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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S4 (R,S) Exam April 2025 (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	What is meant by thermodynamic system? How do you classify it?	3
2	Define a open system, Give an example.	3
3	Define: Specific heat capacity at constant volume.	3
4	How do you classify the property?	3
5	What is meant by thermodynamic equilibrium?	3
6	Define: Perpetual motion machine of first kind	3
7	Define the term Cycle:	3
8	Define the term enthalpy?	3
9	What is meant by thermodynamic work?	3
10	Define entropy of a pure substance.	3

PART B

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

Module -1

11 a) The acceleration of gravity is given as a function of elevation above sea level by g = 980.6 − 3.086 × 100 H − Where g is in cm/s^2 and H is in cm. If an aeroplane weighs 90,000 N at sea level, what is the gravity force upon it at 10,000 m elevation? What is the percentage difference from the sea-level weight? 7

b) The temperature t on a thermometric scale is defined in terms of a property K by the relation t = a ln K + b Where a and b are constants. The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100, respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer. 7

12 a) Assume that the pressure p and the specific volume v of the atmosphere are related according to the equation $\mathbf{pv^{1.4} = 2.3x\ 10^3}$, where p is in N/m^2 abs and v is in m^3/kg. The acceleration due to gravity is constant at 9.81 m/s^2. What is the depth of atmosphere necessary to produce a pressure of 1.0132 bar at the earth's surface? Consider the atmosphere as a fluid column. 7

b) The resistance (R) of a platinum wire is found to be 11.000 ohms at the ice point, 15.247 ohms at the steam point, and 28.887 ohms at the sulphur point (445°C). Find the constants A and B in the equation, $R = R_0(1+AT+BT^2)$, where T is the temperature 7 in °C. Plot R against t in the range 0 to 660°C.

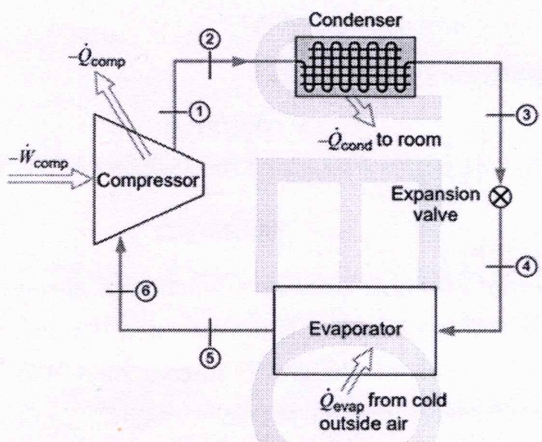
Module -2

13 a) A piston/cylinder contains 1 kg of liquid water at 20°C and 300 kPa. Initially the piston floats, similar to the setup in Problem 4.59, with a maximum enclosed volume of 0.002 m^3 if the piston touches the stops. Now heat is added so a final pressure of 600 kPa is reached. Find the final volume and the work in the process. 7

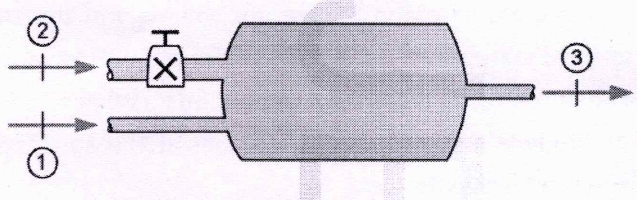
b) Two kilograms of nitrogen at 100 K, x = 0.5 is heated in a constant-pressure process to 300 K in a piston/cylinder arrangement. Find the initial and final volumes and the total heat transfer required. 7

14 a) An R-410a heat pump cycle shown in Figure below has an R-410a flow rate of 0.05 kg/s with 5 kW into the compressor. The following data are given in Table below. 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. 7

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



b) An insulated mixing chamber receives 2 kg/s of R-134a at 1 MPa, 100°C in a line with low velocity. Another line with R-134a as saturated liquid at 60°C flows through a valve to the mixing chamber at 1 MPa after the valve, as shown in figure below. The exit flow is saturated vapor at 1 MPa flowing at 20 m/s. Find the flow rate for the second line. 7



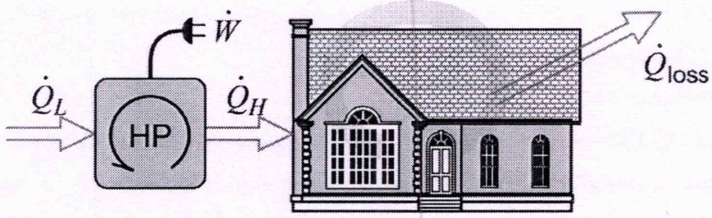
Module -3

15 a) A car engine takes atmospheric air in at 20°C, no fuel, and exhausts the air at –20°C producing work in the process. What do the first and the second laws say about that? 7

b) For each of the cases below, determine if a heat pump satisfies the first law (energy equation) and if it violates the second law. 7

a.	$\dot{Q}_H = 6$ kW	$\dot{Q}_L = 4$ kW	$W = 2$ kW
b.	$\dot{Q}_H = 6$ kW	$\dot{Q}_L = 0$ kW	$W = 6$ kW
c.	$\dot{Q}_H = 6$ kW	$\dot{Q}_L = 2$ kW	$W = 5$ kW
d.	$\dot{Q}_H = 6$ kW	$\dot{Q}_L = 6$ kW	$W = 0$ kW

16 a) A house is heated by a heat pump driven by an electric motor using the outside as the low temperature reservoir. The house loses energy in direct proportion to the temperature difference as $\dot{Q}_{loss} = K(T_H - T_L)$. Determine the minimum electric power required to drive the heat pump as a function of the two temperatures. 7



b) Consider a Carnot-cycle heat engine with water as the working fluid. The heat transfer to the water occurs at 300°C, during which process the water changes from saturated liquid to saturated vapor. The heat is rejected from the water at 40°C. Show the cycle on a T–s diagram and find the quality of the water at the beginning and end of the heat rejection process. Determine the network output per kilogram water and the cycle thermal efficiency. 7

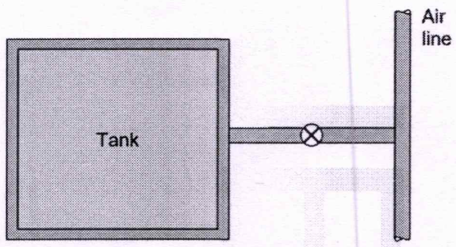
Module -4

17 a) Saturated vapor R-134a at 50°C changes volume at constant temperature. Find the new pressure, and quality if saturated, if the volume doubles. Repeat the problem for the case where the volume is reduced to half of the original volume. 7

b) A 1-m³ rigid tank with air at 1 MPa and 400 K is connected to an airline as shown in Figure. The valve is opened and air flows into the tank until the pressure reaches 5 MPa, at which point the valve is closed and the temperature inside is 450 K. 7

a. What is the mass of air in the tank before and after the process?

b. The tank eventually cools to room temperature, 300 K. What is the pressure inside the tank then?



18 a) Water in a piston/cylinder is at 90°C, 100 kPa, and the piston loading is such that pressure is proportional to volume, $P = CV$. Heat is now added until the temperature 7

reaches 200°C. Find the final pressure and the quality if the water is in the two-phase region.

b) For a certain experiment, R-410a vapor is contained in a sealed glass tube at 20°C. We want to know the pressure at this condition, but there is no means of measuring it, since the tube is sealed. However, if the tube is cooled to −20°C, small droplets of liquid are observed on the glass walls. What is the initial pressure? 7

Module -5

19 a) Water at 40°C is continuously sprayed into a pipeline carrying 5 tonnes of steam at 5 bar, 300°C per hour. At a section downstream where the pressure is 3 bar, the quality is to be 95%. Find the rate of water spray in kg/h. 7

b) A closed system allows nitrogen to expand reversibly from a volume of 0.25 m^3 to 0.75 m^3 along the path **$pv^{1.32}$= const**. The original pressure of the gas is 250 kPa and its initial temperature is 100°C. 7

(a) Draw the p-v and T-s diagrams.

(b) What are the final temperature and the final pressure of the gas?

(c) How much work is done and how much heat is transferred?

(d) What is the Entropy change of nitrogen?

20 a) **Prove that** 7

$$\frac{\beta}{k} = \left(\frac{\partial p}{\partial T}\right)_V \qquad \text{and} \qquad C_p - C_V = \left\{p + \left(\frac{\partial U}{\partial V}\right)_T\right\}\left(\frac{\partial V}{\partial T}\right)_p$$

Hence show that

$$C_p - C_v = \frac{\beta^2 TV}{k}$$

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b) **Derive:** 7

$$TdS = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_p dp$$

Let entropy S be imagined as a function of T and p.

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