Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III(New) EXAMINATION – SUMMER 2016

Subject Code:2131404 Date:04/06/2016

Subject Name:Food Engineering Thermodynamics

Time:10:30 AM to 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
1. **Psychrometric Chart and Steam Tables can be used**

Q.1 **Short Questions** **14**

1 If 2.5 g of a gas is placed in into an evacuated container of 4 liter volume at 90 ^{o}C, calculate the pressure in Pa. Take M for as 44.

2 Name different types of thermometers.

3 What is critical point of water?

4 Define boiling point.

5 Make a block diagram representing heat engine.

6 Define open system.

7 What is wet steam?

8 Define saturation temperature.

9 State unit if R.

10 What is Gibb's phase rule?

11 Calculate vacuum when absolute pressure is 83 kPa?

12 State the limitation of first law of thermodynamics.

13 When do gases deviate from ideal behavior?

14 State the law of corresponding states.

Q.2 **(a)** A vessel of 1000 litre capacity contains CO_2 gas at 5 bar pressure and 37 ^{o}C. Calculate the mass of the gas in kg assuming ideal gas behaviour. [R = 8.314 J/mol K] **03**

(b) Give Van *der* Waal's equation for real gases. Hundred moles of a gas is stored in a 124 liter closed container at – 27 ^{o}C. Calculate the pressure of the gas in kPa using Van *der* Waal's gas equation. Take a = 0.137 Pa $(m^3/mole)^2$, b = 3.86 x 10^{-5} m^3/mole, R = 8.314 J/mole K, M = 28. **04**

(c) Define C_p and C_v and prove that $C_p - C_v = \bar{R}$ for ideal gases. An ideal gas is compressed from initial volume of 0.5 m^3 to a final volume of 0.25 m^3 at a constant pressure of 2 bar. During this process 150 kJ heat was removed from the system. Calculate the work done and the accompanying change in internal energy in kJ. **07**

OR

(c) Define Specific heat and enthalpy. Fifty kilogram of a gas is heated reversibly at constant pressure from an initial state of 1500 K & 2 bar until its volume increases by 75%. Calculate **07**

(i) The work done in kJ

(ii) Change in internal energy and enthalpy in kJ.

[Take Cp = 42 J/mol K, R = 8.314 J/mol K , M= 44]

Q.3 **(a)** Define (i) Thermal reservoirs (ii) Heat Pump **03**

(b) With the help of schematic diagram explain the operation of a heat engine and refrigerator. Write formulae for their indices of performance. Establish energy balance across the system boundaries. **04**

(c) Explain Kelvin-Plank and Clausius statements of second law of thermodynamics & establish their equivalence mathematically. **07**

OR

Q.3 **(a)** Explain Clausius inequality and its significance. **03**

(b) Define PMM1 And PMM2. A heat engine operating between two constant temperature reservoirs at 600 K and 300 K is producing a net work output of 10 HP. If the thermal efficiency of the engine is 60% of the Carnot efficiency, calculate heat inflow to the engine and heat outflow in kW. **04**

(c) State Carnot theorems. Explain Carnot cycle showing various state points and processes and explain the significance of this cycle. **07**

Q.4 **(a)** Explain Triple point of water with the help of a phase diagram. Using steam tables find out the values of saturation pressure, specific volume of steam having 75% quality at 130 ^{o}C **03**

(b) For a pure substance undergoing reversible process prove the following: **04**

a. $dG = VdP - sdT$
b. $dH = TdS + VdP$

(c) Write down SFEE for a fluid stream entering and leaving a control volume in terms of work and energy transfer per unit mass for a turbine. Steam is flowing through a horizontal nozzle in steady state. The inlet and outlet conditions given are: INLET: $h_1 = 4000$ kJ/kg, $V_1 = 110$ m/s, $A_1 = 0.12$ m^2, $v_1 = 0.20$ m^3/kg. OUTLET: $h_2 = 3660$ kJ/kg, $v_2 = 0.55$ m^3/kg. Calculate **07**

(i) Exit velocity in m/s
(ii) Mass flow rate of steam
(iii) Exit area of the nozzle.

OR

Q.4 **(a)** Draw a neat phase diagram of water on P-V coordinates showing all its states. Define the term saturated and superheated vapours. **03**

(b) For a pure substance undergoing reversible process prove the following: **04**

a. $dA = -(PdV + sdT)$
b. $dU = TdS - PdV$

(c) An ideal gas is undergoing a reversible adiabatic process (1↔2). Prove that $PV^{\gamma} =$ Constant. Ten kilogram of an ideal gas at 237 ^{o}C and 20 bar pressure expands isentropically through a volume ratio of 5:1. Calculate the work done during the process in kJ. **07**

[Take $C_p = 1.025$ kJ/kgK, $C_v = 0.714$ kJ/kgK]

Q.5 **(a)** Calculate the degrees of freedom of **03**

(i) Water at its critical point.
(ii) Superheated steam at 5 bar
(iii) Ice at -5 ^{o}C

(b) Explain the following: **04**

(i) Types of equilibria and conditions of stability.
(ii) Flow work
(iii) Steady flow process
(iv) Extensive and intensive properties

(c) Define the following: **0**

(i) Wet Bulb Temperature
(ii) Specific humidity
(iii) Relative humidity
(iv) Saturated air

The weather report on a particular day reads as follows:

Atmospheric pressure = 760 mmHg
Atmospheric temperature = 38 ^{o}C &
Relative humidity = 90%.

Using Psychrometric Chart determine the following:

i. Wet Bulb Temperature
ii. Absolute humidity
iii. Dew point temperature

OR

Q.5 **(a)** Explain Joule-Kelvin effect with the help of a T-P diagram. **03**

(b) Prove the following: **04**

(i) $$\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_V = -1$$

(ii) $$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

(c) Define the following: **07**

(i) Adiabatic saturation temperature
(ii) Degree of saturation
(iii) Relative humidity

The following data are available for atmospheric air:
Barometric Pressure = 760 mm Hg
Relative humidity = 70%.
DPT = 18 ^{o}C
Using Psychrometric Chart determine:

(i) WBT in ^{o}C
(ii) DBT in ^{o}C
(iii) Specific humidity of moist air.

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