Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III EXAMINATION – SUMMER 2015

Subject Code: 131404 **Date:04/06/2015**

Subject Name: Food Engineering Thermodynamics

Time:02.30pm-05.00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Explain first law of thermodynamics. Prove that for an ideal gas undergoing a reversible process: **07**

(i) PV^{γ} = constant (ii) $TV^{\gamma-1}$ = constant

(b) What is ideal gas? What are the assumptions for ideal behaviour of gases? Give reasons why real gases deviate from ideal behaviour. Write Van *der* Waal's equation for real gases and state S.I. units of constants a and b. Assuming ideal gas behaviour, calculate the volume of 128 g SO_2 gas in litre at 27°C and 2 atmosphere pressure. **07**

Q.2 **(a)** Explain Zeroth law of thermodynamics and explain how it forms the basis for temperature measurement. Name different types of thermometers and state their operating principle. The voltage-temperature relationship of an experimental thermocouple was worked out as $e = (0.3t + 5 \times 10^{-4} t^2)$ where e is in mV and t is in ^{o}C. Calculate the temperature for readings at 25 mV and 40 mV. **07**

(b) Prove that $C_p - C_v = \overline{R}$ for ideal gases. An insulated rigid tank of 5 m^3 volume contains 25 kg of CO_2 gas at 2 bar pressure. A paddle agitator is rotated vigorously inside the tank so that its pressure shoots up to 4 bar. Calculate the following in S.I. units: **07**

(i) Work done
(ii) Net heat transfer
(iii) Change in internal energy
(iv) Entropy change.

Give appropriate sign convention. [C_p = 1.04 kJ/kg^{0}C, R = 8.314 J/mol K]

OR

(b) Answer the following questions: **07**

(i) What do you understand by adiabatic process?
(ii) Define compressibility factor of gases?
(iii) What is SI unit of temperature?
(iv) Define reversible process.
(v) State the law of corresponding states
(vi) Gauge pressure
(vi) Define extensive and intensive properties.
(vii) What do you understand by enthalpy of a system?

Q.3 **(a)** Indicate different states of a pure substance (Water) on a P-v diagram and explain the following: **07**

(i) Critical pressure
(ii) Triple point
(iii) Saturated vapours
(iv) Superheated vapours.

Using Steam Tables find out the following:

(i) Saturation pressure of water at 200 ^{o}C.
(ii) Latent heat of vaporization at critical temperature
(iii) Specific entropy of saturated vapours at 140 ^{o}C.

(b) Explain steady and non-steady flow processes by giving examples. Write down SFEE for steam entering and leaving a turbine in terms of energy and work interactions per unit mass. Using this equation show that work done is at the cost of enthalpy change. Make necessary assumptions and state them. **07**

OR

Q.3 **(a)** Draw a T-s diagram of water showing various states. Define critical point & triple point of water. Show that specific volume of steam is given by $\nu = \nu g + (1-x)\nu_{fg}$. **07**

Using Steam Tables determine the following for saturated steam at 200 ^{o}C:
(i) Saturation pressure in bar
(ii) Entropy in kJ/kg K
(iii) Latent heat of vaporization in kJ/kg
(iv) Specific volume in m3/kg

(b) State the thermodynamic function of a nozzle and diffuser. At the inlet of a nozzle the enthalpy of the fluid passing is 3200 kJ/kg and the velocity is 60 m/s while at the discharge end the enthalpy is 2800 kJ/kg. Assume that the nozzle is horizontal and there is no heat loss from it. **07**

(i) Determine the velocity of the fluid exiting the nozzle in m/s.
(ii) Find the mass flow rate of the fluid in kg/s if the inlet area is 0.2 m^2 and its specific volume at inlet is 0.12m^3/kg.

Q.4 **(a)** Explain the operation of a heat engine and a refrigerator with the help of schematic block diagram. How do you express their indices of performance? A heat engine operating between two constant temperature reservoirs at 480 K and 320 K is producing a net work output of 6 kW. If the thermal efficiency of the engine is 85% of the maximum possible efficiency, calculate the heat input to the engine and the heat rejection in kW. What would be its COP? **07**

(b) Explain the operation of a Carnot heat pump with the help of a neat diagram. State the Kelvin–Planck statement of the second law of thermodynamics. Briefly explain PMM2 and PMM2 with schematic diagram. **07**

OR

Q.4 **(a)** Explain the concept of entropy. Describe the thermodynamic meaning of Clausius inequality. Show that for any thermodynamic process (1→2), **07**

$(\Delta s)_{1-2} \geq \int_1^2 (\frac{dQ}{T})$, where Δs is the entropy change during the process in kJ/K and dQ is the heat interaction at absolute temperature T.

(b) Explain the operation of a Carnot refrigerator with the help of a neat diagram. Explain Clausius statement of second law of thermodynamics. A refrigerator is operating between source and sink maintained at 7^0C and 42^0C and respectively. The heat extracted from source is 2 kW and the heat rejected to the sink is 3 kW. Calculate the work needed for the process and COP of the device. What can be the maximum possible COP? **07**

Q.5 (a) Define wet bulb and adiabatic saturation temperatures of moist air. Air having a barometric pressure of 752 mm Hg has a temperature of 40 ^{o}C. If the partial vapour pressure of water vapours present in air is 22 mm Hg, calculate the following in SI units: **07**

(i) Specific humidity
(ii) Dry bulb temperature
(iii) Wet bulb temperature
(iv) Relative humidity
(v) Dew point temperature
(vi) Specific enthalpy of moist air

(b) Show that $\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_V = -1$ **07**

What is thermodynamic degree of freedom? State Gibb's phase rule for multi- component and multi-phase systems. A mixture of water and & ammonia is in equilibrium with its own vapours. Calculate the degrees of freedom and mention the different set of intensive properties which can be used to describe the state of such a system.

OR

Q.5 (a) Define the following terms for moist air: **07**

(i) Dew Point Temperature
(ii) Relative humidity.

Prove that by $\omega = 0.622\left(\frac{p_w}{p_o - p_w}\right)$. Symbols have their usual meanings.

The weather report of a city is given below:
Atmospheric pressure = 760 mm Hg
Ambient Temperature = 27 ^{o}C
RH = 60%
Calculate the DPT, WBT, Specific enthalpy and Absolute humidity of the atmospheric air. Use Psychrometric Chart.

(b) Prove that $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$ **07**

Calculate the degrees of freedom of water at its critical point. If the thermodynamic degrees of freedom of water in a certain state are 2, what could be the number of phases it can exist in.

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