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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree (S, FE) Examination January 2024 (2019 Scheme)

Course Code: MRT202

Course Name: THERMODYNAMICS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks)

		Marks
1	Define the term thermal engineering.	3
2	What is meant by closed system? Give an example.	3
3	Define Specific heat capacity at constant pressure.	3
4	What is meant by thermodynamic property?	3
5	What do you understand by equilibrium of a system?	3
6	State the First law of thermodynamics	3
7	Define the term process	3
8	Explain Zeroth Law of thermodynamics?	3
9	Define the term internal energy	3
10	Define Heat.	3

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) Define Intensive and Extensive properties. What is meant by open and closed cycle? 7

b) A steel cylinder of mass 4 kg contains 4 L of liquid water at 25°AC at 100 kPa. Find the total mass and volume of the system. List two extensive and three intensive properties of the water 7

12 a) What is meant by reversible & irreversible process? What is meant by Point and Path function? 7

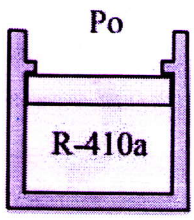
b) The pressure gauge on an air tank shows 75 kPa when the diver is 10 m down in the ocean. At what depth will the gauge pressure be zero? What does that mean? 7

Module -2

13 a) A copper wire of diameter 2 mm is 10 m long and stretched out between two posts. The normal stress (pressure) $\sigma = E(L - L_o)/L_o$, depends on the length L versus the un-stretched 7

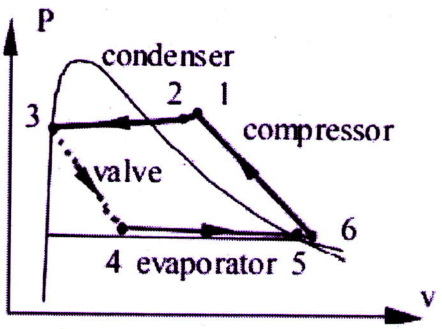
length L_o and Young's modulus $E = 1.1 \times 10^6$ kPa. The force is $F = A\sigma$ and measured to be 110 N. How much longer is the wire and how much work was put in?

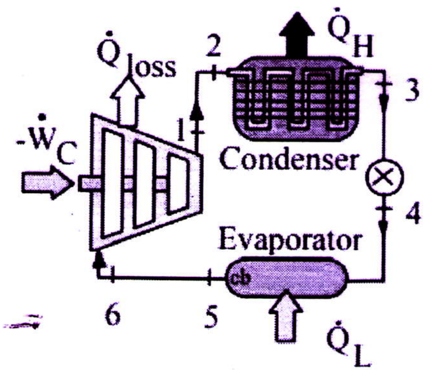
b) A piston cylinder shown in the figure below contains 0.5 m^3 of R-410a at 2 MPa, 150 °C. The piston mass and the atmosphere gives a pressure of 450 kPa that will float the piston. The whole setup cools in a freezer maintained at -20 °C. Find the heat transfer and show the P-v diagram for the 7process when T_2 = -20 °C. 7



14 a) A 200-litre tank initially contains water at 100 kPa and a quality of 1%. Heat is transferred to the water thereby raising its pressure and temperature. At a pressure of 2 MPa, a safety valve opens and saturated vapor at 2 MPa flows out. The process continues, maintaining 2 MPa inside until the quality in the tank is 90%, then stops. Determine the total mass of water that flowed out and the total heat transfer. 7

b) A R-410a heat pump cycle shown in the figure below has a R-410a flow rate of 0.05 kg/s with 5 kW into the compressor. 7





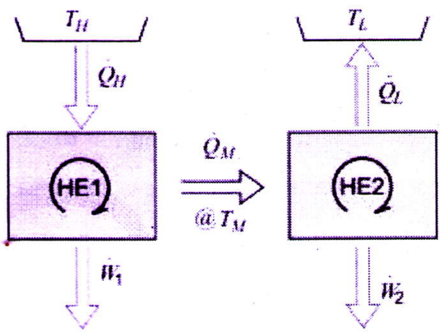
The following data are given

State	1	2	3	4	5	6
P, kPa	3100	3050	3000	420	400	390
T, °C	120	110	45		-10	-5
h, kJ/kg	377	367	134	-	280	284

Calculate the heat transfer from the compressor, the heat transfer from the R-410a in the condenser and the heat transfer to the R-410a in the evaporator.

Module -3

15 a) A combination of two heat engines is shown in the figure below. 7



Find the overall thermal efficiency as a function of the two individual efficiencies.

b) A large heat pump should upgrade 5 MW of heat at 85°C to be delivered as heat at 150°C. Suppose the actual heat pump has a COP of 2.5, how much power is required to drive the unit. For the same COP, how high a high temperature would a Carnot heat pump have assuming the same low T? 7

16 a) An air conditioner cools a house at T_L = 20°C with a maximum of 1.2 kW power input. The house gains 0.6 kW per degree temperature difference to the ambient and the refrigeration COP is $\beta = 0.6\ \beta_{Carnot}$. Find the maximum outside temperature, T_H, for which the air conditioner provides sufficient cooling. 7

b) A foundry form box with 25 kg of 200°C hot sand is dumped into a bucket with 50 L water at 15°C. Assuming no heat transfer with the surroundings and no boiling away of liquid water, calculate the net entropy change for the process. 7

Module -4

17 a) A steel tank contains 6 kg of propane (liquid + vapor) at 20°C with a volume of 0.015 m^3. The tank is now slowly heated. Will the liquid level inside eventually rise to the top or drop to the bottom of the tank? What if the initial mass is 1 kg instead of 6 kg? 7

b) To plan a commercial refrigeration system using R-123, we would like to know how much more volume saturated vapor R-123 occupies per kg at -30 °C compared to the saturated liquid state. 7

18 a) A bottle with a volume of 0.1 m^3 contains butane with a quality of 75% and a temperature of 300 K. Estimate the total butane mass in the bottle using the generalized compressibility chart. 7

b) Determine the pressure of nitrogen at 160 K, v = 0.00291 m^3/kg using Vander Waals Equation of State and the nitrogen table. 7

Module -5

19 a) 3000 kg/h of steam flows through a small turbine with a pressure of 15 bar, 300°C and leaving at 0.1 bar with quality 96%. The steam enters at 80 m/s at a point 2 in above the discharge and leaves at 40 m/s. Compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energy changes. How much error would be made if these terms were neglected? Calculate the diameters of the inlet and discharge tubes. 7

b) A rigid insulated container has two rooms separated by a membrane. Room A contains 1 kg air at 200°C and room B has 1.5 kg air at 20°C, both rooms at 100 kPa. Consider two different cases 7

1) Heat transfer between A and B creates a final uniform T.

2) The membrane breaks and the air comes to a uniform state.

For both cases find the final temperature. Are the two processes reversible and different? Explain.

20 a) Derive: $dS = C_v \frac{dT}{T} + \left(\frac{\partial p}{\partial T}\right) dV$ 7

b) Which one of the following can be considered as property of a system? 7

a) $\int pdv$ b) $\int vdp$ c) $\int \left(\frac{dT}{T} + \frac{p.dv}{v}\right)$ d) $\int \left(\frac{dT}{T} - \frac{v.dp}{T}\right)$

Given: p = pressure, T = Temperature, v = specific volume

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