squirrel cage induction motor with a rated slip of 2% will have a full load rotor speed of

(a) 1470 rpm (b) 980 rpm (c) 1020 rpm (d) none of the above

559 In an induction motor the loss which is independent of motor load

a) I^2R loss of stator b) I^2R loss of rotor c) friction and windage loss d) all of the above

560 Rewinding can affect which of the following factors that contribute to deterioration in motor efficiency:

a) winding and slot design and winding material selection
b) heat applied to strip windings, damage the insulation between laminations, thereby increasing eddy current losses
c) change in the air gap may affect power factor and output torque
d) all the above

561 If measured Line Current of a 3 phase induction motor is 25.98 A, what will be the Phase Current?

a) 15 A b) 45 A c) 8.96 A d) 30 A

562 The efficiency of compressed air system is around

a) 90% b) 60% c) 50% d) 10%

563 The basic function of air dryer in a compressed air system is to

a) remove remaining traces of moisture after the aftercooler

b) store and smoothen pulsating air output

c) reduce the temperature of the air before it enters the next state to increase efficiency

d) prevent dust from entering compressor

564 Select the correct statement for reciprocating air compressors:

a) for every 4^{O}C drop in the inlet air temperature, the increase in energy consumption is by 1%.

b) for every 4 ^{O}C rise in the inlet air temperature, the decrease in energy consumption is by 1%

c) for every 4 ^{O}C rise in the inlet air temperature, the increase in energy consumption is by 1%

d) the energy consumption remains same irrespective of inlet air temperature

565 Which of the following parameters is not required for evaluating volumetric efficiency of the compressor?

a) FAD b) Cylinder bore diameter c) Stroke length d) Power input

566 Which of the following will not occur if a reciprocating compressor is operated at a lower discharge pressure?

a) lower power consumption

b) less load on the piston rods and hence reduced maintenance costs

c) lower leakage losses

d) lower free air delivery than rated

567 Which type of energy efficient dryer can be opted if a user in a plant requires compressed air at a dew point of -40°C ?

a) heatless purge type dryer
b) heat of compression dryer
c) aftercooler
d) refrigerant dryers

568 A 1.5 TR room air conditioner having EER (W/W) of 3.0 , will draw input power of____kW

a) 1.75 b) 3.00 c) 1.50 d) 2.00

569 Identify the wrong statement from the following regarding Vapour Compression Refrigeration system

a) condenser rejects heat to atmosphere
b) evaporator removes heat from process or space
c) compressor sends superheated vapor to condenser
d) high pressure sub-cooled liquid refrigerant returns back to evaporator

570 The head developed by a centrifugal pump is not directly proportional to

a) Impeller diameter
b) Shaft speed
c) Number of impellers
d) Diameter of discharge port

571 Which of the following is incorrect in the case of cooling towers

a)"Range" is the difference between the cooling tower water inlet and outlet temperature.
b) "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature.
d)'Range' is a better indicator of cooling tower performance.
e) Cooling capacity is the heat rejected in kCal/hr or TR

572 Identify the correct statement:

a) the Specific Ratio of Compressors is higher than Blowers
b) the Specific Ratio of Fans is higher than Blowers
c) the Specific Ratio of Compressors is lower than Fans
d) the Specific Ratio of Blowers is higher than Compressors

573 Decreasing the rpm of a fan at partial loading by 10% results in:

a) decrease of 10% in flow rate and decrease of 27% in power requirement
b) decrease of 10% in flow rate and decrease of 19% in power requirement
c) decrease of 10% in flow rate and increase of 10% in power requirement
increase of 10% in flow rate and no appreciable change in power requirement

574 The power drawn by a centrifugal fan is

a) inversely proportional to fan efficiency b) directly proportional to fan efficiency

c) inversely proportional to static pressure d) inversely proportional to flow rate

575 The frictional loss in a piping system is proportional to

d) a) flow b) flow^2 c) 1/flow d) 1/flow^2

576 For the same flow, through which of the following diameter pipes, the pump will work with maximum pressure?

a) 100 mm b) 150 mm c) 200 mm d) 250 mm

577 It is possible to run pumps in parallel if their_____are similar.

a) suction heads b) discharge heads c) closed valve heads d) none of the above

578 Input power to the motor driving a pump is 20 kW. The motor efficiency is 0.9 and pump efficiency is 0.7. The power transmitted to the water is

a) 12.6 kW b) 18.0 kW c) 14.0 kW d) 31.75 kW

579 Small by-pass lines are installed in pumps some times to__.

a) increase flow b) control pump delivery head

c) prevent pump running at zero flow d) reduce pump power consumption

580 The refrigeration load in TR when 10 m^3/hr of water is cooled from a 15 ^oC to 7 ^oC is about

a) 10 b) 8 c) 26.5 d) none of the above

581 The order of movement of thermal energy in HVAC system is:

a) Indoor air - Chilled water - Refrigerant-Condenser water- Cooling tower
b) Chilled water - Indoor air - Refrigerant-Cooling tower - Condenser water
c) Indoor air - Condenser water - Chilled water - Cooling tower - Refrigerant
Indoor air - Chilled water – Refrigerant - Cooling tower - Condenser water

582 In a cooling tower,
Statement A: Surface of heat exchange is the surface area of the water droplets, which is in

583 contact with air.
Statement B: Area of heat exchange is the surface area of the fill sheets, which is in contact with air.

a) statements A & B are false b) statement A is True & B is false
d) c) statements A & B are True d) statement A is false & B is True

584 If the evaporation loss is 16 m^3 /hr per cell and Cycles of Concentration is 3, the blow down requirement in m^3 /hr per cell of a cooling tower:

a) 8 b) 5.33 c) 4 d) 2

585 Cycles of Concentration (C.O.C) of a cooling tower will depend on

a) TDS in circulating water b) TDS in make-up water

c) both a & b d) none of the above

586 The Solar Heat Gain Coefficient (SHGC) of window of a building is 0.30. This means:

a) That the window allows 70 % of the sun's heat to pass through into interior of the buildings
b) That the window allows 30 % of the sun's heat to pass through into the building interior
c) That 70 % of the sun's heat is incident on the window
That the window reflects back to exterior a minimum of 30 % of the sun's heat

587 FRP fans consume less energy than aluminium fans because

a) they are lighter b) they have better efficiencies
c) they encounter less system resistance d) they deliver less air flow

588 The hydraulic power in a pumping system depends on

a) motor efficiency b) pump efficiency
d) c) both motor and pump efficiency d) none of the above

589 The most energy intensive heat transfer loop of a Vapour Compression Refrigeration System is:

a) Indoor air loop b) Chilled water loop
c) Refrigerant loop d) Condenser water loop

590 The efficiency of a pump does not depend on

a) suction head b) discharge head c) motor efficiency
d) density of fluid

591 The power factor of a squirrel cage induction motor

a) decreases at low motor loading
b) decreases at high motor loading
c) remains constant and is independent of load
d) cannot be predicted

592 The slip of a synchronous motor will be

a) more than the induction motor
b) less than the induction motor
c) zero
d) load dependent

593 In BEE Star labeled distribution transformers, which of following losses are defined?

a) total loss at 50% and 100% loading
b) total loss at 75 % loading
c) total loss at 75% and 100% loading
d) total loss at 100% loading

594 To optimize the voltage level fed to the lighting feeder, the best option is to install.

a) servo stabilizer for lighting feeder
b) "exclusive" transformer for lighting
c) microprocessor based controllers
d) high frequency (HF) electronic ballasts

595 Which one of the following device will help to eliminate the hunting problems normally associated with capacitor switching?

a) Intelligent Power Factor Controller
b) maximum demand controller
c) soft starter
d) eddy current drives

596 Which one of the following is an incorrect statement?

a) fluorescent lamp is an electric discharge lamp
b) electronic ballasts make use of semi-conductor devices
c) electronic ballasts have very low internal loss
fluorescent lamps can produce light by direct connection to the power source

597 A 2500 MW super thermal power station generated 15786 million units in the year 2011-12. Its Plant Load Factor (PLF) is:

a) 60% b) 65% c) 72% d) 79%

598 Which of the following statements is not true of maximum demand controller

a) switches off non-essential loads in Logical sequence.
b) alarm is sounded when demand approaches a preset value.
c) voltage level is closely regulated
d) plant equipment selected for the load management can be programmed

599 The main reason for using Variable Frequency Drive (VFD) for capacity control in electrical motor driven centrifugal fans with fluctuating load is :

a) improved power quality
b) fan capacity is proportional to its speed whereas the power drawn by the fan is proportional to the cube of its speed
c) improved power factor
precise closed loop process control

600 Select the incorrect statement:

a) harmonics occur as spikes at intervals which are multiples of the supply frequency
b) harmonics are multiples of the fundamental frequency
c) induction motors are the major sources of harmonics
d) transformers operating near saturation level create harmonics

601 The gross efficiency of a coal based power generating unit with a gross heat rate of 2490 kcal/kWh is

a) 40% b) 34.5 % c) 33.3% d) 45.2%

602 The efficiencies of a power plant and transmission systems are 40%, and 97% respectively. The percentage loss of the distribution system of the same network is 23% . The cascade efficiency

of generation ,transmission and distribution system is given by

a)8,92 % b) 29.87% c) 40 % d) 23%

603 The rating of power factor correction capacitors at induction motor terminals should be

a) 90% of no load magnetizing kVAr of induction motor

b)100 % of no load magnetizing kVAr of induction motor

c) 80% of no load magnetizing kVAr of induction motor

d) none of the above

604 Select the correct statement: Power factor

a) is the ratio of active and reactive power

b) is the ratio of reactive and apparent power c) is the ratio of active and apparent power

d) of a pure inductive and capacitive load is unity

605 The Energy Performance Index (EPI) of a building as per Energy Conservation Building Code (ECBC) and as defined in the Energy Conservation Act,2001 is:

a) kWh per square meter per year b) kWh per square meter

c) kW per square meter d) kWh per year

606 If the maximum demand is 3500 kVA at 0.88 p.f., the maximum demand will reduce by_____kVA if PF is improved to 0.98 :

a) 3143 b) 357 c) 3897 d) maximum demand will not reduce

607 The performance of rewinding of an induction motor can be assessed by which of the following factors?

a) no load current b) stator resistance per phase
c) load current d) <u>both no load current and stator resistance per phase</u>

608 For a synchronous speed of 1500 rpm, at a given mains frequency of 50 Hz, the induction motor will have_____number of poles.

a) 8 b) 6 c) 4 d) 2

609 A 7.5 kW, 415 V, 14.5 A, 1460 RPM rated 3 phase induction motor with full load efficiency of 90%, draws 9.1 A and 4.6 kW of input power. The percentage loading of the motor is about

a) <u>55.2 %</u> b) 61.3 % c) 67.5 % d) none of the above

610 The power input to a rotor of three phase induction motor is 42.3 kW. If the induction motor is operating at a slip of 1.30 % the total mechanical power developed will be:

a) 42.3 kW b) <u>41.75 </u>kW c) 5.48 kW d) 47.79 kW

611 If the apparent power drawn over a recording cycle of 30 minutes is 5000 kVA for 0.5 minutes, 3400 kVA for 20 minutes and 1800 for 9.5 minutes, the MD recorder will compute MD as

a) 5000 kVA b) 3400 kVA c) <u>2920 kVA</u> d) 1800 kVA

612 The rating of the p.f correction capacitors at motor terminals for a 37 kW, 2 poles induction motor will be_____in comparison to the same sized induction motor of 6 poles

a) more b) <u>less</u> c) same d) sometime less or more

613 Which parameters need to be measured to assess the percentage loading of a motor by slip method neglecting voltage correction?

a) motor speed
b) synchronous speed
c) operating motor speed and frequency
d) operating current

614 Isothermal power of a compressor depends on

a) absolute intake pressure
b) pressure ratio
c) free air delivered
d) all of the above

615 Reduction in the delivery pressure of an air compressor working at 7 bar, by 1 bar would reduce the power consumption by

a) 2 – 3 %
b) 4 - 5 %
c) 6 - 10 %
d) none of the above

616 Which of the following is correct for air compressors?

a) for every 5.5^{o}C drop in the inlet air temperature, the increase in energy consumption is by 2%
b) for every 4^{o}C rise in the inlet air temperature, the increase in energy consumption is by 1%
c) for every 4^{o}C rise in the inlet air temperature, the decrease in energy consumption is by 1%
d) the energy consumption remains same irrespective of inlet air temperature

617 The Free Air Delivery of a reciprocating air compressor is directly proportional to

a) speed
b) pressure
c) volume
d) all of the above

618 Which of these desiccant compressed air dryers uses dry compressed air for regenerating the desiccant?

a) blower reactivated type
b) heatless purge type
c) heat of compression type
d) all of the above

619 The unit of specific humidity in a psychrometric chart is

a) grams moisture/kg of dry air
b) moisture percentage in air
c) grams moisture/kg of air
d) all of the above

620 The COP of a vapour compression refrigeration system is 3.1 If the motor draws power of 9.3 kW at an operating efficiency of 88%, the tonnage of refrigeration system is about

a) 8.2 b) 9.3 c) 7.2 d) none of the above

621 Chilled water enters an evaporator at 10^0C and leaves at 6^0C. The flow rate of chilled water was measured as 200 m^3/hr. The tons of refrigeration capacity is

a) 265 b) 200 c) 661 d) 2.65

622 In an air conditioning system analysis which one temperature is sufficient to determine the enthalpy of air?

a) dry bulb temperature
b) wet bulb temperature
c) ambient temperature
d) none of the above

623 The head generated by a centrifugal pump is:

a) independent of the density of the liquid being pumped
b) directly proportional to the density of the liquid being pumped
c) inversely proportional to the density of the liquid being pumped
d) proportional to the square of the density of the liquid being pumped

624 The driving force for refrigeration in a vapour absorption refrigeration system is

a) mechanical energy
b) electrical energy
c) thermal energy
d) chemical energy

625 Which of the following happens to air when it is cooled through evaporation process?

a) humidity ratio of the air decreases

b) dry bulb temperature of air decreases
c) dry bulb temperature of air increases
d) enthalpy of outlet air is less than enthalpy of inlet air

626 The relation between COP and kW/TR for a refrigeration system is given by

a) kW/TR = 3.516/COP b) kW/TR = COP /3.516
c) kW/TR = 860/COP d) none of the above

627 In which of the following fans the air does not change flow direction from suction to discharge?

a) tube axial fan b) vane axial fan c) propeller fan d) all of the above

628 The parameter used by ASME to classify fans, blowers and compressors is_____

a) volume ratio b) specific ratio c) blade ratio d) impeller ratio

629 The pressure to be considered for calculating the power required for centrifugal fans is _____

a) vapour pressure b) dynamic pressure
c) total static pressure d) velocity pressure

630 The inclined manometer connected to a pitot tube is used for measuring which pressure in a gas stream?

a) velocity b) static c) total d) all of the above

631 If the power drawn by the motor driving a pump is 20 kW at a 91% efficiency, and the hydraulic power of a motor pump set is 12.5 kW, the pump efficiency will be__

a) 68.7% b) 62.5% c) 56.8% d) none of the above

632 Which of the following is not true for impeller trimming?

a) pressure □diameter
b) head □diameter^2
c) power □diameter^3
d) flow □diameter

633 If the speed of the pump is doubled, power goes up by

a) 2 times
b) 6 times
c) 8 times
d) 4 times

634 The preferred method of flow control for reducing pump flow permanently in a pumping system is-------

a) throttling
b) speed control
c) impeller trimming
d) none of the above

635 A water pump is delivering 20 m^3/hr at ambient conditions. The impeller diameter is trimmed by 10%. This will reduce the pump discharge by

a) 18 m^3/hr
b) 2 m^3/hr
c) 0.2 m^3/hr
d) none of the above

636 Increasing the suction pipe diameter in a pumping system will

a) reduce NPSHA
b) increase NPSHA
c) decrease NPSHR
d) increase NPSHR

637 The range of a cooling tower with inlet and outlet temperature as 41^o C and 32^o C respectively and wet bulb temperature as 29^o is

a) 9^{o}C
b) 3^{o}C
c) 29^{o}C
d) 12^{o}C

638 Find the correct equation, if M = makeup water (from the mains water supply), E = losses due to evaporation, B = losses due to blow-down and D = drift losses of a cooling tower:

a) M = E + B + D b) M = E + B - D c) M = E - B + D d) M = E - B - D

639 If the wet bulb temperature of air is 38^0C, then its relative humidity in % is

a) 38 % b) 90% c) 100% d) insufficient data

640 For a cooling tower if blowdown is 10 m^3 /hour and Cycles of Concentration (CoC) is 2.5 the evaporation loss is equal to:

a) 25 m^3/hour b) 15 m^3/ hour c) 0.25 m^3/hour d) 6.67 m^3/hour

641 If the metered kWh is 95, kVAh is 100 and kVARh is 31, the power factor will be:

a) 0.95 b) 0.61 c) 0.69 d) unity

642 In T-5 Fluorescent Lamp, "5" is indicative of:

a) Tube diameter b) 5 watt loss
c) 5% Energy Saving with respect to T8 d) 5^{th} generation lamp

643 Identify the statement that is not applicable to heat pumps

a) transfers heat by refrigerant through a cycle of evaporation and condensation
b) an air conditioner can work as a heat pump
c) no external energy is required
d) a vapour absorption refrigeration system can also work as a heat pump

644 A refrigeration system using which of the following compressors is likely to be most efficient?

a) reciprocating b) screw c) scroll d) all the above

645 Which of the following is not true for a fluorescent lamp with electronic ballast

a) presence of stroboscopic effect
b) energy savings
c) increased light output
d) no starter required

646 Which of the following with respect to turbocharger in a Diesel engine is true?

a) operates using energy of exhaust gases
b) decreases supply air pressure to engine
c) preheats the combustion air using energy from exhaust gases
d) all of the above

647 The refrigerant which can be used both in vapour compression chillers and vapour absorption chiller is

a) R22 b) R21 c) ammonia d) pure water

648 Energy efficient distribution transformer core is made up of_____.

a) silicon alloyed iron (grain oriented)
b) copper
c) amorphous core - metallic glass alloy
d) none of the above

649 In a transformer on load, if the secondary voltage is one-fourth the primary voltage, then the secondary current will be

a) four times the primary current
b) equal to the primary current
c) one-fourth the primary current
d) two times the primary current

650 If V1 is actual supply voltage and V2 is the rated voltage of a capacitor, the reactive KVAr produced would be in the ratio of

a) V_2^2/V_1^2 b) V_1^2/V_2^2 c) $1 - V_2^2/V_1^2$ d) $1 + V_2^2/V_1^2$

651 Which loss is considered the most unreliable or complicated to measure in electric motor efficiency testing?

a) stator Cu loss b) rotor Cu loss c) stator Iron loss d) stray loss

652 A pure resistive load in an alternating current (AC) circuit draws

a) lagging reactive power
b) active power
c) leading reactive power
d) none of the above

653 Select the incorrect statement: The advantage of PF improvement by capacitor addition in an electric network is

a) active power component of the network is not affected
b) reactive power component of the network is not affected
c) I^2R power losses are affected in the system
d) voltage level at the load end is affected

654 "Heat Rate" of a thermal power station is the heat input in kilo Calories or kilo Joules, for generating

a) one kW of electrical output b) one kVAh of electrical output c) one kWh of electrical output d) one kVA of electrical output

655 Improving power factor at motor terminals in a plant will

a) increase active power drawn by motor b) reduce system distribution losses
c) reduce contract demand with utility d) increase motor design power factor

656 For a 6 pole induction motor operating at 49.5 Hz, the percentage slip at a shaft speed of 950 RPM will be

a) 4.0 % b) 5.0 % c) 0.04 % d) none of the above

657 A plant had installed three phase shunt capacitors to improve power factor at Motor Control Circuit (MCC). Busbar three phase Voltages at the main electrical panel of a plant were balanced but at the Motor Control Circuit (MCC),receiving three phase power from busbars, the line voltages were found to be unbalanced. The main reason for this unbalanced voltage at MCC among the following could be

a) PF capacitors were operating at higher supply frequency
b) PF improvement in all phase was not uniform due to blown fuse in one phase of the 3 phase PF capacitors
c) PF capacitors were operating at higher voltage then their rated values
d) PF capacitors were operating at lower voltage then their rated values

658 A 50 kVAr, 415 V rated power factor capacitor was found to be having terminal supply voltage of 430 V. The capacity of the power factor capacitor at the operating supply voltage would be approximately

a) 53.67 kVAr b) 50 kVAr c) 46.57 kVAr d) none of the above

659 A 75 kW rated squirrel cage induction motor installed with static PF correction capacitors across the motor terminals got damaged along with capacitors once supply was switched off due to power failure. The possible reason for the motor burn out among the following could be

a) motor was oversized
b) motor was undersized
c) charging current of the capacitors was more than the magnetizing current of the motor
d) charging current of the capacitor was only 85% of the motor magnetizing current

660 An induction motor rated for 75 kW and 94 % efficiency, operating at full load, will

a) deliver 70.5 kW b) deliver 75 kW c) draw 75 kW d) deliver 79.78 kW

661 Higher chiller COP can be achieved with

a) higher evaporator temperature and higher condensing temperature
b) higher evaporator temperature and lower condensing temperature
c) lower evaporator temperature and higher condensing temperature

d) lower evaporator temperature and lower condensing temperature

662 Increase in the delivery pressure of a compressor by 1 bar would reduce the power consumption by

a) 1 to 5 % b) 6 to 10 % c) 11 to 15 % d) none of the above

663 The FAD of a reciprocating compressor is directly proportional to

a) pressure b) volume c) speed d) all of the above

664 Which of the following is not true of air receivers in a compressed air system?

a) smoothens pulsating air output
b) increases the compressed air pressure
c) stores large volumes of compressed air
d) facilitates draining of moisture

665 Typical acceptable pressure drop in mains header at the farthest point of an industrial compressed air network is

a) 1.0 bar b) 0.7 bar c) 0.5 bar d) 0.3 bar

666 All other conditions remaining the same in a refrigeration system, at which of the following condenser temperatures, the power consumption will be the least:

a) 32.6 ^{o}C b) 35.9 ^{o}C c) 40.8 ^{o}C d) 43.4 ^{o}C

667 The pressure of refrigerant in vapour compression system changes in

a) compressor b)expansion valve c) both (a) & (b) d) evaporator

668 A 1.5 ton air conditioner installed in a room and working continuously for one hour will remove heat of

a) 3024 kcals b) 4536 kcals c) 3000 kcals d) 6048 kcals

669 If the power consumed by a 1.5 TR refrigeration compressor is 2.5 kW , what is the energy efficiency ratio?

a) 2.1 b) 1.5 c) 0.6 d) 1.66

670 In the performance assessment of a refrigeration system, which performance ratio (energy efficiency) does not follow the trend "a higher ratio means a more efficient refrigeration system"?

a) Coefficient of performance(COP) b) Energy Efficiency Ratio (EER)
c) kW per ton d) none of the above

671 2 ton of refrigeration (TR) is equivalent to about

a) 100.8 kcal/min b) 7032 W c) 428.7 BTU/min d) all of the above

672 A fan with 25 cm pulley diameter is driven by a 2940 rpm motor through a V-belt system. If the motor pulley is reduced from 20 cm to 15 cm keeping the motor rpm and fan pulley diameter the same, the fan speed will reduce by

a) 1176 rpm b) 1764 rpm c) 588 rpm d) none of the above

673 In series operation of identical centrifugal fans, ideally

a) flow doubles b) static pressure doubles
c) static pressure goes up by four times d) flow goes up by four times

674 The hydraulic power of a motor pump set is 8 kW. If the power drawn by the motor is 16 kW at 90% efficiency, the pump efficiency will be

a) 55.5% b) 50% c) 45% d) none of the above

675 The energy saving with variable speed drives in a pumping system will be maximum for systems with

a) pure static head b) pure friction head
c) high static head and low friction head d) high static head with high friction head

676 A process fluid at 50 m^3/hr, with a density of 0.96, is flowing in a heat exchanger and is to be cooled from 36^{o}C to 29^{o}C. The fluid specific heat is 0.78 kcal/kg. If the chilled water range across the heat exchanger is 5^{o}C,the chilled water flow rate is

a) 67.2 m^3/hr b) 52.42 m^3/hr c) 50 m^3/hr d) none of the above

677 The inner tube of an L-type pitot tube is used to measure …… in the air duct

a) total pressure b) static pressure b) velocity pressure d) dynamic pressure

678 The intersection point of the centrifugal pump characteristic curve and the design system curve is the

a) pump efficiency point b) best efficiency point
c) system efficiency point d) none of the above

679 In case of increased suction lift from open wells, the pump delivered flow rate
a) increases b) decreases c) remains same d) none of the above

680 In pumping systems where static head is a high proportion of the total, the appropriate solution is

a) install two or more pumps to operate in parallel
b) install two or more pumps to operate in series

c) install two or more pumps to operate in independent operation
d) none of the above

681 A Plant wants to replace the existing 100 TR water cooled vapour compression refrigeration system with a waste heat driven vapour absorption chiller. The capacity of the existing cooling tower

a) needs no change
b) is to be doubled
c) is to be raised to 1.2 times
d) none of the above

682 Shaft power of the motor driving a pump is 30 kW. The motor efficiency is 0.92 and pump efficiency is 0.5. The power drawn by the motor will be

a) 65.2 kW b) 15 kW c) 30 kW d) 32.6 kW

683 If water is flowing through a cooling tower at 120 m^3/h with 5^oC range, the load on cooling tower at an ambient wet bulb ambient temperature of 33 ^oC is

a) 198.4 TR b) 357 TR c) 158 TR d) none of the above

684 In a plant, the loading on a transformer was 1000 kVA with the power factor of 0.88. The plant improved the power factor to 0.99 by adding capacitors on the load side. The release in transformer loading(kVA) will be

a) 111 b) 889 c) 999 d) none of the above

685 The wet bulb temperature normally chosen for designing of cooling tower is

a) average maximum wet bulb for rainy months
b) average maximum wet bulb for summer months
c) average minimum wet bulb for summer months
d) average maximum wet bulb for winter months

686 Which one from the following types of cooling towers consumes least power for the same operating conditions?

a) counter flow film fill cooling tower b) cross-flow splash fill cooling tow
c) counter flow splash fill cooling tower d) none of the above

687 Lux is defined as

a) ratio of luminous flux emitted by a lamp to the power consumed by the lamp
b) one lumen per square meter
c) one lumen per square feet
d) none of the above

688 Which among the following is the most energy efficient lamp for the same wattage rating?

a) HPMV b) GLS c) CFL d) Metal halide

689 ———is a measure of effect of light on the perceived colour of objects

a) lux b) lumens c) CRI d) lamp circuit efficacy

690 Which of the following is the best definition of illuminance?

a) luminous flux incident on an object per unit area
b) flux density emitted from an object without regard for direction
c) time rate of flow of light energy
d) flux density emitted from an object in a given direction

691 Two most important electrical parameters, which are to be monitored, among the following for safe operation of Diesel Generator set are:

a) voltage and ampere b) kW and kVA
c) power factor and ampere d) kVA and ampere

692 In a DG set, the generator capacity is 1000 kVA with a rated power factor 0.8. It is consuming 150 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.25 litres/ kWh at that load, then what is the kVA loading of the set at 0.88 PF?

a) 682 kVA b) 800 kVA c) 750 kVA d) none of the above

693 The maximum unbalanced load between phases should not exceed____% of the capacity of the DG set

c) 10 b) 5 c) 1 d) none of the above

694 The capacity of largest motor that can be started in the given DG set is…… of kVA rating of DG set

a) 25% b) 50% c)75% d)100%

695 The jacket cooling water in a diesel engine flows at 12.9 m^3/hr with a range of 10^oC and accounts for 30% of the engine input energy. What will be the hourly Diesel consumption in kg with a calorific value of 10,000 kcal/kg

a) 43 b) 12.9 c) 17.3 d) none of the above

696 Select the incorrect statement:

a) harmonics occur as spikes at intervals which are multiples of the supply frequency
b) harmonics are not multiples of the fundamental frequency
c) induction motors are not the major sources of harmonics
d) transformers operating near saturation level create harmonics

697 If the speed of centrifugal fan is reduced to 80% of its rated speed then the power drawn will_____% of its rated power:

a) 80% b) 51.2 % c) 40 % d) 64 %

698 The order of movement of thermal energy in HVAC system is:

a) Indoor air - Condenser water - Chilled water - Cooling tower - Refrigerant
b) Chilled water - Indoor air - Refrigerant-Cooling tower - Condenser water
c) Indoor air - Chilled water - Refrigerant-Condenser water- Cooling tower
d) Indoor air - Chilled water – Refrigerant - Cooling tower - Condenser water

699 Which one of the following device will help to eliminate the hunting problems normally associated with capacitor switching?

a) Maximum Demand Controller b) Intelligent Power Factor Controller (IPFC)
c) Soft Starter d) Eddy Current Drives

700 The occupancy sensors in a lighting installation are best suited for

a) conference halls b) large production shops/hangars
c) entrances of offices/buildings d) street lighting

701 Which of the following is not a part of vapour compression refrigeration cycle:

a) compressor b) evaporator c) condenser d) absorber

702 Which of the following can be attributed to commercial loss in electrical distribution system

a) lengthy low voltage lines b) low load side power factor c) faulty consumer service meters d) undersize conductors

703 Which loss in a distribution transformer is dominating; if the transformer is loaded at 68% of its rated capacity

a) core loss b) copper loss c) hysteresis loss d) magnetic field loss

704 When evaporator temperature is reduced

a) refrigeration capacity increases b) refrigeration capacity decreases
c) specific power consumption remains same d) compressor will stop

705 What is the function of drift eliminators in cooling towers

a) maximize water and air contact b) capture water droplets escaping with air stream
c) enables entry of air to the cooling tower d) eliminates uneven distribution of water into the cooling tower

706 Trivector meter measures three vectors representing

a) active, reactive and maximum demand b) active, power factor and apparent power
c) active, harmonics and maximum demand d) active, reactive and apparent power

707 Time of the Day metering (TOD) is a way to

a) reduce the peak demand of the distribution company b) increase the revenue of the distribution company
c) increase the peak demand d) increase the maximum demand in a industry

708 The unit of specific humidity of air is:

a) grams moisture/kg of dry air b) moisture percentage in air
c) grams moisture/kg of air d) percentage

709 The purpose of inter-cooling in a multistage compressor is to

a) remove the moisture in the air b) reduce the work of compression
c) separate moisture and oil vapour d) none of the above

710 The percentage reduction in distribution loses when tail end power factor raised from 0.85 to 0.95 is

a) 10.1% b) 19.9% c)71% d)84%

711 The nomenclature T2,T5,T8 and T12 for fluorescent lamps are categorized based on

a) diameter of the tube b) length of the tube
c) both diameter and length of the tube d) power consumption

712 The inexpensive way to improving energy efficiency of a motor which operates consistently at below 40% of rated capacity is by__.

a) operating in star mode b) replacing with correct sized motor
c) operating in delta mode d) none

713 The indicator of cooling tower performance is best assessed by

a) wet bulb temperature b) dry bulb temperature c) range d) approach

714 The illuminance of a lamp at one meter distance is 10 Lm/m^2. What will be the corresponding value at
0.7 meter distance

a)14.28 b) 20.41 c) 10 d) none of these

715 The fan system resistance is predominately due to

a) more bends used in the duct b) more equipments in the system
c) volume of air handled d) density of air

716 The cooling tower size is_____ with the entering WBT when heat load, range and approach are constant.

a) directly proportional b) inversely proportional c) constant d) none of above

717 The components of two part tariff structure for HT & EHT category consumers are

a) one part for capacity(or demand) drawn and second part for actual energy drawn

b) one part for actual Power Factor and second part for actual energy drawn
c) one part for capacity(or demand) drawn and second part for actual reactive energy drawn
d) one part for actual apparent energy drawn and second part for actual reactive energy drawn

718 The adsorption material used in an adsorption air dryer for compressed air is

a) calcium chloride b) magnesium chloride c) activated alumina d) potassium chloride

719 The actual measured load of 1000 k VA transformer is 400 k VA. Find out the total transformer loss corresponding to this load if no load loss is 1500 Watts and full load Copper Loss is 12,000 Watts

a) 1920 watts b) 1500 watts c) 3420 watt d) 13500 watts

720 The percentage imbalance when line-line voltages are 415 V, 418 V and 408 V is

a) 1.047% b) 0.32% c) 1.44% d) none of the above

721 Star – delta starter of an induction motor

a) reduces voltage by inserting resistance in rotor circuit
b) reduces voltage by inserting resistance in stator circuit
c) reduces voltage through a transformer
d) reduces the supply voltage due to change in connection configuration

722 Slip power recovery system is applicable in case of

a) squirrel cage induction motor. b) wound rotor motor c) synchronous motor d) DC shunt motor

723 Rotating magnetic field is produced in a_____

a) single- phase induction motor b) three- phase induction motor
c) DC series motor d) all of the above

724 Power factor is highest in case of

a) sodium vapour lamps b) mercury vapour lamps c) fluorescent lamps d) incandescent lamps

725 Power factor Improvement will result in

a) reduction in active power b) reduction in active current
c) reduction in reactive power d) all the above

726 Motor efficiency will be improved by

a) reducing the slip b) increasing the slip
c) reducing the diameter of the motor d) decreasing the length of the motor

727 Lower power factor of a DG set demands

a) lower excitation currents b) no change in excitation currents
c) higher excitation currents c) none of the above

728 L / G ratio in cooling tower is the ratio of

a) length and girth b) length and gradient of temperature
c) water mass flow rate and air mass flow rate d) water volume flow rate and air volume flow rate

729 Installing larger diameter pipe in pumping system results in

a) increase in static head b) decrease in static head
c) increase in frictional head d) decrease in frictional head

730 Installation of Variable frequency drives (VFD) allows the motor to be operated with

a) constant current b) lower start-up current c) higher voltage d)none of the above

731 In a no load test of a poly-phase induction motor, the measured power by the wattmeter consists of:

a) core loss
b) copper loss
c) core loss, windage & friction loss
d) stator copper loss, iron loss, windage & friction loss

732 In a large compressed air system, about 70% to 80% of moisture in the compressed air is removed at the

a) air dryer b) after cooler c) air receiver d) inter cooler

733 Illuminance of a surface is expressed in

a) radians b) lux c) lumens d) LPD

734 If two identical pumps operate in series, then the combined shutoff head is

a) it does not affect head b) more than double c) doubled d) less than

735 If the speed of a reciprocating pump is reduced by 50 %, the head

a) is reduced by 50%
b) is reduced by 12.5%
c) remains same
d) none of the above

736 If the observed temperature in air receiver is higher than ambient air temperature the correction factor for free air delivery will be:

a) less than one b) greater than one c) equal to one d)equal to zero

737 If the COP of a vapour compression system is 3.5 and the motor draws power of 10.8 kW at 90% motor efficiency, the cooling effect of vapour compression system will be:

a) 34 kW b) 37.8 kW c) 0.36 kW d) none of the above

738 If EER of One Ton Split AC is 3.5, what is its power rating?

a) 1.0 k W b) 1.5 kW c) 0.8 kW d) None of the above

739 Humidification involves

a) reducing wet bulb temperature and specific humidity
b) reducing dry bulb temperature and specific humidity
c) increasing wet bulb temperature and decreasing specific humidity
d) reducing dry bulb temperature and increasing specific humidity

740 Higher COP can be achieved with___.

a) lower evaporator temperature and higher condenser temperature
b) higher evaporator temperature and Lower condenser temperature
c) higher evaporator temperature and higher condenser temperature
d) lower evaporator temperature and Lower condenser temperature

741 Friction losses in a pumping system is

a) inversely proportional to flow b) inversely proportional to cube of flow
c) proportional to square of flow d) inversely proportional square of flow

742 Flow control by damper operation in fan system will

a) increase energy consumption b) reduce energy consumption
c) reduce system resistance d) none of the above

743 Find the Total Harmonic Distortion (THD) for current for the following current readings. Current at 50 Hz fundamental frequency = 250 A, Third harmonic current = 50 A, fifth harmonic current = 35 A

a) 58 % b) 48 % c) 24% d) 34 %

744 Calculate the density of air at 11400 mmWC absolute pressure and 65^0C. (Molecular weight of air:
28.92 kg/kg mole and Gas constant:847.84 mmWC m^3/kg mole K)

a) 1.2 kg/m^3 b) 1.5 kg/m^3 c) 1.15 kg/m^3 d) none of the above

745 A spark ignition engine is used for firing which type of fuels:

a) high speed diesel b) light diesel oil c) natural gas d) furnace oil

746 A hotel building has four floors each of 1000 m^2 area. If the interior lighting power allowance for the hotel building is 43000W, the Lighting Power Density (LPD) is:

a) 10.75 b) 0.09 c) 43 d) data insufficient

747 A DG set consumes 70 litres per hour of diesel oil. If the specific fuel consumption of this DG set is
0.33 litres/ kWh at that load, then what is the kVA loading of the set at 0.8 PF?

a) 212 kVA b) 265 kVA c) 170 kVA d) none of the above

748 A company installed a 130 kVAr, 600 Volt capacitor but the power meter indicates that it is only operating at 119 kVAr. The reason out of the following could be

a) operating at low load b) high voltage c) low voltage d) low current

749 A 50 hp motor with a full load efficiency rating of 90 percent was metered and found to be operating at 25 kW. The percent motor load is

a) 75% b) 50% c) 60% d) 25%

750 A 22 kW, 415 kV, 45A, 0.8 PF, 1475 RPM, 4 pole 3 phase induction motor operating at 420 V, 40 A and 0.8 PF. What will be the rated efficiency

a) 85.0% b) 94.5% c) 89.9% d) 88.2%

751 Which of the following is the most comfortable conditions for an office room?
DBT = Dry bulb temperature, and RH = Relative humidity

a) 20°C DBT and 80% RH
b) 26°C DBT and 100% RH
c) 15°C DBT and 30% RH
d) 25°C DBT and 55% RH

752 Energy Star Label Rating scheme for Fluorescent lamp is based on:

a) Lumens per Watt at 100, 2000 and 3500 hours of use
b) End of Lamp Life in terms of burring hours
c) Lumen depreciation at 2000 hours
d) Color Rendering Index

753 The effect of increasing the air gap in an induction motor will increase:

a) power factor
b) speed
c) capacity
d) magnetizing current

754 The formation of frost on cooling coils in a refrigerator:

a) improves C.O.P. of the system
b) increases heat transfer
c) reduces power consumption
d) increases power consumption

755 In a refrigeration system, the expansion device is connected between the

a. Compressor and condenser
b. Condenser and receiver
c. Condenser and evaporator
d. Evaporator and compressor

756 Which of the following is wrong with respect to Color Rendering Index (CRI)?

a) The CRI is expressed in a relative scale ranging from 0 - 100
b) CRI indicates how perceived colors match actual colors
c) CRI of Sodium Vapour lamp is much higher than that of a normal Incandescent Lamp
d) The higher the color rendering index, the less color shift or distortion occurs

757 Which of the following is wrong with reference to heat rate of a coal fired thermal power plant
?

a) Heat rate indicates the overall energy efficiency of a power plant
b) When calculating plant heat rate, the energy input to the system is GCV of the fuel
c) Lower the heat rate the better
d) 860 kCal per kWh is practically achievable

758 Installing larger diameter pipe in pumping system results in reduction in:

a) Static head
b) Dynamic head
c) Both (a) and (b)
d) None of the above

759 In electrical power system, transmission efficiency increases as

a) both voltage and power factor increase
b) both voltage and power factor decrease
c) voltage increases but power factor decreases
d) voltage decreases but power factor increases.

760 Which of the following is wrong statement with reference to LED lamps?

a) LED lamps are as energy efficient as CFL bulbs or better.
b) LED lampas are more durable than CFLs
c) LED lamps has no hazardous material like mercury
d) LED lamps are not suitable for Street Lighting purpose

761 In no load test of a poly-phase induction motor, the measured power by the wattmeter consists of:

a) core loss
b) copper loss
c) core loss, windage & friction loss
d) stator copper loss, iron loss, windage & friction loss

762 A 10 MVA generator has power factor 0.86 lagging. The reactive power produced will be

a) 10 MVAr
b) 8 MVAr
c) 5 MVAr
d) 1.34 MVAr.

763 The no-load loss and copper loss of a 500 kVA transformer is 900 watts and 6400 watts respectively. What is the total loss at 50% of transformer loading?

a) 4100 watts
b) 6850 watts
c) 2500 watts
d) 3650 watts

764 Kg of moisture / kg of dry air is defined as
a) Absolute humidity
b) Relative humidity
c) Variable humidity
d) Dew Point

765 The basic function of an air dryer in a compressor is to

a) Prevent dust from entering the compressor
b) Remove moisture before the intercooler
c) Remove moisture in compressor suction
d) Remove moisture at the downstream of the after-cooler

766 The term “cooling range” in a cooling tower refers to the difference in the temperature of

a) dry bulb and wet bulb
b) hot water entering the tower and the wet bulb temperature of the surrounding air.
c) cold water leaving the tower and the wet bulb temperature of the surrounding air.
d) hot water entering the tower and the cooled water leaving the tower.

767 The distinction between fans and blowers is based on

a) impeller diameter
b) specific ratio
c) speed
d) volume delivered

768 A better indicator for cooling tower performance is

a) Heat load in tower
b) Range
c) RH of air leaving cooling tower
d) Approach

769 As per the building area method given in Energy Conservation Building Code (ECBC) compute the lighting power allowance; given that : the allowed LPD is 12 watt per square meter and enclosed office area is 500 square meter

a) 6 kW
b) 4.16 kW
c) 6 W
d)
4.16 W

770 The power factor of a synchronous motor

a) Improves with increase in excitation and may even become leading at high excitations
b) Decreases with increase in excitation
c) Is independent of its excitation

771 A 4 pole 50 Hz induction motor is running at 1470 rpm. What is the slip value?

a) 0.2
b) 0.02
c) 0.04
d) 0.4

772 As per Energy Conservation Building Code compute the Effective Aperture (EA); given that Window Wall Ratio (WWR) is 0.40 and Visible Light Transmittance(VLT) is 0.25

a) 0.10
b) 0.65
c) 0.33
d) 0.15

773 Increasing the impeller diameter in a pump

a. Increases the flow
b. decreases the head
c. decreases the power
d. all of the above

774 The percentage reduction in distribution loses when tail end power factor is raised from 0.8 to
0.95 is:

a) 29% b) 15.8% c) 71% d) 84%

775 In a Three Phase Transformer, the secondary side line current is 139.1A, and secondary voltage is 415V. The rating of the transformer would be___.

a. 50 kVA
b. 150 kVA
c. 100 kVA
d. 63 kVA

776 Power factor is highest in case of

a. Sodium vapour lamps
b. Mercury vapour lamps
c. Tube Lights
d. Incandescent lamps

777 Shunt capacitors connection is normally adopted for:

a. Distribution Voltage improvement.
b. Power factor improvement.
c. Both a and b.
d. None of these

778 A company installed a new 100 kVAr, 415Volt capacitor but the power analyzer indicates that it is operating at 93 kVAr. The reason could be

a. Operation is at low load
b. Higher Voltage at terminals
c. Lower voltage at terminals
d. None of the above

779 The kVA reduction by improving the power factor of a plant operating at 400 kW load from 1.85 to 0.95 is

a) 40 b) 49 c) 72 d) None of the above

780 For a supply end Voltage of 10.6 kV and receiving end Voltage of 9.8 kV, the percentage regulation works out to:

a) 0.80 b) 8.16 c) 7.55 d) None of these.

781 Which of the following can be attributed to Commercial Loss in Electrical Distribution System?

a) Lengthy Low Voltage Lines b) Low Load side power factor
c) Faulty consumer service meters d) Undersized conductors

782 An Induction motor rated 15 kW and 90 % efficiency, at full load will:

a) Draw 15 kW b) Draw 13.5 kW c) Deliver 16.66 kW d) Deliver 15 kW

783 A 50 hp motor with a full load efficiency of 90 percent was found to be operating at 25 kW input. The percent Motor Load is

a) 75% b) 67% c) 60% d) 25%

784 A DG set has a 300 HP engine drive and is connected to a 300 kVA alternator with 95% efficiency. When a plant load of 290 amps at 415 Volts and 0.76 power factor is connected, the engine loading works out to

a) 52% b) 74.51% c) 55.4 % d) None of the above

785 Which of the following devices do not produce any harmonics?

a. Electric Motors
b. Filament Lamp
c. Switch Mode power supply of laptops
d. Electromagnetic ballasts

786 At which of the following discharge pressures, the same reciprocating air compressor will consume maximum power

a) 3 bar b) 5 kgf/cm^2 c) 90 psi d) 500 kPa

787 In a DG set, the generator is consuming 70 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.33litres/ kWh at that load, what is the kVA loading of the set at 0.8 PF?

a) 212 kVA b) 262.5 kVA c) 170 kVA d) None of these.

788 If EER of One Ton Split AC unit is 3.51, what is its power rating?

a) 1.0 kW

b) 1.5 kW
c) 0.8 kW
d) 2.0 kW

789 As per the Inverse Square Law of illumination what will be the illuminance at half the distance?

a) 50% b) 4 times c) double d)No change

790 Find the air density at 35^{o}C temperature at one atmospheric pressure. It is given that at one atmospheric pressure the air density at 20 ^{o}C is 1.2041 kg/m^{3}

a) 1.1455 b) 1.2657 c) 1.2024 d) none of the above

791 A spark ignition engine is used for firing which type of fuels:

a) high speed diesel
b) light diesel oil
c) natural gas
d) furnace oil

792 The blow down requirement in m^{3}/hr of a cooling tower with evaporation rate of 16 m^{3}/hr and CoC of 3 is

a) 4 b) 2 c) 8 d) 16

793 Which Loss in a Distribution Transformer is predominant if the transformer is loaded to75% of its rated capacity?

a) core loss
b) copper loss
c) hysteresis loss
d) magnetic field loss

794 Which of the following power plants has the highest efficiency

a. Combined cycle gas turbine

b. Diesel Engine

c. Conventional coal plants

d. Open cycle Gas Turbine

795 The voltage unbalance in three phase supply is 1.5 %. If the motor is operating at 100 ^{o}C, the additional temperature rise in ^{o}C due to voltage unbalance is

a. 4.5 b. 9 c. 0 d none of the above

796 Which of the following cannot be controlled by automatic power factor controllers

a) KW b) voltage c) Power factor d) KiloVAr

797 The parameter used in Star labeling of air conditioner is

a. COP b. EER c. KW/TR d. EPI

798 The refrigeration load in TR when 30 m^3/hr of water is cooled from a 14 ^{o} C to 6.5 ^{o} C is about

a) 74.4 b) 64.5 c) 261.6 d) none of the above

799 In a lithium bromide absorption refrigeration system

a. lithium bromide is used as a refrigerant and water as an absorbent

b. water is used as a refrigerant and lithium bromide as an absorbent

c. ammonia is used as a refrigerant and lithium bromide as an absorbent

d. none of these

800 A good DG set waste heat recovery device manufacturer will take precautions to prevent which of the following problem while DG set is in operation

a) voltage unbalance on generator

b) Excessive back pressure on engine

c) excessive steam generation

d) turbulence in exhaust gases

801 An Industrial Consumer has a load pattern of 2000 kW, 0.8 lag for 12 hrs and 1000 kW unity power factor for 12 hrs. The load factor is:

a) 0.5

b) 0.75

802 Which of the following is not likely to create harmonics in an electrical system?

a) soft starters

b) variable frequency drives

c) uninterrupted power supply source (UPS)

d) induction motors

803 Which of the following is an example of variable torque equipment ?

a) centrifugal pump

b) reciprocating compressor

c) screw compressor

d) roots blower

804 A 10 HP/7.5 kW, 415 V, 14.5 A, 1460 RPM, 3 phase rated induction motor, after decoupling from the driven equipment, was found to be drawing 3 A at no load. The current drawn by the motor at no load is high because of

a) faulty ammeter reading

b) very high supply frequency

c) loose motor terminal connections

d) <u>poor power factor as the load is almost reactive</u>

805 A 500 cfm reciprocating compressor has a loading and unloading period of 5 seconds and 20 seconds respectively during a compressed air leakage test. The air leakage in the compressed air system would be

a) 125 cfm b) 100 cfm c) 200 cfm d) none of the above

806 The percentage reduction in distribution losses when tail end power factor is raised from 0.8 to 0.95 is_____.

a) 29%

b) 15.8%

c) 71%

807 The correction factor for actual free air discharge in a compressor capacity test will be ---------, when the compressed air discharge temperature is 15 ^{0}C higher than ambient air of 40 ^{0}C.

a) 0.727 b) 0.920 <u>c) 0.954</u> d) none of the above

808 If we increase the temperature of air without changing specific humidity, dew point temperature of air will

a) increase b) decrease

c) remain constant d) can"t say

809 Which of the following happens to air when it is cooled through evaporation process in an air washer?

a) Humidity ratio of the air decreases.

b) Dry Bulb Temp of air decreases.

c) Dry Bulb Temp of air increases.

810 In a vapor compression refrigeration system, the component where the refrigerant changes its phase from vapor to liquid is

a) compressor b) condenser c) expansion valve d) evaporator

811 In a vapor compression refrigeration system, the component across which the enthalpy remains constant

a) compressor b) condenser c) expansion valve d) evaporator

812 If 30,000 kcal of heat is removed from a room every hour then the refrigeration tonnage will be nearly equal to

a) 30 TR b) 15 TR c) 10 TR d) 100 TR

813 In a no load test of a 3-phase induction motor, the measured power by the wattmeter consists of:

a) core loss

b) copper loss

c) core loss, windage & friction loss

814 In an engine room 15 m long, 10 m wide and 4 m high, ventilation requirement in m^3/hr for 20 air changes/hr is:

a) 30 b) 3000 c) 12000 d) none of the above

815 Which among the following is one of the parameters used to classify fans, blowers & compressors ?

a) air flow b) speed RPM c) specific ratio d) none of the above

816 The inner tube of a L-type Pitot tube facing the flow ~~is~~ measures_____in the fan system

a) static pressure b) velocity pressure

c) total pressure d) all of the above

817 A pump discharge has to be reduced from 120 m^3/hr to 100 m^3/hr by trimming the impeller. What should be the percentage reduction in impeller size?

a) 83.3% b) 16.7% c) 50.0% d) 33.3%

818 Increasing the suction pipe diameter in a pumping system will

a) reduce NPSHa
b) increase NPSHa
c) decrease NPSHr
d) increase NPSHr

819 If the speed of a reciprocating pump is reduced by 50 %, the head

a) is reduced by 25%
b) is reduced by 50%
c) is reduced by 75%
d) remains same

820 If temperature of air increases, the amount of water vapor required for complete saturation will

a) Increase
b) Decrease
c) not change
d) Can‟t say

821 Which of the following is false
?. Air receivers _____

a) reduce frequent on/off operation of compressors.
b) knock out some oil and moisture
c) increase compressor efficiency
d) act as reservoir to- take care of sudden demands

822 Which among the following inlet air conditions would result in the best cooling tower performance?

a) air with lowest wet bulb temperature and high relative humidity

b) air with lowest wet bulb temperature and low relative humidity

c) air with same dry bulb and wet bulb temperature

823 As the „approach" increases while other parameters remain constant, the effectiveness of a cooling tower:

a) increases

b) remains unchanged

c) decreases

d) none of the above

824 What is the reduction in distribution loss if the current flowing through the distribution line is reduced by 10%?

a)10% b) 81% c) 19% d) None of the above

825 Which among the following types of fans is predominantly used in cooling towers ?

a) centrifugal fan b) axial fan c) radial fan d) all the above

826 Which of the following type of lamps is most suitable for color critical applications ?

a) halogen lamps b) LED lamps

c) CFLs d) metal halide lamps

827 Which of the following factors does not affect waste heat recovery in a DG Set ?

a) DG Set loading in kW

b) DG Set reactive power loading

c) operation period of DG Set

d) back pressure of flue gas path

828 The blow down requirement in m^3/hr of a cooling tower for site Cycle of Concentration of 2.5 and approach of 4^oC is:

a) 10

b) 0.63

c) 1.6

829 Which of the following is not a climate zone as per ECBC classification?

a) Hot - dry b) Warm - humid c) Cold d) Cold humid

830 COP of a single effect absorption refrigeration system is likely to be in the range of

831 Which of the following statements is not true regarding centrifugal pumps?

a) Flow is zero at shut off head

b) Maximum efficiency will be at design rated flow of the pump

c) Head decreases with increase in flow

832 Which of the following is not true regarding system characteristic curve in a pumping system with large dynamic head ?

a) System curve represents a relationship between discharge and head loss in a system of pipes

b) System curve is dependent on the pump characteristic curve

c) The basic shape of system curve is parabolic

d) System curve will start at zero flow and zero head if there is no static lift

833 In a DG set, the generator is generating 1000 kVA, at 0.7 PF. If the specific fuel consumption of this DG set is 0.25 lts/ kWh at that load, then how much fuel is consumed while delivering generated power for one hour.

a) 230 litre

b) 250 litre

c) 175 litre

834 The T2,T5,T8 and T12 fluorescent tube light are categorized based on

a) diameter of the tube

b) length of the tube

c) both diameter and length of the tube

d) power consumption

835 For an air compressor with displacement of 100 CFM and system leakage of 10%, free air delivery is_____.

a) 111.11 CFM

b) 90 CFM

c) 100 CFM

836 The source of maximum harmonics among the following, in a plant power system is

a) 100 CFL lamps of 11 W to 25 W

b) 500 kW, 3 Phase, 415 V, 50 Hz resistance furnace

c) 5 kVA UPS for computer system

837 The lamp based on high frequency electromagnetic field from outside, exciting the mercury gas sealed in the bulb, to produce UV radiation and light is

a) Induction lamp

b) Fluorescent lamp

c) Mercury vapour lamp

838 The combined power factor of a set of incandescent bulbs totaling 20 kW and two motors, each of 20 kW with power factor of 0.80 is

a) 0.88 b) 0.90 c) 0.80 d) none of the above

839 State which of the following statements is true?

a) for a given fan operating at a constant temperature, the power input to fan increases by 4 times when the fan speed becomes double

b) for a given fan operating at a constant temperature, the power input to fan increases by 8 times when the fan speed becomes double

c) for a given fan operating at a constant flow rate, the power input increases as the air temperature increases

840 One tonne of refrigeration has the ability to remove_____kcal of heat in a 24-hour period.

a) 50 kcal b) 3024 kcal c) 72576 kcal d) 12000 kcal

841 In pumping systems where static head is a high proportion of the total, the appropriate solution is

a) install two or more pumps to operate in parallel

b) install two or more pumps to operate in series

c) install two or more pumps to operate independently

842 The daily average power factor is 0.95 and the energy consumption is 2200 kWh. The average kVARh drawn is _____

e) a) 1900 b) 2315 c) 722.5 d) None of the above

843 HVDS (High Voltage Distribution System) is preferred to

a) reduce technical loss in distribution system

844 When evaporator temperature is increased

a) refrigeration capacity decreases

b) refrigeration capacity increases

c) specific power consumption remains same

d) power consumption increases

845 Improving power factor at motor terminals in a factory will

a) increase active power

b) release distribution transformer capacity

c) reduce contract demand

846 If the COP of a vapour compression system is 3.5 and the motor draws a power of 10.8 kW at 90% motor efficiency, the cooling effect of vapour compression system will be

d) a) 34 kW b) 37.8 kW c) 0.36 kW d) none of the above

847 A parameter that indicates adequacy of lighting for a particular application is

a) installed load efficacy

b) installed power density

c) lux d) lumens

848 Which of the following is not an example of lighting controls?

a) dimmers

b) timers

c) photosensors

d) daylight harvesting

849 Which of the following flow controls in a fan system will change the system resistance curve:

a) Inlet guide vane

b) speed change with variable frequency drive

c) speed change with hydraulic coupling

d) discharge damper

850 When the dew point temperature is equal to the air temperature then the relative humidity is

a) 0%

b) 50%

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Short Answer Questions

Each question carries **Five** marks

1 Calculate the transformer total losses for an average loading of 60%. Assume no load and full load losses as 3 kW and 25 kW respectively

2 What is synchronous speed of an induction motor?

3 How does power factor of an induction motor reduce with the reduction of the applied load on the motor? Draw a curve depicting power factor vs percentage loading on the motor.

4 What are the parameters required to be measured while estimating the chiller performance in kW/TR?

5 A fan is operating at 900 RPM developing a flow of 3000 Nm3/hr. at a static pressure of 600 mmWC. What will be the flow and static pressure if the speed is reduced to 600 RPM.

6 What are the various methods of flow control in centrifugal pumps?

7 In a cooling tower, the Cycle of Concentration (C.O.C.) is 3 and evaporation losses are 1%. The circulation rate is 1200 m^3 /min. Find out the blow down quantity required for maintaining the desired level of dissolved solids in the cooling water.

8 Whether it is advisable to install a servo transformer for controlling the operating voltage of the lighting circuit? Justify your answer.

9 A 5 MW DG set with an average load of 3 MW running in parallel with the grid was found to be exporting 100 kVAr. Without calculating, explain what could be the possible reasons for the export of reactive power to the grid. List advantages/disadvantages of the above situation.

10 How are energy savings achieved through electronic ballast in a fluorescent tube light in comparison to the conventional magnetic ballast?

11 A maximum demand recorder for a plant will record the following loads over a period of 30 minutes. Compute the MD as the recorder would do

- 800 kVA for 5 minutes
- 200 kVA for 5 minutes
- 400 kVA for 10 minutes
- 800 kVA for 8 minutes
- 1500 kVA for 2 minutes

12 How does the power factor of a motor reduce with the reduction in the applied load on the motor?

13 Briefly explain about the importance of maintaining optimal pressure settings of a compressed air system

14 Chilled water enters evaporator at 11^0C and leaves at 8^0C. The flow rate of chilled water was measured as 350 m^3/hr. Calculate the tons of refrigeration capacity.

15 A fan is delivering 10,000 Nm^3/hr of air at static pressure rise of 60 mm WC. If the fan static efficiency is 70%, find out the shaft power of the fan.

16 What do you mean by the term cavitation and describe its undesirable effects on the pumping system.

17 How size of cooling tower and wet bulb temperature are related? What Cooling Tower approach value is normally used by Cooling Tower manufacturers.

18 Highlight advantages of CFL (compact fluorescent lamp) over GLS lamp

19 What is the impact of unbalanced loading on DG set?

20 Briefly describe the principle of variable frequency drives used along with squirrel cage induction motors.

21 Compute the maximum demand recorded for a plant where the recorded load is as mentioned below in the recording cycle of 30 minutes.

- 100 kVA for 10 minutes
- 200 kVA for 5 minutes
- 50 kVA for 10 minutes
-150 kVA for 5 minutes

22 Why is it beneficial to operate motors in star mode for induction motors loaded less than 50%?

23 In an engineering industry, while conducting a leakage test in the compressed air system, following data for a reciprocating air compressor was recorded:

Compressor capacity = 35 m^3 per minute
Average load time = 90 seconds
Average unload time = 360 seconds
Find out the leakage quantity in m^3 per day (assume 20 hours per day of operation)

24 What is the main difference between vapor compression refrigeration (VCR) and Vapour Absorption Refrigeration (VAR) system?

25 How the heat is absorbed, or removed from a low temperature source and transferred to a high temperature source in a vapour compression system ?

26 Find out the blow down rate from the following data. Cooling Water Flow Rate is 500 m^3/hr. The operating range is 8°C. The TDS concentration in circulating water is 1800 ppm and TDS in make up water is 300 ppm

27 What is the role of an electronic ballast in a fluorescent tube light ?

28 Explain how stator and rotor I^2R losses are reduced in an energy efficient motor.

29 A centrifugal pump is pumping 70 m^3/hr of water with a discharge head of 5 kg/cm^2 g and a negative suction head of 3 metres. If the power drawn by the motor is 16 kW, find out the pump efficiency. Assume motor efficiency as 90% and water density as 1000 kg/m^3.

30 A genset is operating at 800 kW loading with 480°C exhaust gas temperature. The DG set generates 8 kg gas/ kWh generated, and specific heat of gas at 0.25 kCal/ kg °C. A heat recovery boiler is installed after which the exhaust gas temperature reduces to 180 °C. How much steam will be generated at 3 kg/ cm^2 with enthalpy of 650.57 kCal/ kg. Assume boiler feed water temperature as 80°C.

31 Calculate the transformer total losses for a 100 kVA transformer for an average loading of 40%. Assume no load and full load losses as 1.70 kW and 10.50 kW respectively.

32 Fill in the blanks

a) Slip ring induction motors are normally___ efficient than squirrel cage induction motors

b) Low speed Squirrel cage induction motors are normally _____efficient than high speed Squirrel cage induction motors

c) The capacitor requirement for PF improvement at induction motor terminal _____ with decrease in rated speed of the induction motor

d) Induction motor efficiency _____ with increase in its rated capacity

e) Totally-enclosed, fan cooled (TEFC) motors are _____efficient than Screen –protected, drip-proof (SPDP) induction motors

33 Calculate the free air delivery (FAD) capacity of a compressor in m^3/hr for the following observed data:

Receiver capacity:	0.3 m^3
Initial pressure (with empty receiver):	0 kg/cm^2 (g)
Final pressure:	7 kg/cm^2 (g)
Initial air temperature:	35ºC
Final air temperature:	50 ºC
Additional holdup volume:	0.05 m^3
Compressor pump up time:	4.1 minutes
Atmospheric pressure:	1.026 kg/sq. cm absolute

34 The COP of a vapour compression refrigeration system is 3.0. If the compressor motor draws power of 10.5 kW at 91% motor efficiency, find out the tonnage of the refrigeration system.

35 Estimate the cooling tower capacity (TR) and approach with the following parameters

Water flow rate through CT	= 130 m^3/hr
Specific heat of water	= 1 kcal/kg °C
Inlet water temperature	= 42 °C
Outlet water temperature	= 37 °C
Ambient WBT	= 31 °C

36 How do you calculate the velocity of air/gas in a duct using the average differential pressure and density of the air/gas?

37 Briefly explain the benefit of installing servo stabilizer for lighting feeder

38 A 180 kVA, 0.80 PF rated DG set has diesel engine rating of 220 BHP. What is the maximum power factor which can be maintained at full load on the alternator without overloading the DG set? (Assume alternator losses and exciter power requirement as 5.60 kW and there is no derating of DG set)

39 A pump is delivering 50 m^3/hr of water with a discharge pressure of 35 metre. The water is drawn from a sump where water level is 5 metre below the pump centerline. The power drawn by the motor is 9.5 kW at 91% motor efficiency. Find out the pump efficiency.

40 What are the technical aspects of energy efficient motors with respect to insulation life, slip and starting torque?

41 For any electrical distribution system, list any 5 options for distribution loss optimization

42 Draw a typical curve for efficiency and power factor Vs load for a 3-phase induction motor between 0% and 100% (Note: Explanation not required)

43 A 7.5kW, 3 phase, 415 V induction motor draws 10.5 A and 5 kW input power at 410 V . What is the Apparent and Reactive Power drawn by the motor at the operating load?

44 In an air-handling unit (AHU), the actual airflow rate is 10350 m^3/h and the inlet air has 16 kcal/kg of enthalpy. At the outlet of AHU, air has enthalpy of 13.45 kcal/kg. The density of air of 1.15 kg/ m^3. Estimate the TR of the air-handling unit?

45 Define Range, approach and effectiveness in cooling tower operation

46 A process fluid at 40m^3/hr, with a density of 0.95, is flowing in a heat exchanger and is to be cooled from 35°C to 29°C. The fluid specific heat is 0.78 kCal/kg. Find out the chilled water flow rate if the chilled water range across the heat exchanger is 4°C.

47 List any 5 energy conservation opportunity in air conditioning system

48 A DG set is operating at 750 kW loading with 440°C exhaust gas temperature. The DG set generates 8 kg gas/ kWh generated, and specific heat of gas at 0.25 kCal/ kg °C. A heat recovery boiler is installed after which the exhaust gas temperature reduces to 190°C. How much steam will be generated at 3 kg/ cm^2 with enthalpy of 650.57 kCal/ kg. Assume boiler feed water temperature as 70°C.

49 An engineering industry which was operating with a maximum demand of 1000 kVA at 0.9 power factor brought down its demand to 900 kVA by power factor improvement. Find out the percentage reduction in distribution losses within the plant

50 A cast iron foundry has a load of 450 kVA. It has installed two transformers of 500 kVA each. The no load loss and full load copper loss are 760 W and 5400 W respectively. From the energy efficiency point of view the foundry management wants to take a decision on whether to operate a single transformer on full load or two transformers equally sharing the load. What is your recommendation? Why?

51 A no load test conducted on a three phase delta connected induction motor gave the following values:

No load power = 993 W
Stator resistance per phase at 30°C = 0.246 Ohms
No load current = 14.7 A

Calculate the fixed losses for the motor.

52 A 22 kW rated motor driving a lube oil pump is drawing a constant power of 19 kW at 90% efficiency. If the motor is replaced with an energy efficient motor which operates at 93 % efficiency, find out the

annual energy savings at 8000 hours of operation/year. If the investment is Rs. 30,000/- find out the payback period at Rs.4/kWh energy charges.

53 Air at 25,200 m^3/hr and at 1.2 kg/m^3 density is flowing into an air handling unit of an inspection room. The enthalpy difference between the inlet and outlet air is 10 kJ/kg. If the motor draw a power of 25 kW at an efficiency of 90%, find out the kW/TR of the refrigeration system. (1 J = 4.18 Cal.)

54 Air flow measurements using the pitot tube, in the primary air fan of a coal fired boiler gave the following data

Air temperature	= 30°C
Velocity pressure	= 44 mmWC
Pitot tube constant, Cp	= 0.9
Air density at 0°C (standard data)	= 1.293 kg /m^3

Find out the velocity of air in m/sec

55 In a cooling tower, the cooling water circulation rate is 1200 m^3/hr. The operating range is 8°C. If the blowdown rate of the cooling tower is 1 % of the circulation rate, calculate the evaporation loss and COC

56 A system has a static head of 45 meters and friction head of 10 meters. The pump is operating at 1440 RPM. For reducing the flow, the pump speed is reduced to 1100 RPM. What is likely to happen as a result of this ?

57 The hot water temperature entering the cooling tower is 38°C. If the wet bulb temperature is 26 °C and the range is twice the approach, find out the cold water temperature and effectiveness of the cooling tower.

58 A jockey pump of a fire hydrant system is analysed for efficiency and following data is collected:

59 List any five problems that can arise due to harmonics in a system.

60 Why does the power factor of a induction motor decreases with the decrease in the applied load on the motor?

61 A water pump is delivering 300 m^3/hr flow at 40 meter head at ambient conditions. The pump shaft power is 52kW. The impeller diameter is trimmed by 8%. Find out the new water flow, head and pump shaft power at the changed condition

62 If inlet and outlet water temperatures of a cooling tower are 42°C and 36°C respectively and atmospheric DBT and WBT are 39 °C and 32 °C respectively, find out the range, approach and the effectiveness of cooling tower.

63 Draw a sketch of a typical centrifugal fan characteristic curve along with system resistance. (Note: No explanation is required)

64 The COP of a vapour compression refrigeration system is 3.0. If the compressor motor draws power of 15 kW at 90% motor efficiency, find out the tonnage of the refrigeration system.

65 List any 5 energy conservation opportunity in an air compression system

66 A Reciprocating Compressor with 220 CFM capacity is connected with a 75 HP motor. The energy manager of the plant noticed frequent unloading and loading of compressor .In your opinion, what reasons he may conclude for this situation and accordingly propose the remedial actions.

67 Briefly explain transformer losses and how the total transformer losses at any load level can be computed.

68 The power input to a three phase induction motor is 45 kW. If the induction motor is operating at a slip of 2% and with total stator losses of 1.80 kW, find the total mechanical power developed.

69 List any five energy conservation opportunities in pumping system.

70 Name any five methods of capacity controls for fans (Note: no explanation is required)

71 A genset is operating at 700 kW loading with 450OC exhaust gas temperature: The DG set generates 8 kg gas/ kWh generated, and specific heat of gas at 0.25 kCal/ kg OC. A heat recovery boiler is installed after which the exhaust temperature drops by 260oC. How much steam will be generated at 3 kg/ cm2 with enthalpy of 650.57 kCal/ kg. Assume boiler feed water temperature as 60oC

72 An energy audit of a fan was carried out. It was observed that fan was delivering 15,000 Nm3/hr of air at static pressure rise of 60 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 1.92 kW/ phase on an average. The motor operating efficiency was assessed as 0.88 from the motor performance curves. What would be the fan static efficiency ?.

73 Discuss in brief any three methods by which energy can be saved in an air conditioning system.

74 a) A 10 kVAr, 415 V rated power factor capacitor was found to be having terminal supply voltage of 440 V. Calculate the capacity of the power factor capacitor at the operating supply voltage.

b) What would be the nearest kVAr compensation required for changing the power factor of a 500 kW load from 0.9 lead to unity power factor ?

75 Fill in the blanks

a) Heat Rate of a thermal power plant is expressed in _____
b) With increase in design speed of induction motors ,the required capacitive kVAr for reactive power compensation for the same capacity range will ____
c) An air dryer in a compressed air system reduces _____ point of air.
d) A Pitot tube measures the difference between _____and_____ pressures of the fluid
e) The friction loss in a pipe carrying a fluid is proportional to the_____power of pipe diameter

76 A pump is delivering 40 m^3/hr of water with a discharge pressure of 29 metre. The water is drawn from a sump where water level is 6 metre below the pump centerline. The power drawn by the motor is 7.5 kW at 89% motor efficiency. Find out the pump efficiency.

77 Define one 'Ton of Refrigeration (TR)'. How do you calculate TR across the Air Handling Units?

78 Estimate the cooling tower capacity (TR) and approach with the following parameters

Water flow rate through CT	= 120 m^3/hr
Specific heat of water	= 1 kCal/kg °C
Inlet water temperature	= 42 °C
Outlet water temperature	= 36 °C
Ambient WBT	= 32 °C

79 A fan is delivering 20,000 Nm^3/hr. of air at static pressure difference of 70 mm WC. If the fan static efficiency is 55%, find out the shaft power of the fan.

80 a) Briefly explain the difference between a 'filament lamp' and a 'gas discharge lamp'?

b) State any 3 best practices in a lighting system for energy savings?

81 Calculate the free air delivery (FAD) capacity of a compressor in m^3/min for the following observed data:

Receiver capacity:	0.5 m^3
Initial pressure (with empty receiver):	0 kg/cm^2 (g)
Final pressure:	7 kg/cm^2 (g)
Initial air temperature:	32°C
Final air temperature:	51 °C
Additional holdup volume:	0.03 m^3
Compressor pump up time:	4.5 minutes
Atmospheric pressure:	1.026 kg/ cm^2 absolute

82 Fill in the blanks

a) If the reactive power drawn by a particular load is zero, it means the load is operating at__ power factor

b) Power factor is the ratio of_____

c) As the 'approach' increases while other parameters remaining constant, the effectiveness of a cooling tower_____

d) Lower power factor of a DG set demands_____excitation currents

e) If voltage applied to a 415 V rated capacitors drops by 5 %, its VAr output drops by about_____%

83 A 7.5 kW, 415 V, 2 pole, 50 Hz, 3 Phase squirrel cage induction motor has a full load efficiency of 90% and power factor of 0.88. Find the following if the motor operates at full load rated values.

a) input power in kW
b) current drawn by the motor
c) RPM at a full load slip of 1%

84 In an air-handling unit (AHU), the actual airflow rate is 9300 m^3/hr and the inlet air has 16.12 kCal/kg of enthalpy. At the outlet of AHU, air has enthalpy of 13.33 kCal/kg. The density of air is 1.15 kg/m^3. Estimate the TR of the air-handling unit?

85 A centrifugal pump is pumping 90 m^3/hr of water with a discharge pressure of 3 kg/cm^2 (g) and a negative suction head of 3 m. If the power drawn by the motor is 13 kW, find out the pump efficiency. Assume motor efficiency as 91% and water density as 1000 kg/m^3.

86 Find out the blow down rate of a cooling tower from the following data:

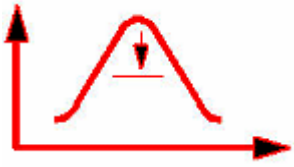
Cooling water flow rate is 600 m^3/hr. The operating range is 8 ^oC. The TDS concentration in circulating water is 1500 ppm and TDS in make up water is 300 ppm.

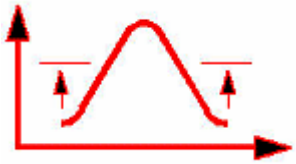
87 In a throttle valve-controlled pumping system with oversized pump, list any five best methods to improve energy efficiency? (Note: Name only methods, no explanation required)

88 Compute AT & C (Aggregate Technical and Commercial) losses for the following data:

Description	Annual Data
Input energy = (import - export), MU	10
Energy billed (metered), MU	6
Energy billed (Un-metered), MU	1
Amount billed (Rs. lakhs)	400
Gross amount collected (Rs. lakhs)	410
Arrears collected (Rs. lakhs)	40

89 Match the following load-shape objectives of any Demand Side Management (DSM) programme of a utility.

i	Peak Clipping	a	
ii	Valley filling	b	
iii	Load shifting	c	

iv	Conservation	d	
v	Load building	e	

90 The power input to a three phase induction motor is 52 kW. If the induction motor is operating at a slip of 1.9% and with total stator losses of 1.30 kW, find the total mechanical power developed.

91 In a Commercial building, five window ACs each of 1.5 TR capacity, were evaluated for replacement with three star labeled new ACs having Energy Efficiency Ratio (EER) of 2.50 kW/kW. The measured EER of existing ACs is as follows.

	Existing EER
AC No 1	2.05
AC No 2	2.19
AC No 3	2.30
AC No 4	2.40
AC No 5	2.17

Calculate the total kW saving potential if all the existing ACs are replaced with 3 star labeled ACs of same capacity?

92 The following data of a water pump of a process plant have been collected

Flow: 70 m^3/hr, Total head: 24 meters, Power drawn by motor– 7.2 kW, Motor efficiency – 89%. Determine the pump efficiency

93 Write any 5 industrial applications of a heat pump.

94 An induced draft-cooling tower is designed for a range of 8 °C. The energy auditor finds the operating range as 2 °C during the conduct of energy audit. In your opinion what could be the reasons for this situation

95 Briefly explain transformer losses and how the total transformer losses at any load level can be computed.

96 A 15 kW, 3 phase, 415 V induction motor draws 25 A and 12 kW input power at 410 V. Calculate the Apparent and Reactive Power drawn by the motor at the operating load?

97 A water pump of a process plant is analysed for efficiency and following data is collected:

Flow - 50 m^3/hr, Suction head -3 meters, Discharge head - 27 meter, meters, Power drawn by motor – 7.5 kW, Motor efficiency – 88%

Determine the pump efficiency

98 Distinguish between NPSH available and NPSH required in case of a centrifugal pump ?

99 A DG set is operating at 600 kW load with 450^{O}C exhaust gas temperature. The DG set generates 8 kg of exhaust gas/ kWh generated. The specific heat of gas at 450^{o}C is 0.25 kCal/ kg^{O}C. A heat recovery boiler is installed after which the exhaust temperature drops to 230^{O}C. How much steam will be generated at 3 kg/ cm^2 with enthalpy of 650.57 kCal/ kg. Assume boiler feed water temperature as 80^{o}C.

100 An energy audit of a fan was carried out. It was observed that the fan was delivering 16,000 Nm^3/hr of air with static pressure rise of 55 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 2.1 kW/ phase on an average. The motor operating efficiency was assessed as 86% from the motor performance curves. What would be the fan static efficiency?.

101 Discuss in brief any three methods by which energy can be saved in a building air conditioning system

102 A pump is delivering 64 m^3/hr of water with a discharge head of 26 metres. The water is drawn from a sump where water level is 3 metres below the pump centerline. The power drawn by the motor is 8.89 kW at 88% motor efficiency. Find out the pump efficiency

103 How do the Time-Of-Day (TOD) metering and billing benefit the utilities as well as consumers?

104 Explain briefly the difference between static and dynamic head of a centrifugal pumping system.

105 A DG set is operating at 700 kW load with 450^{O}C exhaust gas temperature. The DG set generates 7.8 kg of exhaust gas/ kWh generated. The specific heat of gas at 430^{o}C is 0.25 kCal/ kg^{O}C. A heat recovery boiler is installed after which the exhaust temperature drops to 220^{O}C. How much steam will be generated at 3 kg/ cm^2 with enthalpy of 650.57 kcal/ kg. Assume boiler feed water temperature as 65^{o}C.

106 An energy audit of a fan was carried out. It was observed that the fan was delivering 18,500Nm^3/hr of air with static pressure rise of 45 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 2.9 kW/ phase on an average. The motor operating efficiency was assessed as 88% from the motor performance curves. What would be the fan static efficiency?

107 Compute AT & C (Aggregate Technical and Commercial) Losses for the following data:

S. No.	Description	Annual Data
1	Input Energy = (Import-Export), MU	11
2a	Energy Billed (Metered), MU	7
2b	Energy Billed (Un-Metered), MU	1
2c	Total Energy Billed	8
3	Amount Billed (Rs. lakhs)	450
4a	Gross Amount Collected (Rs. lakhs)	460
4b	Arrears Collected (Rs. lakhs)	40

108 List down any 5 energy conservation opportunities in compressed air system

109 A 15 kW, 415 V, 4 pole, 50 Hz, 3 Phase squirrel cage induction motor has a full load efficiency of 92% and power factor of 0.89. Find the following if the motor operates at full load rated values.

a) input power in kW
b) current drawn by the motor
c) RPM at a full load slip of 0.8%

110 Harmonic measurements in an electrical system of an industry gave the following results.

Current at 50 Hz : 300 A Current

at 150 Hz : 42 A Current at 250

Hz : 33 A

Calculate the Total Harmonic Distortion in current for the system

111 Air flow measurements using the pitot tube, in the primary air fan of a coal fired boiler gave the following data

Air temperature = $38^{o}C$
Velocity pressure = 47 mmWC
Pitot tube constant, Cp = 0.9
Air density at $0^{o}C$ (standard data) = 1.293 kg /m^3 Find out the velocity of air in m/sec.

112 Estimate the cooling tower capacity (TR) and approach with the following parameters

Water flow rate through CT = 2 m^3/min
Specific heat of water = 1 kcal/kg °C
Inlet water temperature = 43 °C
Outlet water temperature = 35 °C
Ambient WBT = 30°C

113 A 37 kW, 3 phase, 415 V induction motor draws 56 A and 33 kW power at 410 V . What is the Apparent and Reactive Power drawn by the motor at the operating load?

114 An energy audit of a fan was carried out. It was observed that the fan was delivering 18,500 Nm^3/hr of air with static pressure rise of 52 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 3.1 kW/ phase on an average. The motor operating efficiency was assessed as 88% from the motor performance curves. What would be the fan static efficiency?.

115 State any three major differences between vapor compression refrigeration (VCR) and Vapour Absorption Refrigeration (VAR) system?

116 A 180 kVA, 0.80 PF rated DG set has diesel engine rating of 210 BHP. What is the maximum power factor which can be maintained at full load on the alternator without overloading the DG set? (Assume alternator losses and exciter power requirement as 5.66 kW and there is no derating of DG set)

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Long Answer Questions

Each question carries **Ten** marks

1 A plant has 2 identical 500 kVA transformers, each with a no load loss of 0.84 kW and full load copper loss of 5.7 kW. The plant average load is 300 kVA and has never exceeded 450 kVA in the past.

(a) Compare the transformer losses when single transformer is in operation and when both transformers are in parallel operation.

2 A compressed air leakage test was conducted in an engineering industry, which employs a 500 cfm reciprocating compressor. The compressed air system is maintained at the normal loading-unloading settings of 6.5 kg/cm^{2}g and 7 kg/ cm^{2}g respectively. The following was observed for a period of 15 minutes trial:

On load time = 40 secs
Unload time = 120 secs.

Subsequently some of the air leakage points were attended and the leakage test was repeated. The following was observed while maintaining the same loading & unloading pressure settings and trial period:

On load time = 20 secs
Unload time = 140 secs

The average power drawn during the above 2 trials was observed as 70 kW during load and 15 kW during unload condition. Calculate the annual cost savings for 5000 hr/ year of compressor operation. Assume energy charge of Rs. 5.00 per kWh

3 A centrifugal pump is delivering 30 m^3/s of water at a discharge pressure of 3 kg/cm^{2}g. The pump suction is 1 meter below the pump center line. Find out the power drawn by the motor if the pump efficiency is 60% and motor efficiency is 92%.

4 Briefly explain the step by step approach for the conduct of energy audit of vapour compression refrigeration plants.

5 List 10 energy saving opportunities in a cooling tower.

6 Explain the benefit of reducing maximum demand. Explain step-by-step approach in controlling the maximum demand.

7 A 10 HP, 415 V, 4 pole, 50 Hz, 3 Phase squirrel cage induction motor has a full load efficiency of 90% and power factor of 0.88. Find the following if the motor operates at full load rated values.

a) current drawn by the motor
b) input power in kW
c) RPM at a full load slip of 1%

8 In an engineering industry, a 500 cfm rated capacity reciprocating compressor is operated at 7 kg/cm^{2}g to find out the system leakage loss in the plant during lunch timings when no equipment using compressed air is operated. A free air delivery test was carried out before conducting the leakage test and it was observed that, the compressor was delivering 90% of its rated capacity. The following was observed during the conduct of leakage test:

a) compressor on load timing is 10 seconds and unloading pressure is 7 kg/cm^{2}g

b) compressor power drawn during on load is 75 kW

c) compressor unload timings and loading pressure are 40 seconds and 6.5 kg/cm^2 g respectively.

Find out the following:

(i) % air leakage in the system
(ii) leakage quantity in cfm.
(iii) power lost due to leakage

9 A water pump is delivering 300 m^3/hr at ambient conditions. The impeller diameter is trimmed by 10% and its speed is reduced by 10%. Find out the water flow at the changed conditions.

10 a) A 3 phase, 415 V, 110 kW induction motor is drawing 50 kW at a 0.75 PF.

Calculate the capacitor rating requirements at motor terminals for improving PF to 0.95. Also, calculate the reduction in current drawn and kVA reduction, from the point of installation back to the generating side due to the improved PF.

(b) A process plant consumes of 125,000 kWh per month at 0.9 Power Factor (PF). What is the percentage reduction in distribution losses per month if PF is improved up to 0.96 at load end?

11 a) A V-belt driven reciprocating instrument air compressor was found to be maintaining a distribution system pressure of 7 kg/cm^{2}g. 20% of the instrument air was used for control valves installed in a boiler house and requiring 6.5 kg/cm^{2}g, whereas balance 80% of the instrument air was used for other application requiring 4 kg/cm^{2}g. What would you like to advise in this situation?

b) An energy auditor observes the following load unload condition on two similar reciprocating air compressor installed in two separate industrial locations (A & B)

	A	B
Load setting (kg/cm2g)	6.5	6.5
Unload setting (kg/cm2g)	6.8	7.5

The energy auditor concludes that at location B, the compressed air system in operation is inefficient. Do you agree with his observation. Justify your reply with atleast two reasons in support of your argument

12 List down 10 energy conservation opportunities in pumping systems.

13 In an air conditioning duct of 0.6 m x 0.6 m size, the average velocity of air measured by vane anemometer is 30 m/s. The static pressure at inlet of the fan is 25 mm WC and at the outlet is 35 mm WC. The motor coupled with fan through belt drive draws 19 A at 410 V at a power factor of 0.8. Find out the efficiency of the fan. Assume motor efficiency = 90% and belt transmission efficiency of 98% (density correction can be neglected).

14 An efficiency assessment test was carried out for a standard squirrel cage induction motor in a process plant. The motor specifications are as under.

Motor rated specification: 50 HP/ 415 Volt, 60 Amps, 1475 rpm, 3 phase, delta connected

The following data was collected during the no load test on the motor.

Voltage	= 415 Volts
Current	= 18 Amps
Frequency	= 50 Hz
Stator resistance per phase	= 0.27 Ohms
No load power	= 1080 Watts

Calculate the following:

(i) Iron plus friction and windage losses.
(ii) Stator resistance at 120^{o}C.
(iii) Stator copper loss at operating temperature at 120^{o}C.
(iv) Full load slip and rotor input assuming rotor losses are slip times rotor input.

(v) Motor input assuming that stray losses are 0.5% of the motor rated power.
(vi) Motor full load efficiency and full load power factor.

15 The contract demand of a process plant is 5000 kVA with the electricity supply utility company. The average monthly recorded maximum demand of the process plant is 4600 kVA at a power factor of 0.80. The utility bill analysis provides the following tariff structure.

a) Minimum monthly billing demand is 75% of the contract demand or the actual recorded maximum demand whichever is higher.

b) Monthly maximum demand (MD) charge is Rs. 300 per kVA.

Find out the optimum limit of power factor capacitor requirement entirely from the view of reducing maximum demand so that no excess demand charges are paid to the supply company. Also work out the simple payback period, assuming cost of power factor capacitor installation along with automatic power factor correction controller is as Rs. 500 per kVAr.

16 A 7.5 kW, 415 V, 14.5 A, 4 pole, 50 Hz, 3 phase rated squirrel cage induction motor has a full load efficiency and power factor of 89% and 0.88 respectively.

An energy auditor measures the following operating data of the motor

(a)	Supply voltage	=	410 V
(b)	Current drawn	=	9.5 A
(c)	PF	=	0.8
(d)	Supply frequency	=	49.8 Hz
(e)	RPM	=	1480

Find out the following at the motor operating conditions:

1. Power input in kW
2. % motor loading
3. % slip

17 (a) A fan is delivering 20,000 Nm^3/hr. of air at static pressure difference of 70 mm WC. If the fan static efficiency is 55%, find out the shaft power of the fan.

(b) Explain briefly the difference between static and dynamic head of a centrifugal pumping system.

18 List down any 10 energy conservation opportunities in compressed air system.

19 Briefly explain the step-by-step approach for conducting Energy Performance Assessment of DG set on shopfloor.

20 A plant has 2 identical 500 kVA transformers, each with a no load loss of 0.80kW and full load copper loss of 5.7 kW. The plant average load is 420 kVA and has never exceeded 460 kVA in the past. An energy auditor while conducting the energy audit founds that only single transformer is kept in operation and second transformer is switched off. The plant management was of the view that since the plant load is well within the reach of one transformer, therefore there is no need of keeping the second transformer in parallel operation. As claimed by the management, plant would be saving no load loss of transformer, which is 0.80kW.

a) In your opinion, whether energy auditor would agree with the stand taken by the management.
b) If not, what he would like to like to advise to the plant's management on transformers operation keeping in view the energy saving potential, reliability and safety of the system

21 An energy auditor works out the percentage loading of a particular induction motor as a ratio of current drawn to the rated current of the motor.

a) Do you agree with the above methodology adopted by the consultant? Justify your answer with reasons.
b) In your opinion what is the right approach for working out the motor loading?
c) List any other method ,which is also an indicator of motor loading

22 The management of an industrial plant retains the services of an energy auditor to undertake the performance evaluation of a large fan handling gases. The auditor measures the following data:

i) Average velocity pressure (by Pitot tube measurement) : 70 mm water column

ii) Fan Suction pressure : - 20 mm water column

iii) Fan Outlet pressure : 460 mm water column

iv) Area of duct : 8 square meter

v) Pitot tube constant : 0.85

vi) Corrected gas density : 1.15 kg/ m^3

3 phase motor data.

vii) Motor line current :137 Amps

viii) Motor phase voltage (line to neutral) :6350 volts

ix) Power factor of electric motor : 0.91

x) Efficiency of motor at the operating load (from the performance curve): 94%.

After analyzing the operating data, the energy auditor concludes that the static fan efficiency has fallen to around 50% and there is a need to replace the fan impeller after undertaking a detailed financial analysis. However, plant personnel insist that static efficiency of the plant is still better and is around 85% and there is no need of fan impeller replacement.

a) In your opinion who is correct, assuming that the measurement of data is correct. Justify your answer.

b) Can you catch the mistake committed by either of them in the analysis of electrical parameters?

2 3 a) An energy auditor while conducting the energy audit of a DG set in a plant founds that a 3 MW DG set with an average load of 2.5 MW running in parallel with the grid was exporting 50 kVAr. In your opinion, what electrical parameters should be checked by the auditor? List the disadvantages of the above situation.

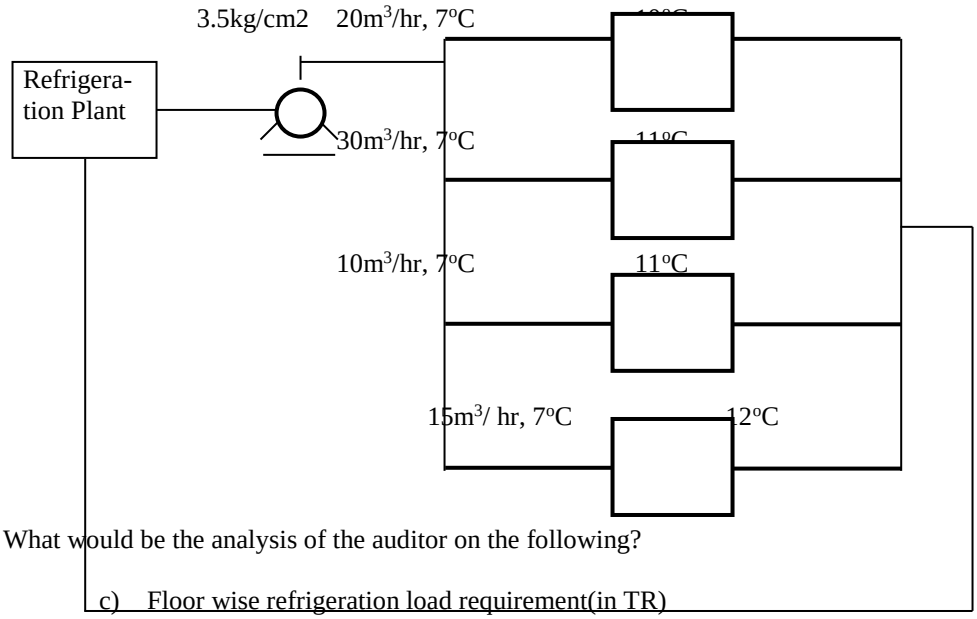
b) An energy auditor observes the following load unload condition on two similar reciprocating air compressor and compressed air system installed in two separate industrial plant locations (A & B)

	Location A	Location B
Load setting (kg/cm2g)	7.0	7.0
Unload setting (kg/cm2g)	7.3	8.0

The energy auditor concludes that at location B, the compressed air system has become inefficient. Do you agree with his observation? Justify your answer with at least two reasons in support of your argument

2 4 The management of a building facility retains the services of an energy auditor to asses the refrigeration load of each floor of the building and efficiency of the chilled water pump. The auditor measures the chilled water flow of each AHU by non contact flow meter and measures the temperature at the inlet and outlet of AHUs, as per the details given below. The discharge pressure gauge of the chilled water pump shows 3.5 kg/cm2 and the refrigeration tank water level is 1 metre above the pump centerline. The power drawn by the refrigeration compressor and pump motor was found to be 89kW and 17.58 kW respectively.

25 1st Floor



What would be the analysis of the auditor on the following?

c) Floor wise refrigeration load requirement(in TR)

Specific power consumption of Refrigeration compressor (kW/TR) at the motor operating efficiency of 92%

d) Chilled water pump efficiency , at the motor operating efficiency of 89%

26 A chemical plant has a contract demand of 2500 kVA with the power supply company. The average maximum demand of the plant is 2000 kVA at a power factor of 0.95. The maximum demand is billed at the rate of Rs.300/kVA. The minimum billable maximum demand is 75 % of the contract demand. An incentive of 0.5 % reduction in energy charges component of electricity bill are provided for every 0.01 increase in power factor over and above 0.95. The average energy charge component of the electricity bill per month for the company is Rs.10 lakhs.

The plant decides to improve the power factor to unity. Determine the power factor capacitor kVAr required, annual reduction in maximum demand charges and energy charge component. What will be the simple payback period if the cost of power factor capacitors is Rs.800/kVAr.

27 A cooling tower is operating at a capacity of 32,40,000 kcal/hr and a range of 6ºC. The cooling tower pump has a positive suction of 1 m and the discharge pressure shows 3.8 kg/cm^2. The measured motor power is 71 kW and the operating efficiency of the motor is 92%. Find out the efficiency of the pump.

28 A fan is driven by a motor through a belt pulley system. The input power to the fan is 36 kW for a 2500 Nm^3/hr fluid flow. The motor speed is 2990 RPM and its pulley diameter is 200 mm. The fan pulley diameter is 300 mm. If the flow is to be reduced by 20% by changing the fan pulley size, what should be the diameter of the fan pulley and what will be the power input to the fan?

29 Draw a sketch of centrifugal pump (head vs flow) characteristic curve incorporating the following. (Draw separate sketches for each of the conditions)

a) System resistance curve (with static and dynamic head) and show the operating point
b) Effect of throttling the pump on head and flow
c) Effect of pump speed reduction on head and flow
d) Effect of impeller diameter reduction on head and flow

A 7.5 kW, 415 V, 14.5 Amp,4 pole, 50 Hz rated, 3 phase squirrel cage induction motor has a half load efficiency of 84% and power factor of 0.7. Find the following if the motor operates at 50% of its rated output.

a) Current drawn by the motor
b) Ratio of the current drawn to its rated current. Is this exactly 50% at half loading? If not, briefly explain the reasons for the same.
c) RPM at a half load slip of 2%

Module 4

Objective Type

Each question carries **One** mark

1	A sum of Rs 10000 is deposited in a bank as a fixed deposit for 3 years. The bank pays 9% interest annually. How much money, in Rs., will be received at the maturity if the fixed deposit is encashed? a) **12950** b) 12700 c) 11800 d) none of the above
2	Which of the following equation is used to calculate the future value of the cash flow? a) NPV $(1 - i)^n$ b) NPV + $(1 - i)^n$ c**) NPV $(1 + i)^n$** d) NPV/ $(1 + i)^n$
3	Select the wrong statement a) NPV of a project is equal to sum of the all present values of the cash flows b) NPV represents the net benefit over and above compensation for time and risk c) **accept the project if NPV is negative** d) NPV takes into account time value of money
4	The internal rate of return is the discount rate for which the NPV is a) less than 1 b) +ve c) –ve d) **zero**
5	_____considers impact of cash flow even after payback period a) **Net present value** b) return on investment c) Sensitivity analysis d) simple payback period

6	The net present value (NPV) is **a) equal to the sum of the present values of all cash flows** b) equal to the sum of returns c) equal to the sum of all cash flows d) none of the above
7	If NPV = 1000 and i = 5% then the future value after 10 years is a) 1,551 b) 614 **c) 1,629** d) 645
8	What is the expected Return on Investment (ROI) from the project with Rs.10 lakhs investment and annual saving of Rs.3.0 lakhs and annual operating cost of Rs.1.0 lakhs **a) 20%** b) 25% c) 30% d) 10 %
9	ROI must always be ___ than interest rate a) lower b) equal c) **higher** d) lower or equal
10	Which subject is not so important in the screening of projects in a need identification **a) implementation period** b) availability of technology c) sustainability of the savings d) cost-effectiveness
11	The factor that reflects the risk of the project while evaluating the present value of the expected future cash flow is a) life of the project **b) discount rate** c) capital cost d) all the above
12	What does the concept of time value of money imply a) present value of money b) future value of money c) discounting of cash flows **d) all of the above**

13	Return on Investment (ROI) as a fraction means a) initial investment / annual return b) annual cost / cost of capital **c) annual net cash flow / capital cost** d) none of the above.
14	Which source of project financing is not from an internal source? **a) loans from employees** b) direct cash from company resources c) new share capital d) payment by savings
15	A factor that reflects the risk of the project while evaluating the net present value for the expected future cash flow is: a) Discount rate **b) Internal rate of return** c) Capital Cost d) All of the above
16	Assume Project A has an IRR of 30% and NPV of Rs. 1,50,000 and Project B has an IRR of 55% and NPV of Rs. 25,000. Which project would you implement first if financing is available and project technical life is the same? a) Neither A nor B b) B **c) A** d) cannot be decided
17	The cost of a new heat exchanger is Rs. 1.0 lakh. The simple payback period in years considering annual savings of Rs 60,000 and annual operating cost of Rs. 10,000 is a) 0.50 b) 1.66 **c) 2.00** d)6.00
18	Which of the following statements regarding Internal Rate of Return (IRR) is correct? a) IRR distinguishes between lending and borrowing **b) Internal rate of return is the discount rate at which net present value is equal to zero** c) if the IRR is higher than current interest rate, the investment is not attractive d) between two alternative projects, the project with lower internal rate of return would be considered more attractive

19	The internal rate of return is the discount rate for which the NPV is a) positive **b) zero** c) negative d) less than 1
20	The retrofitting of a variable speed drive in a plant costs Rs 2 lakh. The annual savings is Rs 0.5 lakh. The maintenance cost is Rs. 5,000/year. The return on investment is a) 25% **b) 22.5%** c) 24% d) 27.5%
21	For a project to be financially attractive, ROI must always be _____than interest rate. a) lower **b) higher** c) equal d) no relation
22	A sum of Rs 100,000 is deposited in a bank at the beginning of a year. The bank pays 10% interest annually. How much money will be in the bank account at the end of the fifth year, if no money is withdrawn? **a) 161050** b) 150000 c) 155000 d) 160000
23	The cost of replacement of inefficient chiller with an energy efficient chiller in a plant was Rs. 10 lakh .The net annual cash flow is Rs 2.50 lakh .The return on investment is: a) 18% b) 20% c) 15 % **d) none of the above**
24	In project financing, sensitivity analysis is applied because a) almost all the cash flow methods involve uncertainty b) of the need to assess how sensitive the project to changes in input parameters c) what if one or more factors are different from what is predicted **d) all the above situation**
25	_____determines the project viability in response to changes in input parameters. a) Life cycle analysis b) Financial analysis c) **Sensitivity analysis** d) Payback analysis

26	A sensitivity analysis is an assessment of a) cash flows **b) risks due to assumptions** c) capital investment d) best financing source
27	Which one is not a macro factor in a sensitivity analysis? a) change in interest rates b) technology changes **c) cost of debt** d) change in tax rates
28	What is the future value of Rs.1000/- after 3 years, if the interest rate is 10% **a) Rs. 1331** b) Rs.1610 c) Rs.3221 d) none of the above
29	Capital cost are associated with a) Design of Project b) Installation and Commissioning of Project c) Operation and Maintenance cost of project **d) both a and b**
30	Costs associated with the design, planning, installation and commissioning of a project are a) variable costs **b) capital costs** c) salvage value d) none of the above
31	Any management would like to invest in projects with a) Low IRR b) Low ROI c) Low NPV of future returns **d) none of the above**
32	A waste heat recovery system costs Rs. 54 lakhs and Rs. 2 lakhs per year to operate and maintain. If the annual savings is Rs. 20 lakhs, the payback period will be a) 8 years b) 2.7 years **c) 3 years** d) 10 years
33	Cost of a new heat exchanger is Rs. 1.5 lakh. The simple payback period (SPP) in years considering annual savings of Rs 60,000 and annual maintenance cost of Rs 10,000 is a) 0.4 b) 2.5 **c) 3** d) 6

34	The cost of replacement of inefficient compressor with an energy efficient compressor in a plant costs Rs. 8 lakhs. The net annual cash flow is Rs. 2 lakhs. The return on investment a) 18% b) 20% c) 15% **d) none of the above**
35	An investment of Rs 96,000 has a simple payback period of two years. The monthly savings must be a) Rs 8,000 **b) Rs 4,000** c) Rs 9,600 d) Rs 12,000
36	For an investment which has fluctuating annual savings over its project life, which of the following financial analysis techniques is the best? a) Simple payback period b) ROI **c) NPV** d) IRR
37	The present value of equipment is Rs. 10,000 and discount rate is 10%. The future value of the cash flow at the end of 2 years is: a) Rs. 10000 **b) Rs. 12,100** c) Rs. 8100 d) Rs. 8264
38	A sum of Rs 10,000 is deposited in a bank at the beginning of a year. The bank pays 10% interest annually. How much money is in the bank account at the end of the fifth year, if no money is withdrawn? **a) 16105** b) 15000 c) 15500 d) 16000
39	A contract in which the costs are paid from all or part of the energy cost savings is called a) performance contract b) traditional contract c) extended technical guarantee contract **d) guaranteed savings performance contract**

40	The annual electricity bill for a plant is Rs 10 lakhs and accounts for 38% of the total energy bill. Furthermore the total energy bill increases by 5% each year. How high is the plant's annual energy bill at the end of the third year? **a) Rs 30.46 lakhs** b) Rs 26.32 lakhs c) Rs 38.42 lakhs d) none of the above
41	Which of the following Financial Analysis Techniques fails to consider the time value of money **a) Simple Payback Period (SPB)** b) Internal Rate of Return (IRR) c) Net Present Value (NPV) d) none of the above
42	Assume project A has an IRR of 85% and NPV of Rs 15,000 and project B has an IRR of 25% and NPV of 200,000. Which project would you implement first if financing is available and project technical life is the same? **a) B** b) A c) cannot be decided d) question does not make sense
43	A waste heat recovery system costs Rs. 54 lakh and Rs. 2 lakh per year to operate and maintain. If the annual savings is Rs. 20 lakhs, the payback period will be a) 8 years b) 2.7 years **c) 3 years** d) 10 years
44	The ratio of annual net cash flow to capital cost is _____ a) net present value b) internal rate of return **c) return on investment** d) discount factor
45	Which of the following is not true of IRR? a) it takes into account time value of money b) it considers the cash flow streams in its entirety c) does not distinguish between lending and borrowing **d) none of the above**

46	To judge the attractiveness of any investment, the project manager must consider: a) Initial capital cost b) Net operating cash inflows c) salvage value **d) all the above**
47	ROI must always be _____ borrowing interest rate for economic feasibility of any project a) lower than **b) higher than** c) equal to d) no relation
48	A factor that reflects the risk of the project while evaluating the net present value for the expected future cash flow is: a) Discount rate **b) Internal rate of return** c) Capital cost d) All of the above

Short Answer Questions

Each question carries **Five** marks

<table>
<tr><td>S-1</td><td>A pressure reducing valve is proposed to be replaced by a steam turbine. The investment required is BDT.40 lakhs. Additional maintenance and operating costs for the turbine is expected to be BDT. 1 lakh per annum. If the annual savings is BDT.9 lakhs, calculate the payback period and Return on Investment.</td></tr>
<tr><td>S- 2</td><td>A plant is using 6 tonnes / day of coal to generate steam. The calorific of coal is 3300 kcal/kg. The cost of coal is BDT 4200/tonne. The plant substitutes coal with agro-residue, as a boiler fuel, which has a calorific value of 3100 kcal/kg and costs BDT 1800/tonne. Calculate the annual cost savings at 300 days of operation, assuming the boiler efficiency remains same at 72% for coal and agro residue as fuel.</td></tr>
<tr><td>S- 3</td><td>The annual fuel cost of boiler operation in a plant is BDT.10 Lakhs. The boiler with 65% efficiency is now replaced by a new one with 78% efficiency. What is the annual cost savings?</td></tr>
<tr><td>S- 4</td><td>Investment for an energy proposal is BDT. 20 lakhs. Annual savings for the first two years is BDT. 4 lakhs each and subsequent two years BDT. 6 lakhs each and fifth year BDT 7 lakhs. Considering cost of capital as 10%, what is the net present value of the proposal> Is it worth investing in this project?</td></tr>
<tr><td>S- 5</td><td>In a heat exchanger, stem is used to heat 5 KL/hour of furnace oil from 30 °C to 90 °C. The specific heat of furnace oil is 0.22 kcal/kg/°C and the density of furnace oil is 0.95.
a) How much steam per hour is needed if steam at 4 kg/cm^2 with latent heat of 510 kcal/kg is used
b) If steam cost is BDT 3.50/kg and electrical energy cost BDT 4/ kWh, which type of heating would be more economical in this particular case</td></tr>
<tr><td>S-6</td><td>Calculate the net present value over a period of 3 years for a project with the following data. The discount rate is 12%.
<table>
<tr><th>Year</th><th>Investment (BDT)</th><th>Savings (BDT)</th></tr>
<tr><td>0</td><td>75,000</td><td></td></tr>
<tr><td>1</td><td></td><td>25,000</td></tr>
<tr><td>2</td><td></td><td>75,000</td></tr>
<tr><td>3</td><td>50,000</td><td>75,000</td></tr>
</table></td></tr>
</table>

	4		35,000	
S-7	Calculate Net Present Value over a period of 3 years for a project with an investment of BDT 70,000 at the beginning of the first year and second investment of BDT 70,000 at the beginning of the second year and fuel cost saving of BDT 95,000 in second and third year. The discount rate is 14%			
S-8	Briefly compare NPV and IRR method of financial analysis.			
S-9	What are the limitations of a simple payback period (SPP)?			
S-10	Calculate the future value of a cash flow with NPV = BDT 1 Lakh at the end of the 7th year if the interest rate is 5%.			
S-11	State the equation how to calculate the Net Present Value (NPV) of an investment and identify the parameters in the equation.			
S-12	Explain why a project with a high IRR is not necessarily more attractive than a project with lower IRR?			
S-13	An energy saving proposal involves an investment of BDT. 25 lakhs in an industry and is expected to yield an average annual net saving of BDT. 5 lakhs/annum. The cost of borrowing of the investment is 14%. Compute the return on investment for this proposal and state with reason whether the investment is justified Also, state the limitations of ROI.			

Long Answer Questions

Each question carries **Ten** marks

<table>
<tr><td>L-1</td><td>The following are the cash flows for a simple insulation up gradation project.

<table><tr><td>YEAR</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Cash flow</td><td>-18,000</td><td>-5,000</td><td>10,000</td><td>10,000</td><td>10,000</td></tr></table>
a) Calculate the NPV if the cost of capital or discount rate is 8%
b) Calculate the IRR</td></tr>
<tr><td>L-2</td><td>The following are the cash flows for retrofitting of a cooling tower project.
<table><tr><td>Year</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Cash flow</td><td>-12,30,000</td><td>3,00,000</td><td>4,00,000</td><td>4,00,000</td><td>4,00,000</td></tr></table>
Calculate the IRR for the project</td></tr>
<tr><td>L-3</td><td>A company has to choose between two projects whose cash flows are as indicated below;

<u>Project 1:</u>
i. Investment – BDT. 15 Lakhs
ii. Annual cost savings – BDT. 4 lakhs.
iii. Bi-annual maintenance cost – BDT. 50,000/-
iv. Reconditioning and overhaul during 5th year: 6 lakhs
v. Life of the project – 8 years
vi. Salvage value – BDT. 5 lakhs

<u>Project 2:</u>

i. Investment – BDT. 14 Lakhs
ii. Annual cost savings – BDT. 3.5 lakhs.
iii. Annual Maintenance cost – BDT. 20,000/-
iv. Reconditioning and overhaul during 4th year: 5 lakhs
v. Life of the project – 8 years
vi. Salvage Value- 2 lakhs

Which project should the company choose? The annual discount rate is 12%.</td></tr>
<tr><td>L-4</td><td>The cash flows in two different energy conservation projects are given in the table below. Please help the management of an infrastructure company to decide which project to invest in as the management is interested in investing in only one project.</td></tr>
</table>

The company is likely to consider any project which gives a minimum return on investment of 18%. Please justify your choice. (Amount in BDT)

	Project A		Project B	
Investment	17,50,000		12,00,000	
Year	Expenses	Savings	Expenses	Savings
1		4,00,000		4,50,000
2		4,00,000		4,00,000
3		4,00,000		3,50,000
4		4,00,000		3,00,000
5	1,00,000	6,00,000		2,50,000
6		6,00,000		2,00,000
7		6,00,000		1,16,650
8		3,80,300		

L-5 A plant is using 4 tonnes/day of coal to generate steam. The calorific value of the coal is 4000 kcal/ kg. The cost of coal is BDT. 2,000/tonne. The plant substitutes coal with rice husks, as a boiler fuel, which has a calorific value of 3000 kcal/ kg and cost BDT. 700/tonne. Calculate the annual cost savings at 300 days of operation, assuming that the boiler efficiency decreases from 78% on coal to 72% on rice husks.

L-6 A company invests BDT.10 lakhs and completes an energy efficiency project at the beginning of year 1. The firm is investing its own money and expects an internal rate of return, IRR, of at least 26% on constant positive annual net cash flow of BDT.2 lakhs, over a period of 10 years, starting with year 1.

i. Will the project meet the firm's expectations?
ii. What is the IRR of this measure?

L-7 Briefly describe the various financial analysis techniques for investments in energy efficiency projects and their suitability of application.

L-8 Assume that the annual per capita electricity consumption of India is 615 kWh and the population is 1.078 Billion people.

(i) If the installed power capacity is 118,419 MW, calculate the average plant load factor of the power mix at 606 kWh per capita consumption.

	(ii) Calculate annual per capita consumption 30 years later if electricity consumption in India goes up by 6% each year, and population growth is 1.0% annually. (iii) How many years will it take to reach the per capita consumption of the USA at 13,500 kWh under a business as usual scenario as in (ii)?
L-9	An agency is implementing Energy efficiency measures in municipal water pumping under ESCO route. The investment is BDT. 6 crores. Present annual bill is BDT. 4 Crores. The expected savings are 20%. (Cost of power = BDT 4/kWh, Annual maintenance cost -10% of investment) The expected CDM revenues would be BDT. 50 Lakhs/year. Calculate IRR for this project after including the CDM benefit
L-10	Investment for a set of interrelated energy efficiency projects identified in a medium size process plant works out to BDT.12.00 lakh. Annual savings for the first four consecutive years are BDT. 350,000, BDT. 400,000, BDT. 400,000 and BDT. 450,000, respectively. The cost of capital is 12% p.a. What is the net present value (NPV)? And as per NPV, suggest weather the plant can go ahead with the projects.
L-11	In a fertilizer plant, the off-site boiler was revamped to improve the efficiency by spending BDT. 200 lakhs. The discount rate for the company is 15%. The projected cost of saving of fuel was BDT. 40 lakhs/ year. Find out the NPV at the end of 10 years of the operation of the boiler. State your opinion about the usefulness of this investment.

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Module 5

Objective Type

Each question carries **One** mark

1.	A chart in Scatter Diagram shows a low degree of scatter. It is indicative of------ a) good fit b) poor fit c) skewed fit d) normal fit
2.	Determines relationship between variables and enables standard equations to be established for energy consumption. a) linear regression analysis b) time-dependent energy analysis c) moving annual total d) CUSUM
3.	In a cumulative sum (CUSUM) chart, if the graph is going up, then a) nothing can be said b) actual and calculated energy consumption are the same c) energy consumption is reduced d) specific energy consumption is going up
4.	Energy monitoring and targeting is built on the principle of " _____". a) "production can be reduced to achieve reduced energy consumption" b) "Consumption of energy is proportional to production rate" c) "You cannot manage what you do not measure" d) None of the above.
5.	Which of the variable does not contribute to energy consumption? a) production b) hours c) climate d) none of the above
6.	Poor scattering on trend line of production Vs Energy consumption indicates ___.

	a) poor level of control b) good level of control c) both the above d) none of above.
7.	Fixed energy consumption can be determined from a a) bar chart b) vertical line chart c) pie chart d) X Y coordinate system
8.	The best way of correlating production and energy data in any plant is….. a) text format b) graphical representation c) oral communication d) none
9.	For any company, energy consumption mostly relates to…….. a) profits b) inventory c) production d) all the above
10.	In a cumulative sum chart, if the graph is horizontal, then a) nothing can be said b) energy consumption is reduced c) specific energy consumption is increasing d) actual and calculated energy consumption are the same
11.	A CUSUM graph follows a random fluctuation trend and oscillates around a) 50% b) 100% c) 0 d) mean value
12.	Large scattering on production versus energy consumption trend line indicates a) poor process control b) many forced outages c) poor process monitoring d) none of the above
13.	The empirical relationship used to plot Production Vs Energy consumption is…… (where Y= energy consumed for the period; C = fixed energy consumption; M = energy

	consumption directly related to production; X= production for same period). a) X=Y+MC b) Y=MX+C c) M=CX+Y d) Y= MX-C
14.	_____is a statistical technique which determines and quantifies the relationship between variables and enables standard equations to be established for energy consumption. a) linear regression analysis b) time-dependent energy analysis c) moving annual total d) CUSUM

Short Answer Questions

Each question carries **Five** marks

S-1	What do you understand by Energy monitoring and targeting?
S-2	What is meant by correlation coefficient? How it is useful in energy monitoring?
S-3	What is the need for a monitoring system?
S-4	List at least 5 steps involved in CUSUM analysis.
S-5	Explain the difference between single variable and multiple variable analysis

Long Answer Questions

Each question carries **Ten** marks

L-1

In a food processing plant the monthly production related (variable) energy consumption was 1.8 times the production and non-production related (fixed) energy consumption was 15,000 kWh per month up to May 2010. In the month of June 2010 a series of energy conservation measures were implemented. Use CUMSUM technique to develop a table and calculate energy savings for the subsequent 6 months period from the data given below

Month	Production (kg)	Actual Energy Consumption (kWh)
Jul' 10	62000	113600
Aug' 10	71000	139000
Sep' 10	75000	158000
Oct' 10	59000	119300
Nov' 10	62000	123700
Dec' 10	73000	143600

L-2

Use CUSUM technique and calculate energy savings for first 6 months of 2011 for those energy saving measures implemented by a plant prior to January,2011.

The average production for the period Jan-Jun 2011 is 1000 MT/Month

The plant data is given in the table below.

2011-Month	Actual Specific Energy Consumption, kWh/MT	Predicted Specific Energy Consumption, kWh/MT
Jan	**1203**	**1121**
Feb	**1187**	**1278**
Mar	**1401**	**1571**
Apr	**1450**	**1550**
May	**1324**	**1284**
Jun	**1233**	**1233**

Module 6
Objective Type
Each question carries **One** mark

1. Define “sub - stoichiometric ratio” in combustion technology. State one technology applying “sub – stoichiometric” combustion?

2. Why does radiation heat loss increase considerably with increase in the temperature of a furnace wall?

3. Draw the schematic diagram of topping cycle cogeneration system.

4. Name the two most common types of extended surface heat exchangers.

5. Explain why efficiency testing of electric motors yields different results, even if same measuring equipment is used.

6. What is meant by the term “specific power requirement” with respect to air compressors? State the units.

7. Define “lamp circuit efficacy”. State the units.

8. Explain why a project with a high IRR is not necessarily more attractive than a project with a lower IRR.

9. How do you classify solar thermal devices?

10. Explain how performance of an internal combustion engine changes when the fuel is switched from petrol to producer gas.

11. If the power consumed by a refrigeration compressor is 2 kW per ton of refrigeration, what is the energy efficiency ratio?

12. When using a chemical cell oxygen measuring device for stack gas analysis, state the equation to find out the excess air in %?

13. Which has more energy content, 1 kg of Hydrogen or 1 kg of gasoline?

14. Write the overall heat transfer coefficient U, as a function of sensible heat (q_s) and latent heat (q_L).

15. Which loss is considered the most unreliable or complicated to measure in electric motor efficiency testing?

16. The inclined manometer connected to a pitot tube is sensing which pressure in a gas stream?

17. When using an ultrasonic flow meter for flow measurements in a water pipe which major additional parameter must be guessed or known to calculate the flow in cubic meter per second.

18. What is the correction factor for actual free air discharge in a compressor capacity test if compressed air discharge temperature is 15^0 C higher than ambient air? Assume ambient air = 40^0 C.

19. Which expression to state the energy efficiency of a chiller does not follow the trend "a higher number means a more efficient system"?

20. What have all boiler efficiency testing standards in common?

21. State two causes for rise in exit flue gas temperature in a boiler.

22. What are the disadvantages of heating the charge above the optimum temperature in steel re-rolling furnaces?

23. State the impact of fouling factor on the overall heat transfer coefficient.

24. List the basic parameters required for assessing refrigeration capacity.

25. While using Pitot tube for airflow measurement in large ducts, series of traverse measurements are recommended. Why?

26. Static fan efficiency $= \frac{(m^3/s) \times \text{pressure gain in Pascal}}{\text{Power input to shaft in Watt}}$ Right or wrong?

Justify your answer

27. State two methods of non-intrusive water flow measurements in a pipe.

28. What is meant by compression ratio for air compressor?

29. How many volt-amperes (VA) does a 60 Watt incandescent light require?

30. A reasonable range of capacity factors for wind electric generators is.…

31. In the determination of which boiler losses, specific heat of superheated steam is used

32. In a shell and tube heat exchanger, engaged in heat transfer between fouling fluid and clear fluid, the fouling fluid should be put on shell side or tube side?

33. The active power consumed by a pure inductive or capacitive load will be zero. State - True / False.

34. A centrifugal pump raises water to a height of 12 metre. If the same pump handles brine with specific gravity of 1.2, to what height the brine will be raised?

35. While reducing excess air in a boiler what two parameters should be closely monitored in the exit flue gases?

36. In an air conditioning system analysis which one temperature is sufficient to determine the enthalpy of air?

37. Installing the capacitor near motor terminals will increase the design power factor of the motor - True / False

38. Between back pressure turbine and condensing turbine which will have more power generation efficiency?

39. What is the power factor for electrical loads having only incandescent lamps?

40. Which loss is assumed in the efficiency determination of an induction motor?

41. Which parameter needs to be measured to assess the percentage loading of a motor by slip method neglecting voltage correction?

42. In the boiler efficiency calculations by heat loss method, assessment of which loss requires the use of fuel firing rate?

43. Write down the term which represents the quantity of heat release by natural convection in the equation for determination of heat loss from the surface of a furnace body

44. Between a thermal power plant and a cogeneration plant with a back pressure turbine, which will have a higher heat rate? Why?

45. Give two examples for constant torque load and variable torque loads?

46. What condition is to be maintained to create sonic flow at the nozzle throat in the test set up for compressor capacity determination by nozzle method?

47. In a heat exchanger the hot fluid inlet and outlet temperatures are 120 °C and 70 °C. The cold fluid inlet and outlet temperatures are 30 °C and 42 °C. Calculate the effectiveness.

48. If the EER of a Refrigeration Unit is 9.3. determine the kW/Ton rating of the system

49. How is the Overall Heat transfer Coefficient related to surface area?

50. Which loss is considered the most unreliable or complicated to measure in electric motor efficiency testing?

51. How is the Overall Heat transfer Coefficient related to surface area?

52. The more fouling fluid should be on which side of a shell & tube heat exchanger and why**?**

53. For which fuel the sulphur dew point of the flue gases is lower: Furnace oil or Natural gas.

54. What is the range of conversion efficiency of the gasification process using biomass?

55. Calculate the annual power generated from a 100 kW wind turbine generator with a capacity factor of 20%?

56. Define Profitability Index?

57. In a power plant boiler if there is air ingress in the flue duct, which auxiliary system would be most affected?

58. A cogeneration plant with a back pressure turbine has a constant steam demand and fluctuating power demand. What is the common option to meet the fluctuating power demand?

59. What are the two major sources of waste heat available from a water-cooled Diesel Generator set?

60. For determining heat loss in flue gases due to incomplete combustion which flue gas constituent needs to be measured?

61. Which parameter needs to be measured to assess the percentage loading of a motor by slip method neglecting voltage correction?

62. How many volt-amperes (VA) does a 100 Watt incandescent light require?

63. In the indirect method of boiler efficiency evaluation, list any two additional losses computed for solid fuel fired boilers as compared to liquid and gas fired boilers?

64. Why do biomass combustion projects qualify for CDM benefits even though they emit carbon dioxide?

65. Name two most common bio fuels used for transportation

66. Which loss is assumed in the determination of electric motor efficiency?

67. In a shell and tube heat exchanger, engaged in heat transfer between fouling fluid and clear fluid, the fouling fluid should be put on shell side or tube side?

68. While optimizing excess air in a boiler what two parameters should be closely monitored in the exit flue gases?

69. Name any two instruments required for efficiency evaluation of a furnace.

70. Which is more energy efficient for the same ratings – an induction motor or a transformer?

71. What will be the volume percentage of nitrogen in flue gas on dry basis, when pure hydrogen is burned with theoretical air?

72. Name the device that upgrades low temperature heat to high temperature heat.

73. Which loss is unique to boilers and does not occur in furnaces?

74. What is profitability index?

75. Write the relation between COP and kW/TR for a refrigeration system

76. The dry bulb temperature is 30 ^{0}C and the wet bulb temperature is 30 ^{0}C. What is the percentage relative humidity?

77. In what type of furnace, a top pressure recovery turbine is used?

78. In a heat exchanger, the hot fluid inlet and outlet temperatures are 110 °C and 70 °C. The cold fluid inlet and outlet temperatures are 30 °C and 45 °C. The effectiveness of heat exchanger is

79. Name two types of discounted cash-flow techniques used in the financial evaluation of energy saving projects

80. Name two areas of major thermal energy consumption in a cement plant

81. For which fuel the difference between GCV and LCV will be higher, Coal or Natural Gas?

82. What are the two major functions of coke in a blast furnace?

83. For a thermal power plant, which type of heat rate (Gross or Net) has a higher value for the same generator output?

84. Why humidification is required in spinning and weaving sections of textile processing?

85. What is the purpose of 'reheat' in a thermal power plant cycle?

86. In a rotary kiln of cement plant, why % CO_2 in exhaust gases cannot be an indicator of excess air?

87. When you do a walk through energy audit of a cooling tower, which two parameters will you quickly spot check for indication of the cooling tower performance?

88. Which component of a cooling tower enhances heat transfer by maximizing water and air contact?

89. What is the index used to express the harmonics level in an electrical system?

90. The EER of an air conditioner as indicated in BEE Star labeling scheme is represented in_____

91. For the determination of which boiler losses by indirect method, the specific heat of superheated water vapour is used?

92. While reducing excess air in a boiler, what two parameters should be closely monitored in the exit flue gases?

93. Between back pressure turbine and condensing turbine which will have more power generation efficiency?

94. Calculate the boiler efficiency where the Turbine heat rate is 1930 kCal/ kWh and the generating unit heat rate is 2250 kCal/kWh

95. In a power plant boiler, if there is air ingress in the flue gas duct, which auxiliary equipment would be most affected?

96. The loading and unloading of a reciprocating compressor is carried out based on_____

97. In a vapour compression refrigeration system, why the heat rejected in the condenser is more than the heat absorbed in the evaporator?

98. If the unit heat rate is 3120 kcal/kWh and the turbine heat rate is 2808 kCal/kWh what is the boiler efficiency?

99. A rise in conductivity of boiler feed water indicates___

100. Why is it preferable to measure the flow at the inlet side of the fan?

101. The critical point of steam occurs at _bar and_____oC

102. In a heat exchanger___**is t**he ratio of actual heat transfer rate to the maximum heat transfer rate**.**

103. In an integrated steel plant pig iron is produced from__furnace?

104. PLF of a 210 MW power plant is 80% , what is the annual gross generation in MWh

105. A pump operates on water with a total head of 12 m. If water is replaced by brine with a

specific gravity of 1.2 what will be the total head developed by the pump?

106. A draft system in a boiler which uses both FD and ID fan is called…….

107. If EER of a 1.5 TR window air conditioner is 2.5 what will be the power input?

108. What is the significance of monitoring dew point of compressed air for pneumatic instruments application?

109. For a thermal power plant, the percentage auxiliary consumption of a 500 MW unit is ……..than that of a 110 MW unit.

110. Between one litre of 'liquid hydrogen' and one litre of 'liquid gasoline' which will have a higher heat content?

111. Why is the COP of a vapour absorption refrigeration system always less than one?

112. Regenerators utilising waste heat are widely used in_furnaces

113. Why small bypass lines are provided in a centrifugal pump?

114. If the speed of a reciprocating pump is reduced by 50 %, what will be its effect on the head?

115. As the 'approach' increases, the other parameters remaining constant, the effectiveness of cooling tower will _

116. In a DG set, waste heat is used for steam generation. This type of cogeneration is called__cycle.

117. Which loss is not considered while evaluating boiler efficiency by "Indirect Method"?

118. What will be the synchronous speed of a VFD driven 4-pole induction motor operating at 40 Hz?

119. What is the refrigerant used in a vapour absorption system with lithium bromide as an

absorbent?

120. Other than rated kW of motor and the actual power drawn, what other parameter is required to determine the percentage loading of the motor?

121. Inclined tube manometer is used for measuring gas flow in a duct when the air velocity is very high: True or False?

122. A pump will cavitate if the $NPSH_{required}$ is___than the $NPSH_{available}$.

123. To determine the effectiveness of the cooling tower, it is required to measure cooling water inlet, outlet and_temperatures.

124. The ratio of actual heat transfer to the heat that could be transferred by heat exchanger of infinite size is termed as ……

125. If the unit heat rate of a power plant is 3070 kcal/kWh, what is the power plant efficiency?

126. The difference between GCV and NCV of hydrogen fuel is Zero: True or False

127. Why the exhaust temperature of furnace oil is fired systems limited to about 1700C?

128. The net present value of a energy conservation project is Rs.48,784/- and the initial capital investment Rs,2,00,000/- calculate the profitability index of the project.

129. The dry bulb and wet bulb temperatures of air entering an air washer are 35 and 28 0C respectively. If the saturation efficiency is 90 %, calculate the air temperature leaving the air washer.

130. Other than exhaust gas what is the major source of waste heat recovery in a water cooled DG set?

131. In poorly loaded motor, current measurements are not a right indicator of motor loading. Why?

132. If the condenser back pressure is 76 mm Hg, calculate the condenser vacuum. if the atmospheric pressure is 745 mmHg.

133. If the coal GCV is 4000 kcal/kg and specific coal consumption is 0.65 kg/kWh, what is the power station gross efficiency?

134. For a process requiring indirect heating to 200oC, thermic fluid is preferred to steam as a heat carrier. Why?

135. Between a natural gas fired boiler and oil fired boiler which will have a higher percentage of hydrogen loss in flue gas? Why?

136. After cleaning of choked AHU filter, AHU fan power increased. Why?

137. An air washer cools the water and a cooling tower cools the air. True or False.

138. A 11 kW induction motor has an efficiency of 90% what will be its maximum delivered output?

139. The COP of a vapour absorption refrigeration system is lower than the COP of a vapour compression refrigeration system-True /false.

140. An industrial electrical system is operating at unity power factor. Addition of further capacitors will reduce the maximum demand (kVA). True or False.

141. Which parameter in the proximate analysis of coal is an index of ease of ignition?

142. The major source of heat loss in a coal fired thermal power plant is through flue gas losses in the boiler. True or false.

143. With evaporative cooling, it is possible to attain water temperatures below the atmospheric wet bulb temperature. True or False

144. A pump is retrofitted with a VFD and operated at full speed. Will the power consumption increase or decrease or remain the same?

145. De-aeration in boiler refers to removal of dissolved gases. True or false

146. In a compressed air system, the function of the after cooler is to reduce the work of compression. True or False

147. A rise in conductivity of boiler feed water indicates a rise in ____ level of feed water.

148. In a parallel flow heat exchanger the hot fluid inlet temperature is 150 °C . The cold fluid inlet and outlet temperatures are 45 °C and 60 °C. Calculate the effectiveness.

149. Integrated Part Load Value (IPLV) in a vapour compression refrigeration refers to average of ____with partial loads

150. A pure resistive load in an alternating current (AC) circuit draws only reactive power – True or False

151. In a reciprocating air compressor, if the speed is reduced to 80%, the power will reduce by about 50% -True or False

152. If slip of an induction motor increases, the shaft speed also increases – True or False

153. The advantage of evaporative cooling is that it is possible to obtain water temperatures below the wet bulb economically. True or false

154. In a step down transformer for a given load the current in the primary will be more than the current in the secondary. True or false

155. For two pumps to be operated in parallel their _____heads should be the same

156. A fluid coupling changes the speed of the driven equipment without changing the speed of the motor. True or false

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Short Answer Questions

Each question carries **Five** marks

1. Assume that the boiler efficiency is calculated by the direct method using either NCV or GCV.

   (i) What is the difference in the efficiency calculation using NCV or GCV?

   (ii) State an example where boiler efficiency is more than 100%, if not, explain why this is not possible.

2. Which is one of the first essential steps in determining the suitability of a variable speed drive in a pump system? Explain why?

3. (i) List any four common losses of boilers and furnaces.

   (ii) Which loss is unique to boilers and does not occur in furnaces?

4. The suction head of a pump is 5 m below the pump centerline. The discharge pressure is 3 kg/cm^2. The flow rate of water is 100 m^3 /hr. Find out the pump efficiency if the actual power input at the shaft is 12 kW.

5. A centrifugal clear water pump rated for 800 m^3/hr was found to be operating at 576 m^3/hr with discharge valve throttled. The pumps speed is 1485 RPM. The discharge pressure of the pump before the throttle valve is 2 kg/cm^{2}g. The pump draws the water from a sump 4 metres below the centerline of the pump. The input power drawn by the motor is 124 kW at a motor efficiency of 92%.

(i) Find out the efficiency of the pump.

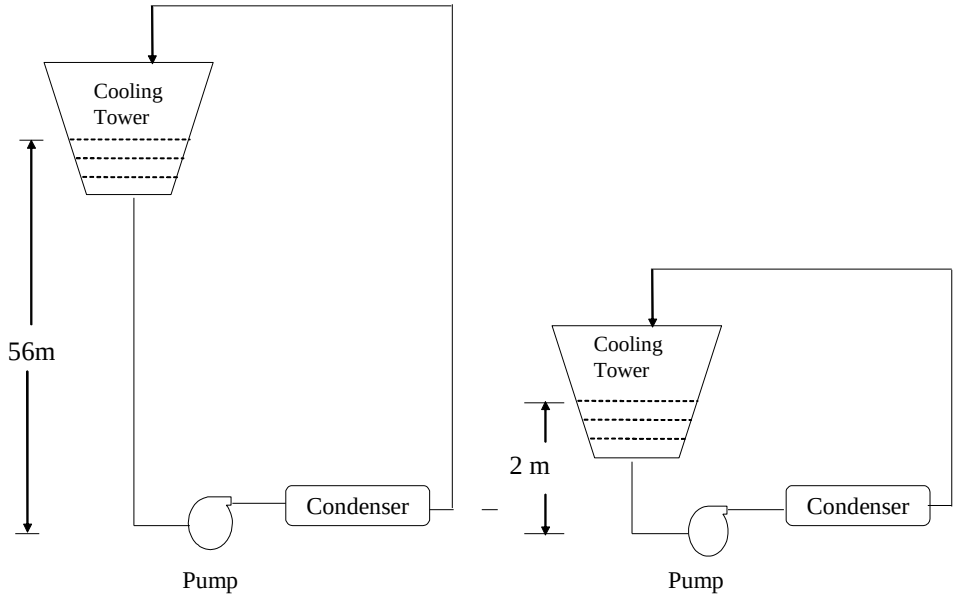
(ii) If the normal required water flow rate is 500 m^3/hr to 700 m^3/hr, what in your opinion should be the most energy efficient option to get the required flow rate variation?

(iii) And what would be the pump shaft power for that most energy efficient option if the pump is delivering the flow rate of 550 m^3/hr.

6. A 30 kW four pole induction motor operating at 50 Hz and rated for 415 V and 1440 RPM, the actual measured speed is 1460 RPM. Find out the percentage loading of the motor if the voltage applied is 425 V.

7. On the recommendations of energy auditor a company replaced a 15 kW, 4 pole standard motor by a 15 kW, 4 pole energy efficient motor for a centrifugal fan. The power consumption of energy efficient motor actually increased, while the grid frequency and voltage remained same. What could be the reason?

8. In a commercial building, an energy auditor recommended to bring down the cooling tower from the terrace to the ground with a view to save energy in the pump. Details are given in the sketch below. Ignoring the friction losses, will this measure save energy? Explain with reason



9. In a heat exchanger, the hot stream enters at 80°C and leaves at 50°C. On the other hand, the cold stream enters at 20°C and leaves the heat exchanger at 50°C. Determine whether the heat exchanger is counter-current type or co-current type.

10. A retail store has 100 numbers of 40 W fluorescent tube lights (FTL). The length and width of a retail store is 15 m and 10 m respectively. The ballast of the FTLs were measured to be 13 W per ballast on an average. The mounting height is 2.4 m from the working plane

and the average maintained illuminance is 900 lux. Determine the room index, Target lux/W/m^2 and annual energy wastage in kWh if the FTLs operate for 5000 hours in a year.

11. A trial for finding out the actual capacity of a reciprocating instrument air compressor of nominal capacity of 900 Nm^3/Hr was done.

    The following observations were made:

    Atmospheric pressure: 1.033 kg/sq.cm

    Ambient temperature: 30 deg. C

    Receiver capacity: 12 m^3

    Additional hold-up volume: 10% of receiver volume

    Initial pressure (after bleeding): 0.2 kg/sq.cm g

    Final pressure (after pump-up): 7.0 kg/sq.cm g

    Pump-up time: 5 min: 30 sec

    Motor power (avg): 105 kW (as per power analyzer)

    Discharge temperature: 45 deg. C

    Calculate:

    i) The actual compressor capacity

    ii) The specific power consumption in kW/nm3/hr

12. The following parameters were observed during the performance testing of pump.

    Flow rate of fluid: 900m3/hr.

    Density of fluid: 950kg/m3

    Discharge pressure: 5.0kg/cm2(a)

    Suction head: 5 metre above the pump centerline.

    Measured power: 180kW

    Motor efficiency: 90%

    Calculate the pump efficiency.

13. The suction head of a pump is 5 m below the pump centerline. The discharge pressure is 4 kg/cm^2. The flow rate of water is 100 m^3 /hr. Find out the pump efficiency if the actual power input at the shaft is 15 kW.

14. Calculate the blow down rate for a boiler with an evaporation rate of 3 tons/hr, if the maximum permissible TDS in boiler water is 3000 ppm. The make-up water addition rate is 10 % and the feed water TDS is around 250 ppm.

15. The steam flow to a process plant is 5000 kg/hr. 2000 kg/hr of condensate at 173°C is returned to boiler feed water tank due to its own pressure. However there is 10% heat loss in transit to boiler feed tank. The balance is made up as feed water at 30°C. The final feed water temperature observed was 95°C. Comment on the feed water temperature. The plant personnel are sure that the temperature gauge is in order.

16. The maximum demand registered by an automobile plant is 5000 KVA and the power factor is 0.95. The plant management converts the existing electrical resistance heated furnace with an average load of 750 kW to gas heating as a cost reduction measure. What will be effect on maximum demand and power factor with this conversion?

17. In a double pipe heat exchanger hot fluid is entering at 220 °C and leaving at 115 °C. Cold fluid enters at 10 °C and leaves at 75 °C. The mass flow rate of the hot fluid is 100 kg/hr, C_p of hot fluid 1.1 kCal/kg°C and C_p of cold fluid 0.95 kCal/kg°C. Calculate LMTD, if the flow is counter current.

18. Determine the actual output power of an induction motor using the following data?

No. of poles	= 2
Frequency	= 50 Hz
Rated voltage	= 415 V
Name plate full load speed	= 2980 rpm
Measured speed at 430 V	= 2989 rpm
Name plate rated power	= 22 kW

19. The following are the operating parameters of a regenerative feed water heater in a thermal power plant

Saturation temperature of steam to heater	- 84.3 °C
Inlet feed water temperature	- 44 °C
Outlet feed water temperature	- 75 °C
Drain outlet temperature	- 58.4 °C

Calculate the Terminal Temperature Difference (TTD) and Drain Cooler Approach (DCA).

20. In a 30 kW four pole induction motor operating at 49.9 Hz and rated for 415 V and 1470 RPM, the actual measured speed is 1485 RPM. Find out the percentage loading of the motor if the voltage applied is 425 V.

21. An open cycle gas turbine was running with naphtha as fuel. The following are the data collected during the gas turbine operation:

Fuel (Naphtha) consumption	: 180 kg/hr
GCV of naphtha fuel	: 11500 kCal/kg

Overall Efficiency of gas turbine which includes
air compressor and alternator : 25%
Cost of naphtha fuel : Rs.40,000/Ton

Find out the cost of fuel for generating one unit of electricity.

22. In an air conditioning duct 0.5 m x 0.5 m, the average velocity of air measured by vane anemometer is 28 m/s. The static pressure at suction of the fan is -20 mmWC and at the discharge is 30 mmWC. The three phase induction motor draws 10.8 A at 415 V with a power factor of 0.9. Find out the efficiency of the fan if motor efficiency = 90% (Neglect air density correction).

23. Calculate pressure drop in meters when pipe diameter is increased from 250 mm to 300 mm for a length of 600 meters. Water velocity is 2 m/s in the 250 mm diameter pipe and friction factor is 0.005.

24. A three phase 37 kW four pole induction motor operating at 49.8 Hz is rated for 415 V, 50 Hz and 1440 RPM. The actual measured speed is 1460 RPM. Find out the percentage loading of the motor if the voltage applied is 410 V.

25. An automobile plant has a maximum demand of 5000 kVA at a PF of 0.95. The plant has shifted its electric annealing furnace with a steady resistive load of 600 kW to its foundry unit in a nearby location after suitable modifications. What will be the new PF of the automobile plant without the electric annealing furnace?

26. In a medium sized engineering industry a 340 m3/hr reciprocating compressor is operated to meet compressed air requirement at 7 bar. The compressor is in loaded condition for 80% of the time. The compressor draws 32 kW during load and 7 kW during unload cycle.

After arresting the system leakages the loading time of the compressor came down to 60%. Calculate the annual energy savings at 6000 hours of operation per year

27. Hot water at 80 ^{o}C is used for room heating in a 5 Star hotel for 4 months in a year. About 200 litres per minute of hot water is maintained in circulation with the return temperature at 50 ^{o}C. The hot water is generated using a „hot waste stream", through a Plate Heat Exchanger (PHE). The hot stream enters the PHE in counterflow direction at 95 ^{o}C and leaves at 60 ^{o}C. The area of the heat exchanger is 20 m^2.

Calculate the LMTD and the overall heat transfer coefficient.

28. A gas turbine generator is delivering an output of 20 MW in an open cycle with a heat rate of 3440 kcal/kWh. It is converted to combined cycle plant by adding heat recovery steam

generator and a steam turbine raising the power generation output to 28 MW. However, with this retrofitting and increased auxiliary consumption, the fuel consumption increases by 5% in the gas turbine

Calculate the combined cycle gross heat rate and efficiency.

29. A pump is drawing water through a 150 mm diameter pipe with a suction head of 3.5 m below the pump centre line. Find out the pump efficiency if the actual power input the motor is 17.6 kW at a motor efficiency of 90 %. The discharge pressure is 4.5 kg/cm2 and the velocity of water through the pipe as measured by an ultrasonic flow meter is 1 m/s.

30. A luxury hotel is using a diesel fired heater with an efficiency of 70% for supplying hot water at 55oC from an initial temperature of 20oC. The hot water requirement is 24,000 litres per day.
The management is considering to install a specially designed electric heat pump for the specific high hot water temperature requirement with a heat pump coefficient of performance (C. O. P.) of 2. Find out the reduction in daily operating cost with heat pump in place of diesel fired heater ignoring auxiliary energy consumption. The following data are given.

Electricity cost = Rs.10/kWh
Diesel cost = Rs.50/litre
G.C.V. of diesel = 9100 kcal/litre

31. In a petrochemical industry the LP & HP boilers have the same evaporation ratio of 14 using the same fuel oil. The operating details of LP & HP boiler are given below:

Particulars	LP Boiler	HP Boiler
Pressure	10 Kg./cm2a	32 Kg./cm2a
Temperature	Saturated Steam	400oC
Enthalpy of steam	665 Kcal/kg	732 Kcal/kg
Enthalpy of feed water	80oC	105oC
Evaporation Ratio	14	14

Find out the efficiency of HP boiler if the LP boiler efficiency is 80%.

32. While carrying out an energy audit of a pumping system, the treated water flow (in open channel) was measured by the tracer method. 20% salt solution was used as the tracer which was dosed @ 2 lts/min. The water analysis about 500 mtrs away revealed salt concentration of 0.5%. Assuming complete mixing and no losses, calculate the water flow rate.

33. In a Process Industry the L.P and H.P boilers have the same efficiency of 83%. The operating parameters and data are given below:

Boiler	**L.P. (Low Pressure)**	**H.P. (High Pressure)**
Efficiency on G.C.V.	83%	83%
Fuel	Furnace Oil	Furnace Oil
G.C.V.	10,000 Kcal/Kg.	10,000 Kcal/Kg.
Steam enthalpy	666 Kcal/Kg.	737 Kcal/Kg.
Feed water temperature	95^{o}C	105^{o}C

The cost of steam from L.P boiler is Rs. 3000 per tonne. Find out the cost of steam from H.P boiler

34. A shell-and-tube heat exchanger with 2-shell passes and 8-tube passes is used to heat ethyl alcohol (Cp= 2670 J/kgoC) in the tubes from 25oC to 70oC at a rate of 2.1 kg/s.
The heating is to be done by water (Cp= 4190 J/kgoC) that enters the shell side at 95oC and leaves at 45oC.
The LMTD correction factor for this heat exchanger is 0.82
If the overall heat transfer coefficient is 950 W/m2oC, determine the flow rate of water in kg/s and surface area of the heat exchanger in m2.

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Numerical Questions

Each question carries **Twenty** marks

1. Determine the simple payback period of the incremental investment for two transformers with the following details:

	Option A	Option B
Capacity	500 kVA	500 kVA
Efficiency at rated capacity	98%	98.5%
Capital cost	Rs. 3.15 lakhs	Rs. 4.05 lakhs

Assume the following for both the transformers

Operating PF at rated capacity	= 0.9
No load losses	= same
Energy charge	= Rs. 4.50/kWh

For the analysis consider two cases for the length of time during which the transformers are used at rated capacity

(a) 10 hours/day and 250 days/year of operation
(b) 16 hours/day and 300 days/year of operation

Two solutions are possible depending on whether the kVa is taken as transformer input or output. Both are acceptable

2. A reciprocating single stage compressor coupled with an electric motor has a mechanical shaft power requirement of 50 kW at a discharge pressure of 700 kPa. Determine the energy cost savings if the discharge pressure is reduced to 600 kPa for both isothermal and adiabatic compression processes. Assume the following for the existing and modified pressure conditions:

Intake air pressure = 1 atmosphere, motor operating efficiency = 90%

Average load factor = 75%, operating hours = 8000 hours/year

Average energy charge = Rs. 4.5/kWh

No change in remaining parameters

3. It is proposed to install at the beginning of the year a heat recovery equipment in a food processing industry. The capital cost of the equipment is Rs 20,000/. The savings accrued by the unit are constant and Rs 5,000/- annually. The discount rate is 8%.

(i) Calculate the Net Present Value (NPV) for 5 years.
(ii) Is the investment recovered after 5 years? Explain!
(iii) Is the investment recovered after 7 years? Explain!

(iv) Estimate the IRR for this investment after 7 years if the salvage value of the equipment is Rs 2,000 at the end of 7th year.

4. The following are the data collected for a boiler using furnace oil as the fuel. Determine the boiler efficiency based on GCV by indirect method ignoring radiation and convection losses.

Ultimate chemical analysis (% weight): Carbon: 84, Hydrogen: 12, Nitrogen: 0.5, Oxygen: 1.5, Sulphur: 1.5, Moisture: 0.5, NCV of fuel 9,763 kCal/kg and humidity 0.025 kg moisture /kg of dry air.

Flue gas analysis: CO_2: 9.8% volume, flue gas exit temperature: 190°C and ambient temperature: 30°C.

5. You as an energy auditor have the task to quickly assess within 20 minutes the technical/ financial performance of a paddy husk fired power plant to be installed.

The plant owner provided you the following information.

- Nominal capacity : 7 MW
- Assumed plant load factor : 0.75
- Number of hours of operation : 8760/ year
- Analysis of paddy husk

Fuel property	Weight %
Moisture	10.79
Mineral Matter	16.73
Carbon	33.95
Hydrogen	5.01
Nitrogen	1.00
Oxygen	32.52
GCV (kCal/kg)	3,568

Provide solutions to the following to the plant owner.

(i) Tonnes of paddy husk to be fired per year if the power plant has an overall efficiency of 25%.

(ii) The area required in square meters to store an inventory of paddy husk 30 cm high for 4 days of operation. Assume paddy husk bulk density of 100 kg/m^3.

(iii) Power plant capital cost is Rs. 28 crores and rice husk cost as delivered is Rs. 1500/ tonne. Annual repair, maintenance and operation costs are 10% of capital costs. What is the simple payback period if electricity is sold at Rs.3/kWh.

6. A performance evaluation of a large air fan resulted in the following data.

Pitot tube measurement average Velocity pressure	: 75 mm water column
Suction pressure	: - 20 mm water column
Outlet pressure	: 480 mm water column
Area of duct	: 8 square meter
Pitot tube constant	: 0.85
Corrected gas density	: 1.15 kg/ m^3

(i) Calculate flow in m^3/sec.

(ii) Calculate the static fan efficiency based on the following 3 phase motor data.

Line current	:	100 Amps
Line voltage	:	11,000 volts
Power factor of electric motor	:	0.9

Efficiency of motor at the operating load is 95%.

7. A multi-storied shopping mall has installed 5 x 110 TR reciprocating compressors of which four compressors are in use and fully loaded for 14 hours per day. The specific power consumption of reciprocating compressor is 0.8 kW/TR. Due to higher energy cost the shopping mall chief engineer has decided to replace reciprocating compressors with screw compressors having specific power consumption of 0.65 kW/TR. The chief engineer needs following input from energy consultant:

(i) Comparison of power and electricity consumption of both reciprocating and screw compressors?

(ii) Annual energy bill savings (for 320 days operation). Present unit cost is Rs 6.00 per kWh

(iii) What should be the size of cooling tower required for proposed screw compressors?

8. (i) What is the total weight of flue gas generated when 20 kg of Methane (CH_4) is burned with 10% excess air?

(ii) How much heat will be recovered from the flue gas by providing an additional water heater if the flue gas is cooled from 300^0 C to 140^0 C?

Additional Information:

Atomic weights C=12, H = 1, O = 16;

Specific heat of flue gas = 0.24 kCal/kg^{o}C).

Assume combustion air is 77% Nitrogen (N_2) and 23% Oxygen (O_2) by weight.

9. A process plant requires 28 tons of steam per hour and 2250 kW of electric power. The plant operates for 8000 hours per annum. Steam is generated at 2 bar (g) in a coal fired boiler with an efficiency of 75%. The feed water temperature is 80^OC. The calorific value of coal is 4000 kcal/kg. The cost of coal is Rs. 2000/ton. Power is drawn from the grid at Rs. 4/kWh. The contract demand is 3000 kVA with the electricity supply company and the plant is charged for 100% of the contract demand at Rs. 300/kVA/month. The plant has never exceeded its contract demand in the past.

The plant is planning for a back pressure cogeneration system using the same coal with the following parameters. The power and steam demand are to be fully met by the cogeneration plant and a contract demand of 1000 kVA with the grid is to be kept for emergency purposes.

Find out the IRR over a project life cycle of 6 years for the proposed cogeneration system

<u>Cogeneration System data</u>:

Boiler generation pressure	- 18 bar (g), 310^OC
Boiler efficiency	- 81%
Investment required	- Rs. 20 crores
Generated power	= 2250 kW

<u>Steam enthalpy data</u>:

Total enthalpy at 2 bar (g)	= 647.13 kcal/kg
Total enthalpy at 18 bar (g), 310^{o}C	= 730.28 kcal/kg

10. In a double pipe heat exchanger hot fluid is entering at 220°C and leaving at 115°C. Cold fluid enters at 10°C and leaves at 75°C. The following data is provided for hot and cold fluids.

Mass flow rate of hot fluid = 100 kg/hr

Cp of hot fluid = 1.1 kcal/kg°C

Cp of cold fluid = 0.95 kcal/kg°C

(i) Calculate LMTD

a) For parallel flow

b) For counter current flow

(ii) Which flow arrangement is preferable and why?

(iii) Find the mass flow rate of cold fluid if the heat loss during the exchange is 5%.

11. An efficiency trial was conducted in furnace oil fired boiler during the conduct of energy audit study and the following data were collected.

Boiler Data:

Rated capacity = 10 TPH (F&A 100°C)

Rated efficiency = 84%

Actual steam generation pressure = 7 kg/cm^2 (g) saturated

Feed water temperature = 45°C

Boiler was found to be operating at rated steam pressure and flow conditions

Furnace Oil Data:

Furnace oil consumption = 600 litre per hour

GCV of oil = 10200 kcal/kg

Specific gravity of oil = 0.92

% Carbon = 84%

% Hydrogen = 12%

% Sulphur = 3%

% Oxygen = Nil

% Nitrogen = 1%

Cost = Rs. 20/kg

Flue Gas Data:

% O_2 in flue gas = 5.5% by volume

CO in flue gas = Nil

Flue gas temperature = 240°C

Specific heat of flue gas = 0.24 kcal/kg°C

Moisture in ambient air = 0.03 kg/kg of air

Ambient air temperature = 40°C

Assume surface heat and unaccounted losses = 2%

Determine the following:

(i) Boiler efficiency by indirect method

(ii) Find out the annual savings in Rs per year if the boiler was operating at its rated efficiency.

(iii) Also suggest possible measures to improve the efficiency of the boiler.

12. A V-belt centrifugal fan is supplying air to a chemical process. The performance test on the fan gave the following parameters.

Ambient temperature	40°C
Density of air at 0°C	1.293 kg/m^3
Diameter of the discharge air duct	1 m
Velocity pressure measured by Pitot tube in discharge duct	47 mmWC
Pitot tube coefficient	0.9
Static pressure at fan inlet	- 22 mmWC
Static pressure at fan outlet	188 mmWC
Power drawn by the motor coupled with the fan	72 kW

Belt transmission efficiency	95%
Motor efficiency at the operating load	90 %

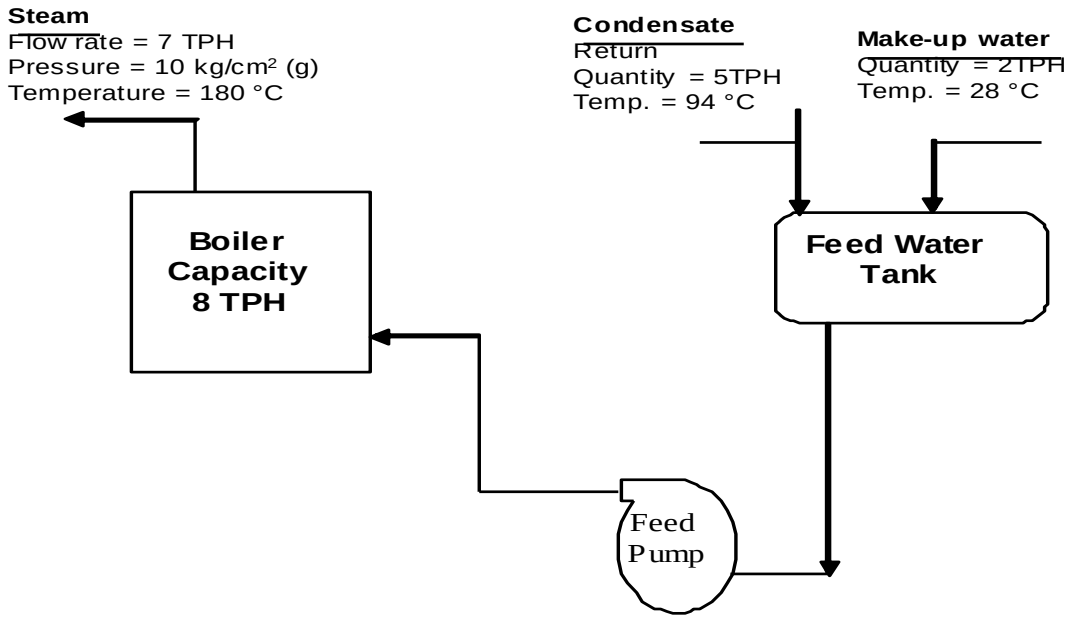
(i) Find out the efficiency of the fan.

(ii) Due to modification in the chemical process, only half of the operating flow will be required in future. This is to be effected by damper control method. The fan characteristic curve shows that the total static head developed by the fan will be 333 mmWC and static fan efficiency will be 61% by damper control method.

Find out what will be the annual savings at 8000 hours of operation per year and an energy cost of Rs. 4.50 /kWh. Assume that the motor efficiency and belt transmission efficiency remains same.

(iii) List down the various energy conservation options to achieve the modified flow rate.

13. An energy auditor undertakes the energy audit of a steam system. The operating data is given as per the schematic diagram given below



Key data and assumptions are enunciated below:

a) Specific enthalpy of water at 10 kg/cm^2 (g) pressure : 186 kCal/kg

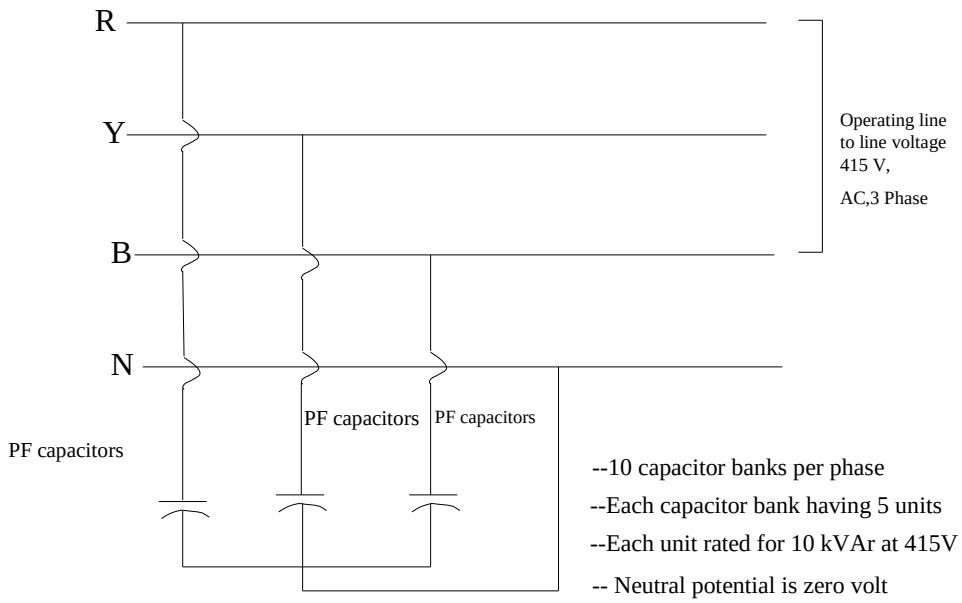
b)	Specific enthalpy of evaporation/latent heat at 10 kg/cm^2 (g) pressure	:	478 kCal/kg
c)	Dryness fraction of steam generated	:	0.95
d)	Coal consumption	:	840 kg/ hr
e)	Net calorific value (NCV) of imported coal	:	6269 kCal/kg
f)	Moisture in coal	:	3.5%
g)	Hydrogen in coal	:	4%
	Other parameters as indicated in the above figure	:	

Based on preliminary data assessment as stated above, calculate the following:

i. Feed water temperature to boiler
ii. Boiler efficiency by direct method on GCV basis
iii. If the condensate return is enhanced to 6 TPH (steam generation of 7 TPH remaining same) what will be the reduction in coal consumption?

14. A process industry invites an energy auditor to suggest ways and means to reduce the maximum demand on the grid supply. The process industry has a contract demand of 3940 kVA with Electricity Supply Company. The average monthly maximum demand is recorded as 3250 kVA at the power factor of 0.9. The process industry has to pay minimum demand charges of 75% of the contact demand to the electricity supply company.

After analyzing the electricity bill, the auditor studies the existing PF capacitors installation at the plant LT substation bus bar and observes the following connections.



The auditor observes that, there are 10 capacitor banks per phase, each bank comprises of 5 units of PF capacitors and each unit is rated for 10 kVAr at 415 V. Give your answer on the following

a) What is the optimum limit of Power factor improvement, so that plant avoids paying demand charges over and above the minimum demand charges?
b) What would be the annual maximum demand charge saving if the existing power factor is improved to optimum power factor (MD charges @ Rs. 300/- per kVA per month) ?
c) What is the additional PF capacitors kVARs requirement to achieve the desired PF?
d) What is the present operating capacity of PF capacitors installation at the LT substation bus bar?
e) Whether energy auditor would still recommend installation of extra power factor capacitors in the above situation to achieve the additional PF capacitors kVARs requirement with the existing capacitors installation at the LT bus bar? Support your answer with reasons.

15. Government of India has undertaken various schemes to promote energy efficiency in the country. In the last one year implementation of these schemes have resulted in savings as given below:

S. No.	Name of the scheme	Energy Source	Units	Quantity Saved

1	Energy Efficiency in Buildings	Electricity from grid	Million kWh	62
2	Energy Efficiency in Industries	Electricity from Grid	Million kWh	1216
		Electricity from Captive Diesel Generation	Million kWh	1000
		Fuel Oil	Lakh kilo liter	1.85
		Coal	Lakh tons	3.5
		Natural Gas	Lakh Sm^3	15728
3	Domestic Appliance Labelling Scheme	Electricity from grid	Million kWh	1374
4	Various other schemes as reported by different States exclusive of GOI schemes	Electricity from grid	Million kWh	635
		Thermal Energy Saved	MTOE	80702

Given that:

1 kWhr = 860 kCal
GCV of Coal = 4000 kCal/ kg
GCV of Natural Gas = 8500 k Cal/Sm^3
Assuming GCV of fuel Oil & Diesel = 10000 kCal/kg
Specific gravity of fuel Oil = 0.94, & for diesel 0.85
Assume average Transmission and Distribution Losses in India = 20%
Average Plant Load Factor = 78%
Specific diesel consumption = 3.5 kWh/ltr

Calculate : i) Total Energy Saved in MTOE (metric ton oil equivalent)
ii) Total Generation Capacity Avoided (in MW) in the country because of energy savings due to grid connected power.

16. A pharma unit had installed a centralized refrigeration system of 120 TR Capacity several years ago. The refrigeration system operators 24 hours a day, 200 days per annum and the average electricity cost is Rs. 4.5/ kWh. The following are the key operational parameters.

- Compressor operating current and power factor : 153 amps. 0.9 pf
- Condenser pump operating current and power factor: 43 amps, 0.88 pf
- Chiller pump operating current and power factor : 25 amps, 0.9 pf
- CT fan operating current and power factor : 20 amps. 0.65 pf
- ΔT across the chiller (evaporator) : $3.5^{O}C$
- Chilled water flow : 23 Lit / Sec
- Total head developed by chiller pump : 35 mtrs.

- Condenser water flow : 41 Lit / Sec
- Total head developed by condenser pump : 30 mtrs.

PS: *all the motors operate at 415 Volts:*

Calculate:

- The power consumed by the compressor, condenser pump, chiller pump and CT fan.
- TR developed by the system
- Specific power consumption i.e. overall kW/TR and COP and Energy Efficiency ratio (EER)
- Combined efficiency (motor and pump) of condenser and chiller pumps

The unit proposes to replace the existing condenser and chilled water pumps with efficient pumps having a combined efficiency of 65%. Also the unit goes in for condenser cleaning by which the power consumption of compressor has reduced by 10%.

Calculate:

- The envisaged power consumption of the compressor, condenser and chiller pump
- Hourly energy savings (compressor, condenser and chilled water pump)
- Annual energy and equivalent monetary savings (compressor, condenser and chilled water pump)
- Specific power consumption i.e. overall kW/ TR and COP and Energy Efficiency ratio (EER)

17. A fertilizer plant consuming 100TPH of saturated steam at 45 kg/sq.cm pressure has been using Indian coal as fuel to the boiler and is now switching over to imported coal.

Typical ultimate analysis of the two types of coals:

Parameters	Indian coal %	Imported coal %
Carbon	41.11	58.96
Hydrogen	2.76	4.16
Nitrogen	1.22	1.02
Oxygen	9.89	11.88
Sulphur	0.41	0.56
Moisture	5.98	9.43
Ash	38.63	13.99
GCV (kCal/kg)	4,000	5,900

Determine:

(i) Coal requirement in each case

(ii) Calculate % dry flue gas losses in both cases

Assume: in both cases

Flue gas temperature = 200^{o}C

Ambient temperature = 30^{o}C

Enthalpy of steam = 668 kCal/kg

Feed water temperature = 80^{o}C

Specific heat of flue gases = 0.23

Boiler efficiency with Indian coal = 75%

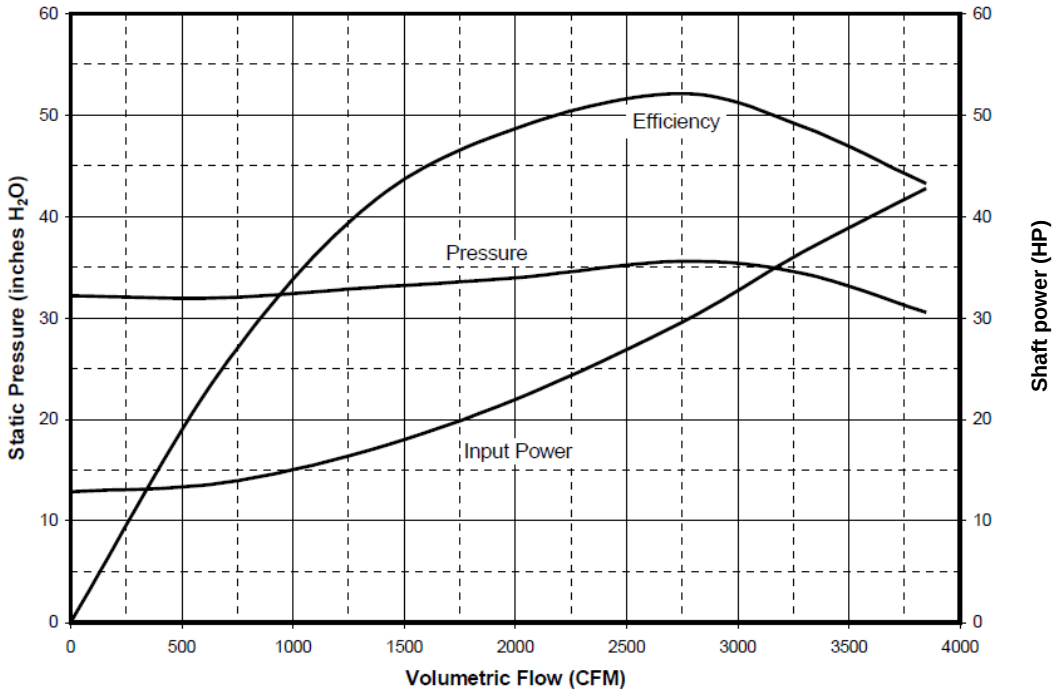
Boiler efficiency with Imported coal = 82%

Oxygen content in flue gases with Indian coal = 10%

Oxygen content in flue gases with Imported coal = 4%

18. Given below is a set of curves for a centrifugal fan. At its Best Efficiency Point (BEP) determine to the **nearest approximation** the following:

a) Static pressure in mmwc
b) Flow in m^3/hr
c) Shaft power in kW
d) Work out the static efficiency of the fan by calculation
e) Power drawn by the motor if the motor operating efficiency is 90%



19. In a Continuous Process Industry 5 Tonne per hour hot oil on process stream has to be cooled from 230°C to 110°C by DM water at 25°C heated to 80°C on its route to boiler de-aerator.

(i) Depict the heat exchange process on a schematic for both parallel and counter flow heat exchanger clearly indicating inlet and outlet temperature and terminal temperature difference.

(ii) Find out LMTD for parallel and counter flow heat exchangers and comment on the preference of the heat exchanger.

(iii) Find out the DM water flow rate through the heat exchanger. Assume specific heat of hot oil to be 0.5 kCal / kg°C.

20. The following are the data collected for a boiler using furnace oil as the fuel. Determine the boiler efficiency based on GCV by indirect method ignoring radiation and convection losses.

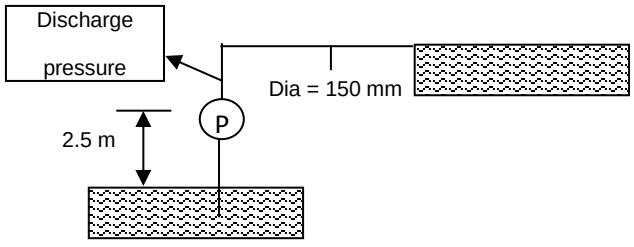
Ultimate chemical analysis (% weight) : Carbon : 84, Hydrogen : 12, Nitrogen : 0.5, Oxygen : 1.5, Sulphur : 1.5, Moisture : 0.5, GCV of fuel 10,397 kCal/kg and humidity 0.015 kg moisture/kg of dry air.

Flue gas analysis: CO_2 : 12% volume, flue gas temperature : 180°C and ambient temperature : 20°C

21. A process plant is installing a 5 MW gas turbine cogeneration system with 12 TPH waste heat boiler to meet the power and steam demand of the plant. The plant will operate at 90% of capacity, meeting the entire power requirement of the plant, which is presently drawn from grid supply. The co-gen plant will also meet the steam requirement of 10 TPH, which is presently generated in a gas fired boiler with 86% efficiency on N.C.V. basis. Calculate the differential cost between cogenerated power and grid power per unit and also the additional natural gas requirement per day based on the following data.

Capacity of gas turbine	=	5000 kW
Plant load factor	=	90%
Auxiliary power consumption	=	1%
Operating hrs. per annum	=	8000
Net calorific value of natural gas	=	9500 kCal / Sm^3
Cost of natural gas	=	Rs.8 / Sm^3
Steam produced by co-gen waste heat	=	10 TPH boiler
Annual expenditure towards depreciation and interest	=	Rs 500 lacs
Annual expenditure for operation & maintenance of co-gen plant	=	Rs 200 lacs
Heat Rate of gas turbine on NCV	=	3050 kCal / kWh
Cost of electric power from grid supply	=	Rs. 4.5/ kWh
Enthalpy of steam	=	665 kCal/ kg
Feed water temperature	=	85°C

22. i) Analyze the following figure and answer the questions with brief justification (Note: No calculation is required for the answer to be given and answer should not be more than 3 sentences for each part)



Pump rated parameters

Flow (Q) : 30 lps

Head (H) : 18 m

a) In normal operation what will happen to the operating flow rate compared to rated value and why?

b) In normal operation what will happen to the operating efficiency compared to rated value and why?

ii) Match the following

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 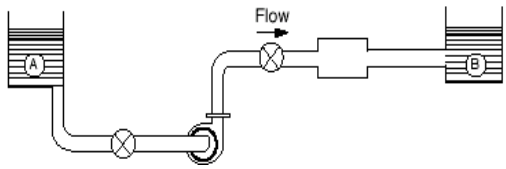
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 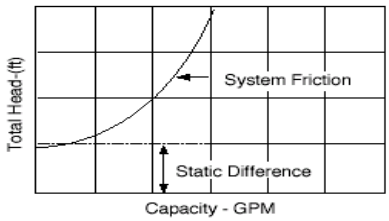
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 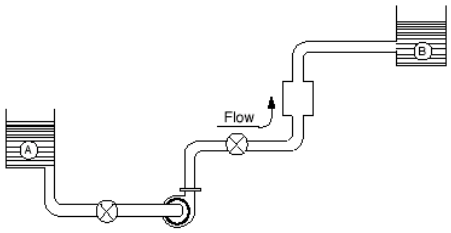
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 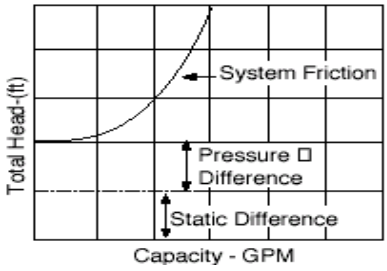
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 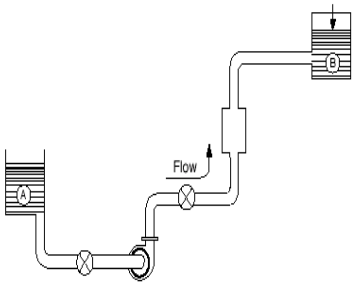
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 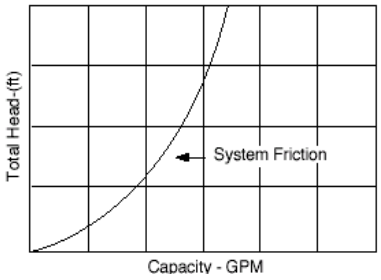
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23. A plant has a compressor of capacity 1680 m^3/hr. Free air delivery of the compressor is carried out by filling the receiver.

<u>The test data are as follows:</u>

Receiver capacity	: 10 m^3
Interconnecting pipe	: 1 m^3
Initial pressure in receiver	: 1.0 kg/cm^2a
Inlet air pressure to compressor	: 1.0 kg/cm^2a

Final pressure	: 8.25 kg/cm^{2}a
Time taken to fill the receiver	: 3 minutes (180 seconds)
Inlet air temperature	: 30 ^{o}C
Air temperature in the receiver	: 40 ^{o}C
Motor rpm (D1)	: 1400
Motor pulley diameter (N1)	: 300mm
Compressor rpm (D2)	: 700 rpm
Compressor Pulley diameter (N2)	: 600 mm
Average duration of loading	: 40 minutes in an hour
Average duration of unloading	: 20 minutes in an hour
Power consumption during loading	: 150 kW
Power consumption during unloading	: 25 kW
Cost of energy	: Rs. 5.00 per kWh

a) Find the Free air delivery of the compressor and % output when compared to rated capacity.

b) Evaluate average hourly consumption of air.

c) How much energy (kWh) will the compressor consume in an hour and in a day. Also evaluate the cost of energy per day (24 hours operation).

d) Evaluate the specific power (cfm/kW) during loading period and overall specific power after considering the loading & unloading of compressor.

e) Plant was interested to reduce the unloading time of the compressor by reducing the pulley diameter of the motor. Evaluate the speed of the compressor required for 10 minutes unloading and 50 minutes loading and accordingly evaluate the diameter of the pulley of the motor

24. A chemical plant is using furnace oil as fuel for firing in their boiler, generating steam on an average of 20 T/hr. The unit has decided to take advantage of carbon credits under CDM and accordingly decided to switch over to natural gas as fuel. The boiler feed water temperature is 80 ^{0}C and enthalpy of steam is 660 kCal/kg.

The other data are as under:

Furnace Oil

GCV of furnace oil	: 10200 kCal/kg
Cost of furnace oil	: Rs. 30000/T
% Carbon in furnace oil	: 84
Efficiency of furnace oil fired boiler	: 82%

Natural Gas

Calorific value of Natural gas	: 9500 kCal/Sm^3
Density of natural gas	: 0.8 kg/Sm^3
Cost of natural gas	: Rs. 20/Sm^3
% Carbon in natural gas	: 74
Annual operating hours	: 8000
Efficiency of natural gas fired boiler	: 86%
Value of one CER	: Rs. 400

Calculate the following

a) Annual monetary savings due to switch over from furnace oil to Natural gas.

b) Calculate the annual monetary savings due to carbon trading.

25. Flow rates of the hot and the cold water streams flowing through a heat exchanger are 12 and 30 kg/min, respectively. Hot and cold water stream inlet temperatures are 72 °C and 27 °C, respectively. The exit temperature of the hot stream is required to be 52 °C. The specific heat of water is 4.179 kJ/kg K. The overall heat transfer coefficient is 800 W/m^2 K.

    Neglecting the effect of fouling, calculate the heat transfer area for

    a) Parallel-flow
    b) Counter-flow

26. In an air conditioning system of a food processing industry, the cold air flow rate is 20,000 m^3/hr at a density of 1.2 kg/m^3 .The inlet and outlet enthalpy of the air are 105 kJ/kg and 80 kJ/kg. The COP of the existing vapour compression system is 3.75. The efficiency of the motor coupled with the compressor is 90%.

    The management wants to install a Vapour Absorption System (VAR).The saturated steam for VAR will be supplied either from a new waste heat boiler to be installed with the existing

DG sets or from the existing FO fuel fired boiler. The plant is operating for 8000 hr/annum. The investment of VAR system is Rs. 20 lakhs. The investment for waste heat boiler is Rs. 6 lakhs. The power cost is Rs. 6/kWh.

As an energy auditor which one of the following options will you recommend to the management?

Option1: Supply steam from the existing FO fuel fired boiler to VAR system and avoid the investment of waste heat boiler

Option2 - Supply steam from the waste heat boiler, which needs an investment in addition to VAR system

The steam consumption per TR will be 5.5 kg/TR. The cost of FO is Rs.32,000/ tonne. The evaporation ratio of the existing FO fired boiler is 14. Neglect losses in transmission of steam and chilled water.

27. The following are the data obtained from a pulverized coal fired thermal power plant

Main steam pressure and temperature	: 155 kg/cm^2 (g), 540 ^{o}C
Main steam flow rate	: 624 TPH
Enthalpy of main steam	: 815.2 kCal/kg
Feed water temperature	: 229 ^{o}C
Cold reheat steam pressure and temperature	: 36 kg/cm^2(g), 330 ^{o}C
Enthalpy of cold reheat steam	: 730 kCal/kg
Hot reheat steam pressure and temperature	: 35 kg/cm^2(g), 540 ^{o}C
Enthalpy of hot reheat steam	: 844.5 kCal/kg
Reheat steam flow	: 563 TPH
Generator output	: 207.3 MW
Boiler efficiency	: 85.5%
Back pressure	: 0.9 kg/cm^2 (g)
Condenser CW inlet temperature	: 26 ^{o}C
Condenser CW outlet temperature	: 37 ^{o}C
Exhaust steam saturation temperature	: 45.4 ^{o}C
Enthalpy of wet steam at vacuum	: 508 kCal/kg
Condenser CW flow	: 24800 m^3/hr

Calculate

a) Turbine heat rate, unit heat rate and turbine cycle efficiency
b) Condenser heat load, effectiveness and calculated condenser vacuum in millibar

28. a) What are the major advantages of using sinter in a Blast furnace

b) A furnace is fired with blast furnace gas having an analysis by volume as follows

CO_2 – 13 %, CO – 25 %, H_2 - 3.5 %, N_2 – 58.5 %

Calculate the percentage of excess air when the dry product of combustion contains 3.5 % O_2

29 a) 125 kg of fabric is to be dyed in a jigger. The dye liquor is heated from 30 ^{0}C to 90 ^{0}C. Calculate steam (steam enthalpy 660 kCal/kg) requirement per batch and specific steam consumption (kg of steam per kg of cloth), if liquor ratio is 1:6.5; allowing 10% margin for losses.

b) In a textile mill, a thermic fluid heater of 15 lakh kCal/hr capacity is meeting process heat requirements.

The observed parameters of thermic fluid heater are:

Thermic fluid circulation rate	- 100 m^3/hr
Outlet temperature of fluid	- 270 ^{0}C
Return temperature of fluid	- 256 ^{0}C
Specific heat of fluid	- 0.55 kCal/kg ^{0}C
Density of fluid	- 830 kg/m^3
Present coal consumption	- 300 kg /hr
GCV of coal	- 3500 kCal/hr

i) What is the % loading of the thermic fluid heater?

ii) What is the existing thermal efficiency?

iii) The management is proposing to add a five chamber, (each chamber 1 Lakh kCal/hr duty) to the heater. Will it be able to take the load?

30. Calculate the efficiency of the Atmospheric Fluidised Bed Combustion Boiler by indirect method using the following data:

Analysis of blended coal (% by mass)

Carbon	:	53.9 %
Hydrogen	:	3.1 %
Nitrogen	:	1.1 %
Sulphur	:	0.3 %
Ash	:	23.8 %
Oxygen	:	10.5 %
Moisture	:	7.3 %
GCV	:	5060 kCal / kg

The boiler operating parameters are given below.

Steam pressure	:	62.0 kg / cm^2g
Steam temperature	:	470 ^oC
Actual air supplied	:	8.91 kg/kg of coal
Mass of dry flue gas	:	9.31 kg/kg of coal
Specific heat of flue gas	:	0.23 kCal/kg ^oC
Flue gas temperature	:	160 ^oC
CO_2 in flue gas	:	14.7 %
CO in flue gas	:	325 ppm
GCV of bottom ash	:	800 kCal/kg
GCV of fly ash	:	452.5 kCal/kg
Ratio of bottom ash to fly ash:		15 : 85
Ambient temperature	:	32.4 ^oC
Loss due to hydrogen in fuel	:	3.54 %
Loss due to moisture in fuel	:	0.93 %
Loss due to moisture in air	:	0.2 %
Surface heat losses	:	2 %
(as assessed)		

31. A multi-product chemical plant has an oil fired boiler for meeting its steam requirements for process heating. The average fuel oil consumption for the boiler was found to be 950 litres per hour. Calculate the cost of steam per tonne considering only the fuel cost.

    The performance and other associated data are given below: O2 in the flue gas (dry) at boiler exit = 6%

    Temperature of the flue gas at boiler exit = 200oC

    Enthalpy of steam = 665 kcal/kg

    Enthalpy of feed water = 80 kcal/kg Steam is dry saturated.

    Fuel analysis data:

    Carbon (C) = 85%

    Hydrogen (H2) = 12%

    Nitrogen (N2) = 0.5%

    Oxygen (O2) = 1%

    Sulfur (S) = 1.5%

    Gross calorific value of fuel oil = 10,000 kcal/kg

    Specific gravity of fuel oil = 0.95

    Cost of fuel oil per KL = Rs.40,850/-

    Specific heat of flue gas = 0.262 kcal/kgoC

    Specific heat of superheated vapour in flue gas = 0.43 kcal/kg^{O}C

    Humidity in combustion air = 0.025 kg/kg dry air

    Ambient air temperature = 30^{O}C

    Radiation & convection loss from boiler = 1.8%

    Calculate boiler efficiency by

    indirect method

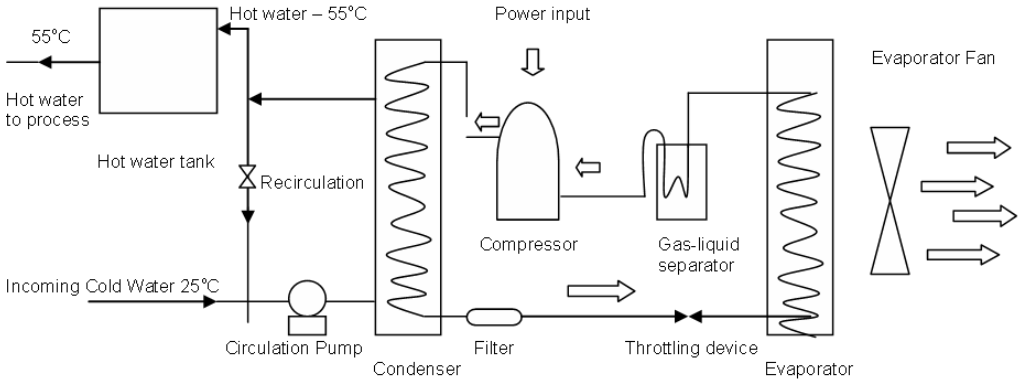
    Calculate evaporation ratio Kg

    steam / Kg fuel oil and then

    compute fuel cost of steam

32. In a food processing unit, 24,000 litres of water per day is to be heated from 25oC to 55oC. Presently this requirement is met by an electrical heater. The management is

planning to install a vapour compression heat pump system having a COP of 2.3 which includes the compressor motor losses. The schematic of the heat pump hot water system is given below:



Schematic of Heat Pump

Hours of operation of water circulation pump = 24 hours/day

Evaporator fan operation = 20 hours/day

Energy consumption of water circulation pump and evaporator fan per day = 50 kWh

Compressor motor efficiency = 88 %

Annual operating days of heat pump = 330 days

Cost of electrical energy = Rs.10/kWh Heat loss in the condenser and hot water tank

in addition to the heat load = 5%

Investment for heat pump = Rs.15 Lakhs The compressor and evaporator fan are interlocked in operation.

Find out

i) Heat pump capacity in TR in terms of heat delivered

ii) The payback period of investment towards heat pump

iii) Evaporator capacity in TR

33. In an organic chemical industry 10 tonne per hour of hot oil is to be cooled from 210^{O}C to 105^{O}C by DM water. The DM water enters the heat exchanger at 25^{O}C and exits at 85^{O}C after which it is fed to the feed water storage tank of the boiler.

i. Depict the heat exchanger process on a schematic for the parallel and counter flow indicating the hot and cold stream temperatures along with terminal temperature difference.

ii. Find out the LMTD for parallel and counter flow heat exchange and justify the choice of the heat exchanger.

iii. Estimate the DM water flow rate through the heat exchanger. The specific heat of oil is 0.5 kcal/kg^{o}C

34. An energy audit was conducted on a 110 MW thermal power generating unit. The details of design parameters and operating parameters observed during the audit are given below

Parameters	**Design**	**Operating**
Generator output	110 MW	110 MW
Boiler outlet superheated steam temperature	540^{O}C	520^{O}C
Boiler outlet steam pressure	140 kg/cm^{2}(a)	130 kg/cm^{2}(a)
Feed water inlet temperature to Boiler	120 ^{O}C	120 ^{O}C
Feed water enthalpy	120 kcal/kg	120 kcal/kg
Boiler efficiency	87%	87%
GCV of coal	3650 kcal/Kg	3650 kcal/Kg
Turbine exhaust steam pressure	0.09 kg/cm^{2}(a)	0.12 kg/cm^{2}(a)
Dryness fraction of exhaust steam	88%	88%
Unit gross heat rate	2815 kcal/kWh	?
Efficiency of turbine & generator (including gear box) -		90 %

Steam properties are as under:

Enthalpy of steam at 520^{O}C and 130 kg/cm^{2}(a) is 808.4 kcal/kg

Enthalpy of Exhaust steam at 0.12 kg/cm^{2}(a) is 550 kcal/kg

For the changed current operating parameters calculate the following..

I. Steam flow rate to the Turbine

II. Specific steam consumption of Turbine

III. Specific coal consumption and unit gross heat rate

IV. Additional quantity of coal required based on 8000 hours/year of operation of the plant

Increase in annual coal cost due to increase in coal consumption at a cost of Rs. 3400 per tonne of coal.

35. The steam requirement of an export oriented unit is met by a 6 TPH oil fired package boiler generating steam at 10 kg/cm^2. The monthly steam consumption of the unit is 3000 tonnes.

Other data are given below:

Fuel oil composition:

Carbon = 86%;

Hydrogen = 12%;

Oxygen = 0.5%;

Sulphur =1.5%

Specific heat of flue gases, Cp	= 0.27 kcal/kg^{o}C
G.C.V. of fuel oil	= 10,000 kcal/kg
Sp.heat of super heated water vapour	= 0.45 kcal/kg^{o}C
Enthalpy of steam at 10 kg/cm^2	= 665kcal/kg Feed
water temperature	= 85 ^{o}C
% O_2 in dry flue gas	= 6% Flue
gas temperature at boiler outlet	= 240 ^{o}C
Ambient temperature	= 30^{o}C
Cost of fuel oil	= Rs.43 per kg.
Radiation and other unaccounted losses	= 2.45%

The export oriented unit is costing its steam cost based on the fuel consumption cost with additional 15% to account for the auxiliary and consumables.

A neighbouring continuous process plant now offers to supply the required steam at 10 kg/cm2 to the export oriented unit at a cost of Rs 3300 per tonne with a condition that all the condensate will be returned back.

Calculate the following:

a) Boiler efficiency
b) Cost advantage per tonne of availing steam from neighbouring plant in place of in-house generation and also monthly monetary saving.

36. The operating parameters of a Vapour Compression Refrigeration system are indicated below.

Parameter	Chiller side	Condenser side
Water Flow (m^3/hr)	89	87
Inlet Temperature (^OC)	10.1	32.3
Outlet Temperature (^OC)	6.8	36.6
Density (kg/m^3)	1000	990

Find the COP of the Refrigeration system ignoring heat losses.

37. A 6 pole, 415 volt, 3 phase, 50 Hz induction motor delivers 22 kW power at rotor shaft at a speed of 950 rpm with PF of 0.88. The total loss in the stator including core, copper and other losses, is 2 kW. Calculate the following.

i) Slip
ii) Rotor Copper Loss
iii) Total Input to motor
iv) Line current at 415 V and motor pf of 0.88
v) Motor operating efficiency