Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III(OLD) EXAMINATION – SUMMER 2019

Subject Code: 131404 **Date: 11/06/2019**

Subject Name: Food Engineering Thermodynamics

Time: 02:30 PM TO 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)** Differentiate between ideal and real gases. **07**

A container of 1000 liter contains CO_2 gas at 6 atmosphere pressure and 27 ^oC. Calculate the mass of gas in kg. Assume ideal gas behaviour.
[Take R = 8.314 J/mol K]

(b) What is Van der Waals gas equation? Hundred kilogram of N_2 gas is stored in a 20 liter sealed container at 7 ^oC. Calculate the pressure of the gas in kPa using compressibility factor of z = 0.88. [Take M = 28 and R = 8.314 J/mole K] **07**

Q.2 **(a)** Explain Zeroth law of thermodynamics. List different types of thermometers and explain the principle of operation of any one. **07**

(b) Explain Joule–Kelvin coefficient specifying its importance. **07**

For a 2-phase Liquid-Vapour system in thermal equilibrium, prove that: $\ln\left(\frac{P_2}{P_1}\right) = \frac{h_{fg}}{\bar{R}}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$.

OR

(b) Define enthalpy and specific heats C_p and C_v. Prove that $C_p - C_v = \bar{R}$ for ideal gases. The temperature of 5 kg of a gas held in a rigid cylinder was increased from 24 ^oC to 37^oC by adding 45 kJ of heat externally. Calculate the work done and the change in internal energy of the system. [Take C_v = 745 J/kg K] **07**

Q.3 **(a)** State first law of thermodynamics. Prove that the work done by an ideal gas undergoing a reversible adiabatic process is given by $W = \frac{m\bar{R}}{\gamma - 1}(T_1 - T_2)$. **07**

(b) What is turbine? Write down SFEE for a fluid stream entering and leaving a system in terms of work and energy transfer per unit mass. Steam is flowing through a horizontal nozzle in steady state. The inlet and outlet conditions given are: **07**

INLET: h_1 = 3200 kJ/kg, V_1 = 110 m/s, A_1 = 0.11 m^2, v_1 = 0.2 m^3/kg
OUTLET: h_2 = 2900 kJ/kg, v_2 = 0.51 m^3/kg.
Calculate (i) Exit velocity in m/s
(ii) Mass flow rate of steam in kg/s
(iii) Exit area of the nozzle in m^2

OR

Q.3 **(a)** State the first law of thermodynamics. Prove that PV^{γ} = Constant for an ideal gas undergoing a reversible adiabatic process. Ten kilogram of an ideal gas at 200 ^{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]

(b) Define thermodynamic degrees of freedom and state Gibb's phase rule. Explain different types of thermodynamic equilibrium. Calculate the thermodynamic degrees of freedom of pure water at its critical point. **07**

Q.4 **(a)** Explain the following: **07**
(i) Second law of thermodynamics
(ii) Clausius inequality
(ii) PMM1 And PMM2

(b) Explain Carnot theorems. A heat engine operating between two constant temperature reservoirs at 600 K and 400 K is producing a net steady work output of 24 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**

OR

Q.4 **(a)** With the help of schematic diagram explain the operation of a heat engine and refrigerator A refrigerator is operating between 1 ^{o}C and 30 ^{o}C at a COP of 50 % of the maximum possible COP. If the net cooling effect generated is 2 kW, calculate the power requirement. **07**

(b) Prove the following: **07**

(i) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

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

Q.5 **(a)** Draw a neat labeled P-v diagram of a pure substance (water) showing its various states. Determine the following using steam tables for saturated steam at 10 bar pressure: **07**

(i) Saturation temperature in ^{o}C
(ii) Entropy in kJ/kg K
(iii) Latent heat of vaporization in kJ/kg
(iv) Specific volume in m^3/kg

(b) The weather report on a particular summer day in Anand states the following: **07**
Atmospheric pressure = 1.01325 bar
Atmospheric temperature = 42 ^{o}C &
Relative humidity = 60%.
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

OR

Q.5 **(a)** Draw and explain phase diagram of water on a T-s diagram. **07**

Using Steam Tables determine the following for saturated steam at 160 ^{o}C:

(i)Specific enthalpy (ii) Latent heat of vaporization (iii) Density
(iv) Specific entropy (v) Saturation pressure in kPa

(b) Define the following in relation to moist air: **07**

i. Dry bulb temperature
ii. Wet bulb and temperature
iii. Adiabatic saturation temperature
iv. Relative humidity
v. Absolute humidity
vi. Sensible heating
vii. Dehumidification

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