Group – E

8. (a) In a steam power plant, steam at 20 bar, 360°C is expanded to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back water into boiler. Assuming ideal processes, find (i) dryness fraction at turbine exit (ii) specific turbine work (iii) specific pump work (iv) cycle efficiency.

(b) A standard vapour compression refrigerator using F-12 as the refrigerant operates between the condenser pressure of 10 bar and the evaporator pressure of 1.5 bar. The evaporator absorbs 75 kJ/min of energy as heat and the vapour is dry saturated at exit from the compressor. There is no sub-cooling in the condenser. Calculate (i) mass flow rate of refrigerant (ii) power consumed (iii) COP of the cycle.

The table of properties of Freon-12 is given below:

Pressure (bar)	Saturation temperature (°C)	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
		Liquid	Vapour	Liquid	Vapour
10	41.7	76.8	203.65		0.682
1.5	-20.1	17.82	178.84	0.073	0.709

6 + 6 = 12

9. (a) In a reheat steam power cycle, steam is supplied to HP turbine at 25 bar and 400°C. After its expansion to dry saturated state, it is reheated at constant pressure to its original temperature. Subsequent expansion occurs in LP turbine to 0.4 bar. Considering feed pump work, calculate (i) quality of steam at at entry to condenser (ii) thermal efficiency (iii) specific steam consumption.

(b) In a regenerative cycle, the steam is fed to the turbine at 20 bar, 350°C. The condenser pressure is 0.04 bar. Steam is bled at 2 bar pressure for heating feed water from condenser in an open feed water heater. Assuming negligible work for pumping feed water from 0.04 bar to 2 bar, calculate the mass of feed water bled per kg of steam.

7 + 5 = 12

B.TECH/ME/3RD SEM/MECH 2101(BACKLOG)/2019

APPLIED THERMODYNAMICS
(MECH 2101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The internal energy of an ideal gas is a function of its absolute temperature only. This statement is referred to as
(a) Avogadro's law (b) Maxwell's law
(c) Joule's law (d) Renault's law.

(ii) Which property remains constant in a throttling process?
(a) Pressure (b) Temperature
(c) Entropy (d) Enthalpy.

(iii) Sensible heat
(a) does not allow rise in temperature
(b) results in rise in temperature that can be sensed by a thermometer
(c) brings about a change of phase of a substance
(d) is absorbed by a liquid at saturation temperature for conversion into vapour at the same temperature.

(iv) In a Carnot cycle, the addition and rejection of heat take place at constant
(a) pressure (b) temperature
(c) volume (d) enthalpy.

(v) The INCORRECT statement about the characteristics of critical point of a pure substance (water) is that
(a) there is no constant temperature vaporization process
(b) it has point of inflection with zero slope
(c) the ice directly converts from solid phase to vapour phase
(d) saturated liquid and saturated vapour states are identical.

(vi) For a reciprocating compressor if the clearance increases then volumetric efficiency
(a) increases (b) remains the same
(c) decreases (d) cannot be predicted.

(vii) Entropy generation for a reversible isothermal heat rejection process is always
(a) positive (b) negative
(c) zero (d) unpredictable.

(viii) An isentropic process
(a) is always adiabatic (b) is always reversible
(c) is always frictionless (d) need not be adiabatic or reversible.

(ix) An ideal gas at 27°C is heated at constant pressure till the volume increases to three times. The temperature of the gas will then be
(a) 81°C (a) 900°C (a) 927°C (a) 627°C.

(x) Sublimation is a process of
(a) conversion of solid directly into vapour
(b) conversion of vapour directly into solid
(c) conversion of liquid into vapour at constant pressure
(d) conversion of vapour into liquid at constant temperature

Group – B

2. (a) When is work said to be done by a system? What are positive and negative work interactions? What is displacement work?

(b) 2 kg of a gas is contained in a piston-cylinder assembly at initial conditions of 2 m^3 volume and 100 kPa pressure. The gas is allowed to expand to a final volume of 5 m^3. Determine the amount of work done for the following processes:
(i) pressure remains constant (ii) isothermal process (iii) PV^2 is constant.

6 + 6 = 12

3. (a) Steam flows through a turbine at a rate of 2.5 kg/s. the inlet and exit enthalpy of steam are 2700 kJ/kg and 1800 kJ/kg respectively. Velocity of steam at inlet and outlet are 35 m/s and 250 m/s. There is heat loss to the surroundings at 40 kW. Calculate the power output from the turbine.

(b) A rigid vessel contains 200 kg of a mixture of saturated water and saturated steam at a pressure of 2 MPa. When the mixture is heated, the state passes through critical point. Determine (i) the volume of the vessel (ii) the mass of liquid and vapour initially (iii) the quantity of heat addition till critical point.

7 + 5 = 12

Group – C

4. (a) A reversible heat engine operates between a source at 1200 K and two sinks at 300 K and 400 K. If the amount of heat rejected to lower temperature sink is twice that of the higher temperature sink, what is the efficiency of the heat engine?

(b) State and prove Carnot's theorem.

6 + 6 = 12

5. (a) Source A can supply thermal energy at 320°C @ 12000 kJ/min while source B can supply thermal energy at 70°C @ 50000 kJ/min. Which source would you choose for running a reversible heat engine to supply large amount of power if the temperature of the surrounding is 35°C?

(b) An AC motor delivers power in a steady state, at its output shaft @ 16 kW, while it draws a current of 80 amp at 240 V AC with a power factor of 0.9. The outer surface of the motor remains steady at a temperature of 47^0C. Assume the motor as the system and find out (i) the rate of heat transfer (ii) the rate of entropy generation and (iii) the rate of entropy transfer (all with proper signs).

6 + 6 = 12

Group – D

6. (a) A single cylinder reciprocating air compressor has a bore of 120 mm and a stroke of 150 mm, and is driven at a speed of 1200 rpm. It is compressing CO_2 gas from a pressure of 120 kPa and a temperature of 20°C to a temperature of 215°C. Assuming polytropic compression with n = 1.3, no clearance and volumetric efficiency 100%, calculate (i) pressure ratio (ii) indicated power (iii) shaft power required with a mechanical efficiency of 80% (iv) mass flow rate.

(b) Draw the p-v diagram of an air standard dual cycle and name the individual processes that comprise the cycle.

7 + 5 = 12

7. (a) Define the volumetric efficiency of a reciprocating compressor. On what factors does it depend? What is the need of an inter-cooling in a two stage compression process?

(b) An engine working on the Otto cycle is supplied with air at 0.1 MPa, 35°C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the heat rejection.

6 + 6 = 12