Seat No.: ________ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (New) EXAMINATION – WINTER 2019

Subject Code: 3131404 **Date: 26/11/2019**

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.**
4. **Standard Steam Tables and normal range Psychrometric Chart can be used**

Q.1 **(a)** Define ideal and real gases. Why do real gases deviate from ideal behaviour? A sealed container contains air at 87 ^oC and 1 bar. The container was evacuated using a vacuum pump so that the vacuum inside the container is recorded as 18 kPa. Calculate the final temperature & absolute pressure inside the container. **03**

(b) Write down Van *der* Waal's equation of state for real gases. Two hundred moles of CO_2 gas is stored in a 2 liter closed container at – 13 ^oC. Calculate the pressure of the gas in kPa using Van *der* Waal's gas equation. **04**
Take a = 0.360Pa $(m^3/mole)^2$, b = 4.28 x 10^{-5} m^3/mole, R = 8.314 J/mole K

(c) Match Column-I with most appropriate entity from Column-II and reconstruct a matched table. **07**

Column-I	Column-II
Vacuum of 380 mm Hg equals	(i) Van der Waal's gas equation
Ideal gases	(ii) $C_p - C_v$ is > 0
Real gases	(iii) NkT (iv) 14 g
Specific gas constant for O_2 gas is	(v) 77^{o}F (vi) 56 g (vii) $\bar{R}T$
For ideal gases PV is equal to	(viii) < 0 for real gases
Mass of 2 mole N_2 gas at NTP is	(ix) Sublimation (x) 14.67kPa
25 ^oC is equal to	(xi) 259.8 J/kg K
Freeze drying	

Q.2 **(a)** Explain Zeroth law of thermodynamics. List different types of thermometers. **03**

(b) A gas at 5 bar and 177 ^oC kept in a container of 200 liter volume. It is cooled isobarically to 27 ^oC. Calculate the following in kJ: **04**
(a) Heat transferred.
(b) Change in internal energy.
[Take Cp = 40 J/mol K, R = 8.314 J/mol k]

(c) Derive SFEE for a fluid stream entering and leaving a thermodynamic system in terms of work and energy transfer per unit mass. Specify the assumptions made. **07**

OR

(c) Explain how first law of thermodynamics can be applied for closed systems operating in a cyclic and non-cyclic process. Prove that "$TV^{\gamma-1}$ = constant" for an ideal gas undergoing a reversible process. **07**

Q.3 **(a)** Draw and show the following processes on a psychrometric chart: **03**
(i) Sensible heating
(ii) Dehumidification
(iii) Humidification

(b) Atmospheric air for Anand city on a certain day in October records the following: **04**
Temperature = 32 °C
Barometric Pressure = 760 mm Hg
WBT = 27 °C
Using Psychrometric Chart determine:
(i) DPT in °C
(ii) % RH
(iii) DBT in °C
(iv) Specific humidity in kg/kg d.a

(c) Draw a labeled 'P-V diagram' of pure water showing zones of thermodynamic interest. Determine the following using Steam Tables for saturated steam at 10 bar pressure: **07**
(i) Saturation temperature in Kelvin
(ii) Specific Entropy in kJ/kg K
(iii) Latent heat of vaporization in kJ/kg
(iv) Enthalpy of saturated vapours in kJkg.

OR

Q.3 **(a)** Indicate the following processes on psychrometric chart for moist air: **03**
i. Sensible cooling
ii. Dehumidification and heating
iii. Cooling and dehumidification

(b) Atmospheric air on a certain day has the following parameters: **04**
Temperature = 40 °C
Barometric Pressure = 760 mm Hg
Relative humidity = 80%.
Using Psychrometric Chart determine:
(i) DPT in °C
(ii) WBT in °C
(iii) Absolute humidity in kg/kg d.a
(iv) Enthalpy in kJ/kgd.a

(c) Show state points of water on a "T-S phase diagram". Explain sub-cooling, superheating, critical point & triple point of water. Using Steam Tables, for saturated steam at 180 °C, determine **07**
(i) Saturation pressure in bar
(ii) Specific Entropy in kJ/kg K
(iii) Enthalpy of saturated vapours in kJkg.

Q.4 **(a)** Prove that for any thermodynamically feasible cyclic process $\oint \frac{dQ}{T} \leq 0$. **03**

(b) What is Joule-Kelvin effect? Show that for ideal gases, $\mu_{j,T} = 0$ **04**

(c) State first law of thermodynamics for a closed system undergoing a state change process. An ideal gas is allowed to expand isothermally in a reversible manner. Establish that the work done per mole of gas is given by $W = nRT \ln \frac{V_2}{V_1}$. **07**

OR

Q.4 **(a)** Define Specific heat and enthalpy. Prove that $C_p - C_v = \overline{R}$ for ideal gases. **03**

(b) An insulated rigid tank of 0.2 m^3 volume contains 25 kg of nitrogen gas at 4 bar pressure. A paddle wheel is rotated inside the tank so that its pressure increases to 5 bar. Calculate the following: **04**

(i) Net heat transfer (ii) Change in internal energy
(iii) Work done (iv) Entropy change.
[Take C_p = 1.04 kJ/kgK, R = 8.314 J/mol K]

(c) Differentiate between steady and non-steady flow processes with examples. Write down SFEE for a fluid stream entering and exiting a turbine. For a steady flow of steam through a turbine the following data are available: **07**

Inlet Condition	Outlet Condition
P_1 = 50 bar t_1 = 500 ^{0}C h_1 = 3600 kJ/kg v_1= 0.072 m^3/kg	P_1 = 38 bar t_1 = 470 ^{0}C h_1 = 3500 kJ/kg v_1= 0.082 m^3/kg

A heat loss of 12kJ/kg occurs through the turbine due to poor insulation. Calculate the inlet and outlet velocities of steam. Assume that inlet and outlet cross-sectional areas and elevations are same.

Q.5 **(a)** What is Gibb's phase rule? Calculate the degrees of freedom of liquid water at 25 ^{0}C and 1 atmosphere pressure and at its critical point. **03**

(b) Prove the following for a pure substance undergoing an infinitesimally reversible process: **04**

(i) dU = TdS – PdV
(ii) dH = TdS + VdP
(iii) dA = - (PdV + sdT)
(iv) dG = VdP – sdT

(c) State second law of thermodynamics. Draw a block diagram of a heat engine indicating work-energy flow directions and write energy balance equations. How will you express its Carnot and actual thermal efficiency? A heat engine operating on Carnot cycle produces 200 kW of power while operating between temperature limits of 750°C and 50ºC. Determine the engine efficiency and the amount of heat input to the engine. **07**

OR

Q.5 **(a)** Explain types of thermodynamic equilibrium for a system and conditions for its stability. **03**

(b) Using first principles, prove that $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$ **04**

(c) State Kelvin-Plank statement of second law of thermodynamics and explain the equivalence of Kelvin –Planck and Clausius statements with neat diagram. **07**

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