

Full Marks : 60

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Group - A

$$12 \times 1 = 12$$

- (i) Regeneration leads to an increase in Rankine cycle efficiency due to
 - (a) work done by turbine increases
 - (b) pressure of boiler increases
 - (c) heat added to the stream before it enters to low pressure turbine
 - (d) average temperature of heat addition in boiler increases.
- (ii) Babcock and Wilcox boiler is an example of
 - (a) horizontal, internally fired, natural circulation type, stationary boiler
 - (b) horizontal, externally fired, natural circulation type, stationary boiler
 - (c) horizontal, externally fired, forced circulation type, stationary boiler
 - (d) horizontal, externally fired, forced circulation type, locomotive boiler.
- (iii) The path followed in a vapour power cycle is
 - (a) boiler-condenser-turbine-pump
 - (b) boiler-turbine-condenser-pump
 - (c) boiler-turbine-pump-condenser
 - (d) boiler-pump-turbine-condenser.
- (iv) Under ideal conditions, the velocity of stream at the outlet of a nozzle for a drop of 450 kJ/kg from inlet reservoir condition up to the exit is
 - (a) 649 m/s
 - (b) 749 m/s
 - (c) 849 m/s
 - (d) 949 m/s.
- (v) Rankine cycle comprises of
 - (a) two isentropic processes and two constant volume processes
 - (b) two isentropic processes and two constant pressure processes
 - (c) two isothermal processes and two constant pressure processes
 - (d) two isothermal processes and two constant volume processes.
- (vi) In an impulse turbine, the heat drops in the fixed and moving blades are 15 kJ/kg and 30kJ/kg respectively. The degree of reaction for this stage will be
 - (a) $1/2$
 - (b) $1/3$
 - (c) $2/3$
 - (d) $3/4$

- (vii) Air enters a nozzle with negligible velocity. The enthalpy of air decreases by 180 kJ/kg. What will be the exit velocity of air?
 (a) 600 m/s (b) 500 m/s
 (c) 60 m/s (d) 6 m/s.
- (viii) Compounding of steam turbine is done to
 (a) balance the rotor (b) reduce the blade friction
 (c) reduce the rotor speed (d) reduce the axial thrust.
- (ix) Which of the following terms is not related to nuclear power plants?
 (a) Control Rod (b) Electrostatic precipitator
 (c) Nuclear Reactor (d) Moderator.
- (x) The connected load of a consumer is 3kW and maximum demand is 1.5 kW. The demand factor of the consumer is
 (a) 0.5 (b) 0.25 (c) 0.33 (d) 1.33.

Fill in the blanks with the correct word

- (xi) In a cooling tower 'approach' is the temperature difference between: _____.
- (xii) The efficiency of a regenerative steam cycle increases when the number of extraction are _____.
- (xiii) _____ pump is used to extract out the air and dissolved gases from the condenser.
- (xiv) The air standard Brayton cycle consist of two isentropic and two _____ process
- (xv) When the nozzle operates with the maximum mass flow, the nozzle is said to be _____.

Group - B

2. (a) A cyclic steam power plant is to be designed for steam temperature at turbine inlet of 360°C and an exhaust pressure of 0.08 bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is 15%. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition. [[CO1](Analyse/HOCQ)]
- (b) Show that the overall efficiency of two cycles coupled in series equals the sum of the individual efficiencies minus their product. [[CO1](Understand/LOCQ)]
- 7 + 5 = 12**
3. A mercury cycle is superposed on the steam cycle operating between the boiler outlet conditions at 40 bar, 400°C and the condenser temperature of 40°C. The heat released by mercury condensing at 0.2 bar is used to impart the latent heat of vaporization to the water in the steam cycle. Mercury enters the mercury turbine as saturated vapour at 10 bar. (i) Draw the T-s diagram, compute (ii) kg of mercury circulated per kg of water, and (iii) the efficiency of the combined cycle.

P(bar)	t(°C)	h_f (kJ/kg)	h_g (kJ/kg)	S_f (kJ/kg K)	S_g (kJ/kg K)	v_f (m ³ /kg)	v_g (m ³ /kg)
10	515.5	72.23	363.0	0.1478	0.5167	80x10 ⁻⁶	0.0333
0.2	277.3	38.35	336.55	0.0967	0.6385	77.4x10 ⁻⁶	1.163

[[CO1](Analyse/HOCQ)]

12

Group - C

4. (a) Determine the height of chimney to get net draught of 12 mm, if the total draught losses are 4 mm. The temperature of air is 25°C and the temperature of the chimney gases is 300°C. The mass of air used per kg of fuel used is 18 kg. One kg of air occupies a volume of 0.7734 m³ at NTP. [[CO2](Apply/IOCQ)]
- (b) What is a superheater? State the advantages of superheated steam. [[CO2](Remember/LOCQ)]
- (4 + 2) + (3 + 3) = 12**
5. (a) The steam used by the turbine is 5.4 kg/kWh at a pressure of 50 bar and a temperature of 350°C. The efficiency of boiler is 82 per cent with feed water at 150°C. How many kg of coal are required per kWh, if the calorific value of coal is estimated as 28100 kJ/kg? If the cost of coal/tonne is Rs. 5000, what is fuel cost/kWh? [[CO2](Apply/HOCQ)]
- (b) What is mechanical (artificial) draught? What is the function of the forced draught fan and where is it located? [[CO4](Understand/LOCQ)]
- (4 + 2) + (4 + 2) = 12**

Group - D

6. The velocity of steam entering a simple impulse turbine is 1000m/s, and nozzle angle is 20°. The mean peripheral velocity of blades is 400 m/s and the blades are symmetrical. If the steam is to enter the blades without shock, what will be the blade angles? (i) Draw the velocity diagram (ii) neglecting the friction effects on the blades, calculate the tangential force on the blades and the diagram power for a mass flow of 0.75 kg/s. Estimate also the axial thrust and diagram efficiency. (iii) If the relative velocity at exit is reduced by friction to 80% of that at inlet, estimate the axial thrust, diagram power and diagram efficiency. [[CO3](Analyse/HOCQ)]
- 12**
7. (a) Air at 7.8 bar and 180°C expands through a convergent-divergent nozzle into a space at 1.03 bar. The flow rate of air is 3.6 kg/s. Assuming isentropic flow throughout and neglecting the inlet velocity, calculate the throat and exit areas of the nozzles. [[CO3](Analyse/HOCQ)]
- (b) Explain (i) supersonic nozzle (ii) subsonic nozzle (iii) subsonic diffuser and (iv) supersonic diffuser. [[CO3](Remember/LOCQ)]
- 6 + 6 = 12**

Group - E

8. (a) A power plant has the following annual factors: load factor = 0.75, capacity factor = 0.62, use factor = 0.65. Maximum demand is 63 MW. Estimate (i) the annual

energy production, (ii) the reserve capacity over and above the peak load, and (c) the hours during which the plant is not in service per year. *[[C04](Analyse/HOCQ)]*

(b) What is High Temperature Gas Cooled Reactor? Explain its main feature.

[[C06](Remember/LOCQ)]

6 + 6 = 12

9. (a) Define (i) approach (ii) range of cooling tower.

[[C05](Remember/LOCQ)]

(b) Water at 30°C flows into a cooling tower at the rate of 1.15 kg per kg of air. Air enters the tower at the dbt of 20°C and a relative humidity of 60% and leaves it at a dbt of 28°C and 90% relative humidity. Makeup water is supplied at 20°C. Determine (i) the temperature of water leaving the tower (ii) the fraction of water evaporated and (iii) the approach and range of the cooling tower. The characteristics of the air at the inlet include a wet-bulb temperature (WBT) of 15.20°C, an enthalpy of 43 kJ/kg of dry air, and a specific humidity of 0.0088 kg of water vapour per kg of dry air. At the exit, the WBT is 26.70°C, the enthalpy is 83.5 kJ/kg of dry air, and the specific humidity is 0.0213 kg of water vapor per kg of dry air.

[[C05](Analyse/HOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.38	6.25	59.37

Course Outcome (CO):

After the completion of the course students will be able to

C01: Analyze and evaluate different types of thermodynamic cycles used in thermal power plants and list their advantages and disadvantages.

C02: Evaluate the boiler performance and calculate chimney height.

C03: Differentiate and Evaluate the impulse and reaction turbine and nozzle performance.

C04: Compare the power requirement of auxiliary equipment used in combustion process.

C05: Design surface condensers and calculate the water flow requirement.

C06: Understand the working principle of nuclear and hydel power plant.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*