Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III EXAMINATION – SUMMER 2016

Subject Code:131404 **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.**
4. **Psychrometric Chart and steam tables can be used.**

Q.1 **(a)** Compare the behaviour of ideal and real gases and explain why real gases deviate from ideal behaviour? A sealed container of 0.3 m^3 capacity contains nitrogen gas at a temperature of -57 ^oC and 20 bar pressure. Calculate the mass of nitrogen gas in kg using ideal gas equation. [R = 8.314 J/mol K] **07**

(b) Define enthalpy and specific heats C_p and C_v and prove that C_p - C_v = $\overline{R}$ for ideal gases. The temperature of 5 kg of a gas held in a rigid cylinder was increased from 27 ^oC to 37 ^oC by adding 50 kJ of heat externally. Calculate the work done and the effected change in internal energy of the system. Specify the direction and nature of the change. [C_v = 745 J/kg K] **07**

Q.2 **(a)** Differentiate between a nozzle and a diffuser. Explain their operation and applications. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 4000 kJ/kg and the velocity is 50 m/s. At the discharge end, the enthalpy is 2700 kJ/kg. The nozzle is horizontal and there no heat loss. **07**

(i) Find the exit velocity from the nozzle.

(ii) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187m^3/kg, find the mass flow rate through the nozzle.

(b) Show different states of a pure substance (Water) on a neatly drawn T-s diagram and explain the following terms: **07**

(i) Critical temperature (ii) Triple point

(iii) Sub-cooled zone (iv) Superheated vapours.

OR

(b) Define dryness fraction (x) of steam. What is the state of water when x = 1 and x = 0? A rigid vessel contains wet steam (x = 0.9) at a pressure of 2 bar. Calculate the following for wet steam using Steam Tables: **07**

(i) Saturation temperature in K (ii) Density in kg/ m^3

(iii) Sp. Enthalpy in kJ/kg (iv) Internal energy in kJ/kg

(v) Specific entropy in kJ/kg K

Q.3 **(a)** State the first law and Clausius's statement of second law of thermodynamics. Discuss the consequences and practical limitations of first law of thermodynamics for a closed system. **07**

(b) Explain Zeroth law of thermodynamics and discuss how it serves as a basis for temperature measurement. A platinum resistance thermometer has a resistance of 5 Ω at 0 ^{o}C and 7 Ω at100 ^{o}C. Calculate the temperature coefficient of resistance (α) in per ^{o}C. What would be the temperature in Kelvin when the thermometer indicates a resistance of 12 Ω? **07**

OR

Q.3 **(a)** With the help of schematic diagram explain the operation of a heat engine, a refrigerator and a heat pump mentioning their indices of performance and energy balance equations. Show that the COP of a heat pump is one more than the COP of a refrigerator. **07**

(b) Explain first law of thermodynamics. An ideal gas is undergoing a reversible adiabatic process (1↔2). Prove that the work done by the system during this process is given by $W = \frac{m\bar{R}}{\gamma - 1}(T_1 - T_2)$. **07**

Q.4 **(a)** What are thermal reservoirs? A heat engine operating between two constant temperature reservoirs at 500 K and 350 K is producing a net steady work output of 20 kW. If the thermal efficiency of the engine is 80% of the maximum possible efficiency, calculate heat input to the engine and heat rejection in kW. **07**

(b) Explain the following: **07**
(i) Kelvin-Plank statement of second law of thermodynamics
(ii) Clausius inequality
(ii) PMM1 And PMM2

OR

Q.4 **(a)** Prove that $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$ **07**

Explain Gibb's phase rule with an example. State the types of equilibrium for a thermodynamic system and conditions for its stability.

(b) Explain the following: **07**
(i) Joule-Kelvin effect
(ii) Flow work
(iii) Carnot theorems

Q.5 **(a)** Define the following with regard to moist air: **07**

(i) WBT
(ii) Dew point temperature
(iii) Relative humidity
(iv)Adiabatic saturation temperature.

The weather report on a certain day states that atmospheric air is at 40 ^{o}C DBT, 24 ^{o}C WBT. Calculate specific humidity, specific enthalpy and % relative humidity.

(b) For a pure substance undergoing an infinitesimal reversible process prove the following: **07**

a. $dG = VdP - sdT$
b. $dH = TdS + VdP$
c. $dA = -(PdV + sdT)$
d. $dU = TdS - PdV$

OR

Q.5 **(a)** Define moist air. The weather report on a particular summer day states the following: **07**

Atmospheric pressure = 1.01325 bar
Atmospheric temperature = 44 ^{o}C &
Relative humidity = 80%.

Using Psychrometric Chart find out the following:

(i) Dry Bulb Temperature (DBT)
(ii) Wet Bulb Temperature (WBT)
(iii) Absolute humidity
(iv) Mass of moist air
(v) Dew point temperature
(vi) Specific volume
(vii) Specific enthalpy

(b) Prove that for an ideal gas **07**

(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) $\left(\frac{\partial V}{\partial T}\right)_P = \frac{1}{\left(\partial T / \partial V\right)_P}$

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