

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE - SEMESTER-III • EXAMINATION – WINTER • 2014****Subject Code: 131404****Date: 30-12-2014****Subject Name: Food Engineering Thermodynamics****Time: 02.30 pm - 05.00 pm****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) Define ideal gases and state assumptions of “kinetic theory of gases” which are required for its ideal behaviour. Write down Van der Waals equation for real gases and explain the correction factors introduced in the equation. A rigid vessel of 460 liter volume contains oxygen gas at 37 °C at 10 bar pressure. Calculate the mass of oxygen in the vessel in kilograms. Some oxygen leaks from the vessel isothermally over a period of time so that the final pressure was reduced to 8 bar. Calculate the mass of oxygen left in the vessel in kilograms. [R = 8.314 J/mol K, M = 32] **07**
- (b) Air in a vessel at 27 °C and 2 bar is compressed ideally at constant pressure until its volume changes from 300 liter to 150 liter. The process involves removal of 40 kJ of heat from the system. Calculate **03**
- (i) The work done in kJ
  - (ii) Change in internal energy in kJ
  - (iii) Change in enthalpy in kJ.
- (c) Answer the following: **04**
- (i) What do you understand by adiabatic process?
  - (ii) Define compressibility factor of gases?
  - (iii) Prove that  $C_p - C_v = \bar{R}$  for ideal gases
  - (iv) Define specific enthalpy.
- Q.2**
- (a) Explain Zero<sup>th</sup> law of thermodynamics and illustrate the concept of temperature measurement. Name different types of thermometers. The voltage-temperature relationship of a thermocouple is  $e = (0.25t + 6 \times 10^{-4} t^2)$  where e is in mV and t is in °C. Determine the temperature if mV readings are 20 mV and 35 mV. **07**
- (b) State first law of thermodynamics for a closed system undergoing a cyclic process. Differentiate between isothermal compression and adiabatic compression processes. Prove that for an ideal gas undergoing a reversible process  $PV^\gamma = \text{constant}$ . **07**
- OR**
- (b) Explain first law of thermodynamics for a closed system undergoing a state change process. Differentiate between reversible and irreversible processes. Prove that for an ideal gas undergoing a reversible process  $TV^{\gamma-1} = \text{constant}$ . **07**
- Q.3**
- (a) What do you understand by steady and non-steady flow processes? Explain giving examples. Write down SFEE for a fluid stream entering and exiting a throttling device in terms of energy and work transfer per unit mass. Apply this equation to prove that enthalpy of a fluid remains constant during a throttling process. Make necessary assumptions and mention them clearly. **07**

- (b) State and explain Kelvin-Planck statement of second law of thermodynamics. Explain the operation of a Carnot heat pump with the help of a neat diagram. Write down basic energy balance and coefficient of performance equations. What do you mean by PMM2? **07**

**OR**

- Q.3 (a)** Define steady and non-steady flow processes giving examples. Write down generalized SFEE for a fluid stream entering and leaving a turbine in terms of its K.E., P.E., enthalpy, heat and work interactions. Apply it to steam entering and leaving a turbine to show that the work done is at the expense of change in enthalpy of steam. Make necessary assumptions and mention them clearly. **07**

- (b) Explain Clausius statement of second law of thermodynamics with the aid of a neat sketch. A heat pump is operating between source and sink maintained at 327 °C and 27 °C respectively. The heat input to the device from source is 2 kW and the heat pumped to the utility is 3 kW. Calculate the work needed for the process and COP of the heat pump. What would be the maximum COP possible? **07**

- Q.4 (a)** If P, v, T, h, u, g, a and s are state coordinates and exact differentials, prove the following: **06**

(i)  $du = Tds - Pd v$

(ii)  $dg = v dP - s dT$

(iii)  $dh = Tds - v dP$

(iv)  $da = -Pd v - s dT$

- (b) Show that for an ideal gas undergoing a reversible process 1 → 2, **05**

$$(\Delta s)_{1 \rightarrow 2} = C_v \ln \left[ \frac{T_2}{T_1} \right] + \bar{R} \ln \left[ \frac{v_2}{v_1} \right]$$

The symbols have their usual thermodynamic meanings.

- (c) State Gibb's phase rule. What are the maximum degrees of freedom which a thermodynamic system can enjoy? Calculate the degrees of freedom of superheated steam at 5 bar. **03**

**OR**

- Q.4 (a)** Prove that for a reversible process  $\oint \frac{dQ}{T} = 0$ . What would you interpret if (i) **05**

$\oint \frac{dQ}{T} > 0$  and (ii)  $\oint \frac{dQ}{T} < 0$ . Explain.

- (b) Prove the following: (i)  $\left( \frac{\partial s}{\partial v} \right)_T = \left( \frac{\partial P}{\partial T} \right)_v$  (ii)  $\left( \frac{\partial T}{\partial v} \right)_s = - \left( \frac{\partial P}{\partial s} \right)_v$  **06**

- (c) What is Gibb's phase rule? Calculate the degrees of freedom of liquid water at 95 °C and 2 atmosphere pressure. If the thermodynamic degrees of freedom of water in a certain state are 3, calculate the number of phases it can exist in. **03**

- Q.5 (a)** Draw a neat labeled P-V diagram of water showing its various states. Define critical point. Show that the specific volume of wet steam is given by  $v = v_g + (1-x) v_{fg}$ . Using Steam Tables determine the following for saturated steam at 100 °C: **07**
- (i) Saturation pressure in bar
  - (ii) Entropy in kJ/kg K
  - (iii) Latent heat of vaporization in kJ/kg
  - (iv) Specific volume in m<sup>3</sup>/kg

- (b)** Define the following: (i) Wet bulb temperature (ii) Relative humidity. **07**

On a certain WINTER day, the weather report of a place was recorded as:

Ambient Temperature = 30 °C, WBT = 20 °C,

Barometric pressure = 760 mm Hg. Using Psychrometric Chart, calculate the Dew Point Temperature, Relative humidity, Absolute humidity specific enthalpy and specific volume of the atmospheric air.

**OR**

- Q.5 (a)** Prove that absolute humidity ( $\omega$ ) of moist air is given by  $\omega = 0.622 \left( \frac{P_w}{P - P_w} \right)$ . Define **07**

the following: (i) Wet Bulb Temperature (ii) Specific humidity

On a certain spring WINTER day, the weather report of a city was recorded as:

Ambient Temperature = 20 °C, % RH = 90

Atmospheric pressure = 760 mm Hg

Using Psychrometric Chart, calculate the DPT, WBT, Absolute humidity specific volume and specific enthalpy of the atmospheric air.

- (b)** Draw a neat phase diagram of water on T-s coordinates showing all its states. Define the following terms: **07**

- (i) Triple point (ii) Superheated vapours
- (iii) Critical point (iv) Saturated steam

Using Steam Tables, calculate the specific volume and specific enthalpy of steam at 110 °C having a dryness fraction of 80%.

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