			Marks	BL	PO	CO	PSO
Q.6		Attempt any two:					
	i.	Derive an expression for work input in a single stage compressor.	**5**	2	1,2	2	2
	ii.	Explain the working of nozzle with diagram.	**5**	2	1,2	2	2
	iii.	Write a short note on intercooling and multistage compression.	**5**	2	1,2	2	2

******

Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....................................

Faculty of Engineering

End Sem Examination Dec 2024

ME3CO44 Engineering Thermodynamics

Programme: B.Tech. Branch/Specialisation: ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

			Marks	BL	PO	CO	PSO
Q.1	i.	What is the internal energy (ΔE) of a system? (a) Sum of kinetic and potential energies (b) Sum of heat and work (c) Difference between heat and work (d) Product of heat and work	**1**	1	1,2	1	2
	ii.	What corresponds to second law of thermodynamics? (a) $\Delta S = \Delta Q / T$ (b) $\Delta S = \Delta Q \times T$ (c) $\Delta S = \Delta Q - T$ (d) $\Delta S = \Delta Q + T$	**1**	2	1,2	2	2
	iii.	Which of the following is a characteristic of a pure substance? (a) Fixed composition and variable properties (b) Variable composition and fixed properties (c) Fixed composition and fixed properties (d) Variable composition and variable properties	**1**	1	1,2	1	2
	iv.	What is the term for a pure substance that can exist in multiple phases? (a) Homogeneous (b) Heterogeneous (c) Polymorphic (d) Allotropic	**1**	1	1,2	1	2
	v.	Which factor affects the efficiency of a vapor power cycle? (a) Pressure ratio (b) Temperature difference (c) Heat transfer rate (d) All of these	**1**	1	1,2	1	2

vi. Which process occurs in the turbine of a vapor power cycle? **1** 1 1,2 1 2
(a) Isentropic expansion
(b) Isobaric expansion
(c) Isothermal expansion
(d) Adiabatic compression

vii. What is the primary application of a condenser in a power plant? **1** 1 1,2 1 2
(a) To generate steam
(b) To condense steam
(c) To cool equipment
(d) To increase efficiency

viii. What is the recommended frequency for boiler maintenance? **1** 1 1,2 1 2
(a) Daily (b) Weekly
(c) Monthly (d) Annually

ix. Which component reduces vibration in a compressor? **1** 1 1,2 1 2
(a) Flywheel
(b) Crankshaft
(c) Connecting rod
(d) Mounting bracket

x. What is the primary function of a nozzle in a thermodynamic system? **1** 1 1,2 1 2
(a) To increase the pressure of a fluid
(b) To decrease the velocity of a fluid
(c) To convert thermal energy into kinetic energy
(d) To mix two or more fluids

Q.2 i. Define 1^{st} law of thermodynamics applied to a non-flow process. **2** 1 1,2 1 2

ii. Define heat engine, heat pump & refrigerator. **3** 1 1,2 1 2

iii. Derive the steady flow energy equation. **5** 2 1,2 2 2

OR iv. A fluid is confined in a cylinder by a spring loaded, frictionless piston so that the pressure in the fluid is a linear function, of the volume (p = a + b V). The internal energy of the fluid is given by the following equation- **5** 3 1,2 4 2

$$U=34+3.14pV$$

where U is in kJ, p in kPa, and V in cubic metre. If the fluid changes from an initial state of 170 kPa. 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer.

Q.3 i. What is a calorimeter? Why it is used? **2** 1 1,12 1 2

ii. Explain the steam formation process from -20^0C ice to 120^0C superheated steam at 1atm pressure with T – q diagram. **8** 2 1,2 12 2 2

OR iii. A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, the enthalpy, the entropy, and the internal energy. **8** 3 1,2 12 4 2

Q.4 i. Compare Carnot cycle and Rankine cycle. **3** 2 1,12 2 2

ii. Steam at 20 bar, 360°C is expanded in a steam turbine to 0.08 bar. it then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler- **7** 3 1,2 3,12 4 2
(a) Assuming ideal processes, find the cycle efficiency.
(b) If the turbine and the pump have each 80% efficiency, find the percentage reduction in the net work and cycle efficiency.

OR iii. Explain the working of Binary Vapor Cycle with component diagram & T-S diagram. **7** 2 1,12 2 2

Q.5 i. Write a short note on- **4** 1 1,12 1 2
(a) Condenser (b) Cooling tower

ii. Explain the working of any one high pressure boiler with diagram. **6** 2 1,12 2 2

OR iii. Discuss any two boiler performance parameters. **6** 2 1,12 2 2

Marking Scheme
ME3CO44 (T) Engineering Thermodynamics (T)

Q.1	i)	A	**1**
	ii)	A	**1**
	iii)	C	**1**
	iv)	C	**1**
	v)	D	**1**
	vi)	A	**1**
	vii)	B	**1**
	viii)	C	**1**
	ix)	A	**1**
	x)	C	**1**
Q.2	i.	Definition	**2**
	ii.	Definition of heat engine, heat pump & refrigerator 1M each	**3**
	iii.	Derivation with diagram	**5**
OR	iv.	Work done 10.67 KJ 3M	**5**
		Heat Transfer 92.57 KJ 2M	
Q.3	i.	Definition	**2**
	ii.	Explanation, 4M	**8**
		Diagram 4M	
OR	iii.	P=39.776 bar, H=1188.67 KJ/ KG, S=2.99KJ/KGK	**8**
		ΔU= 1172 KJ/kg (4*2M)	
Q.4	i.	Compare Carnot cycle and Rankine cycle.	**3**
	ii.	Weight=966.61kj/kg, 3M	**7**
		n=32.5% 4M	
OR	iii.	Binary Vapor Cycle, 2M	**7**
		diagram, 2M	
		T-S diagram. 3M	
Q.5	i.	Condenser, 2M	**4**
		Cooling tower 2M	
	ii.	Working, 3M	**6**
		Diagram 3M	
OR	iii.	Two boiler, 3M	**6**
		performance parameters 3M	
Q.6		Attempt any two:	
	i.	Derivation	**5**
	ii.	Working, 3M	**5**
		Diagram 2M	
	iii.	intercooling, 2M	**5**
		multistage compression. 3M	

******

2 IV Solution

Solution The change in the internal energy of the fluid during the process.

$$U_2 - U_1 = 3.15\,(p_2V_2 - p_1V_1)$$
$$= 315\,(4 \times 0.06 - 1.7 \times 0.03)$$
$$= 315 \times 0.189 = 59.5 \text{ kJ}$$

Now

$$p = a + bV$$
$$170 = a + b \times 0.03$$
$$400 = a + b \times 0.06$$

From these two equations

$$a = -60 \text{ kN/m}^2$$
$$b = 7667 \text{ kN/m}^5$$

Work transfer involved during the process

$$W_{1-2} = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} (a + bV)\,dV$$
$$= a(V_2 - V_1) + b\frac{V_2^2 - V_1^2}{2}$$
$$= (V_2 - V_1)\left[a + \frac{b}{2}(V_1 + V_2)\right]$$
$$= 0.03 \text{ m}^3\left[-60 \text{ kN/m}^2 + \frac{7667}{2}\,\frac{\text{kN}}{\text{m}^5} \times 0.09 \text{ m}^3\right]$$
$$= 8.55 \text{ kJ}$$

Work is done by the system, the magnitude being 8.55 kJ.

∴ Heat transfer involved is given by

$$Q_{1-2} = U_2 - U_1 + W_{1-2}$$
$$= 59.5 + 8.55$$
$$= 68.05 \text{ kJ}$$

68.05 kJ of heat flow into the system during the process.

3 II SOLUTION

Solution From Table A.1(a), at 250°C $\quad p_{sat} = 3.973$ MPa

$$v_f = 0.0012512 \text{ m}^3\text{/kg}, \quad v_g = 0.05013 \text{ m}^3\text{/kg}$$
$$h_f = 1085.36 \text{ kJ/kg}, \quad h_{fg} = 1716.2 \text{ kJ/kg}$$
$$s_f = 2.7927 \text{ kJ/kg K}, \quad s_{fg} = 3.2802 \text{ kJ/kg K}$$

Volume of liquid, $\quad V_f = m_f v_f$

$$= 9 \times 0.0012512$$
$$= 0.01126 \text{ m}^3$$

Volume of vapour, $\quad V_g = 0.04 - 0.01126$

$$= 0.02874 \text{ m}^3$$

∴ Mass of vapour

$$m_g = \frac{V_g}{v_g} = \frac{0.02874}{0.05013} = 0.575 \text{ kg}$$

∴ Total mass of mixture,

$$m = m_f + m_g = 9 + 0.575 = 9.575 \text{ kg}$$

Quality of mixture,

$$x = \frac{m_g}{m_f + m_g} = \frac{0.575}{9.575} = 0.06$$

∴

$$v = v_f + x v_{fg}$$
$$= 0.0012512 + 0.06\,(0.05013 - 0.0012512)$$
$$= 0.00418 \text{ m}^3\text{/kg}$$
$$h = h_f + x h_{fg}$$
$$= 1085.36 + 0.06 \times 1716.2$$
$$= 1188.32 \text{ kJ/kg}$$
$$s = s_f + x s_{fg}$$
$$= 2.7927 + 0.06 \times 3.2802$$
$$= 2.9895 \text{ kJ/kg K}$$
$$u = h - pv$$
$$= 1188.32 - 3.973 \times 10^3 \times 0.00418$$
$$= 1171.72 \text{ kJ/kg}$$

Also, at 250°C, $\quad u_f = 1080.39$ and $u_{fg} = 1522.0$ kJ/kg

∴

$$u = u_f + x u_{fg}$$
$$= 1080.39 + 0.06 \times 1522$$
$$= 1071.71 \text{ kJ/kg}$$

4 II SOLUTION

Solution The property values at different state points (Fig. Ex. 12.2) found from the steam tables are given below.

$$h_1 = 3159.3 \text{ kJ/kg} \quad s_1 = 6.9917 \text{ kJ/kg K}$$
$$h_3 = h_{fp_2} = 173.88 \text{ kJ/kg} \quad s_3 = s_{fp_2} = 0.5926 \text{ kJ/kg K}$$
$$h_{fgp_2} = 2403.1 \text{ kJ/kg} \quad s_{gp_2} = 8.2287 \text{ kJ/kg K}$$
$$v_{fp_2} = 0.001008 \text{ m}^3\text{/kg} \quad \therefore s_{fgp_2} = 7.6361 \text{ kJ/kg K}$$

Now $$s_1 = s_{2s} = 6.9917 = s_{fp_2} + x_{2s} s_{fgp_2} = 0.5926 + x_2 \cdot 7.6361$$

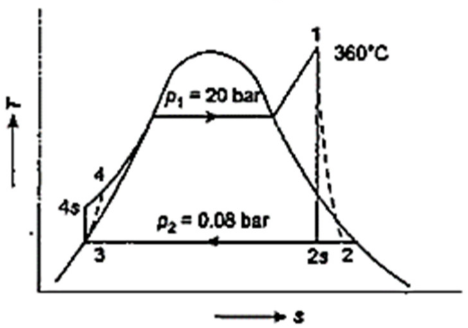

Fig. Ex. 12.2

$$\therefore \quad x_{2s} = \frac{6.3991}{7.6361} = 0.838$$

$$\therefore \quad h_{2s} = h_{fp_2} + x_{2s} h_{fgp_2} = 173.88 + 0.838 \times 2403.1$$
$$= 2187.68 \text{ kJ/kg}$$

(a) $$W_P = h_{4s} - h_3 = v_{fp_2}(p_1 - p_2) = 0.001008 \frac{\text{m}^3}{\text{kg}} \times 19.92 \times 100 \frac{\text{kN}}{\text{m}^2}$$
$$= 2.008 \text{ kJ/kg}$$
$$h_{4s} = 175.89 \text{ kJ/kg}$$
$$W_T = h_1 - h_{2s}$$
$$= 3159.3 - 2187.68 = 971.62 \text{ kJ/kg}$$
$$\therefore \quad W_{net} = W_T - W_P = 969.61 \text{ kJ/kg}$$
$$Q_1 = h_1 - h_{4s} = 3159.3 - 175.89$$
$$= 2983.41 \text{ kJ/kg}$$

Ans.

$$\therefore \quad \eta_{cycle} = \frac{W_{net}}{Q_1} = \frac{969.61}{2983.41} = 0.325, \text{ or } 32.5\%$$

(b) If $$\eta_P = 80\%, \text{ and } \eta_T = 80\%$$

$$W_P = \frac{2.008}{0.8} = 2.51 \text{ kJ/kg}$$
$$W_T = 0.8 \times 971.62 = 777.3 \text{ kJ/kg}$$
$$\therefore \quad W_{net} = W_T - W_P = 774.8 \text{ kJ/kg}$$

$\therefore$ % Reduction in work output

$$= \frac{969.61 - 774.8}{969.61} \times 100 = 20.1\%$$
$$h_{4s} = 173.88 + 2.51 = 176.39 \text{ kJ/kg}$$
$$\therefore \quad Q_1 = 3159.3 - 176.39 = 2982.91 \text{ kJ/kg}$$
$$\therefore \quad \eta_{cycle} = \frac{774.8}{2982.91} = 0.2597, \text{ or } 25.97\%$$

$\therefore$ % Reduction in cycle efficiency

$$= \frac{0.325 - 0.2597}{0.325} \times 100 = 20.1\%$$