Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (New) EXAMINATION – WINTER 2015

Subject Code:2131404 **Date:29/12/2015**

Subject Name: Food Engineering Thermodynamics

Time: 2:30pm to 5:00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of Steam Tables and Psychrometric Chart is permitted**

Q.1	1	Define isolated system with an example.	**01**
	2	Explain gauge pressure. If P_g = 1 bar, calculate P_{abs}.	**01**
	3	Give SI unit of specific gas constant and write its dimensions.	**01**
	4	How much volume would 1 mole of CH_4 molecules take up if they were stacked on each other? Take b = 0.04278 liter/mole.	**01**
	5	If 2.5 g of XeF_4 is placed in into an evacuated container of 3 liter volume at 80 ^oC, calculate the pressure in the container in Pa. Take M for as 207.3.	**01**
	6	State the law of corresponding states. What is compressibility factor?	**01**
	7	State Zeroth law of thermodynamics and state its importance.	**01**
	8	Name different types of thermometers and state their working principle.	**01**
	9	What is triple point of water? State its significance.	**01**
	10	Define normal boiling point.	**01**
	11	Make a block diagram representing Carnot refrigerator.	**01**
	12	State Gibb's phase rule with an example.	**01**
	13	What is superheated steam?	**01**
	14	Define adiabatic saturation temperature.	**01**

Q.2 (a) Define ideal gases and explain under what conditions gases deviate from ideal behavior. A vessel of 250 litre volume contains nitrogen gas at 2 bar pressure and 27 ^oC. Calculate the mass of nitrogen in kg assuming ideal gas behaviour. [Take R = 8.314 J/mol K] **03**

(b) What are real gases? Write down Van *der* Waal's equation of state for real gases. What do the constants 'a' and 'b' in the equation stand for? Five hundred moles of N_2 gas is stored in a 75 liter closed container at – 28 ^oC. Calculate the pressure of the gas in kPa using Van *der* Waal's gas equation. Take a = 0.137 Pa $(m^3/mole)^2$, b = 3.86 x 10^{-5} m^3/mole, R = 8.314 J/mole K **04**

(c) Define Specific heat and enthalpy. Express each one in terms of state functions u, v t, and p. Prove that $C_p - C_v = \overline{R}$ for ideal gases. Ten kilogram of CO_2 gas is heated reversibly and isobarically from an initial state of [T = 3250 K, P= 2 bar] until its volume doubles. Calculate **07**

(i) The expanded work in kJ

(ii) Change in internal energy and enthalpy in kJ.

[Take Cp = 40 J/mol K, R = 8.314 J/mol k]

OR

(c) Define C_p and C_v and prove that $C_p - C_v = 0$ for liquids and solids. An ideal gas is compressed from initial volume of 0.5 m^3 to a final volume of 0.25 m^3 at a constant pressure of 2 bar. During this process 150 kJ heat was removed from the system. Calculate the work done and the accompanying change in **07**

internal energy in kJ specifying proper sign convention.

Q.3 **(a)** Define control volume. Write down SFEE for a stream of fluid entering and leaving a control volume. Specify each term in the equation and mention their SI units. **03**

(b) Steam is being injected into a cylinder through a horizontal nozzle in steady state. The inlet and outlet conditions (1 & 2) are: **04**

h_1 = 3600 kJ/kg, V_1 = 90 m/s, A_1 = 0.12 m^2, v_1 = 0.2 m^3/kg

h_2 = 3260 kJ/kg, v_2 = 0.52 m^3/kg.

Calculate (i) Exit velocity

(ii) Mass flow rate of steam

(iii) Area of the nozzle at the exit end.

(c) Explain first law of thermodynamics for a closed system undergoing a state change process. Prove that $PV^{\gamma} =$ Constant for an ideal gas is undergoing a reversible adiabatic process. Ten kilogram of an ideal gas at 237 ^{o}C and 20 bar pressure expands isentropically until its volume increases to five times. Calculate the work done during the process in kJ. **07**

[Take C_p = 1.025 kJ/kgK, C_v = 0.714 kJ/kgK]

OR

Q.3 **(a)** Define flow work. What is diffuser? Write down SFEE for steam jet entering and leaving a diffuser in terms of work and energy transfer per unit time and state the assumptions made while doing so. **03**

(b) A steam turbine developing 500 kW receives a flow of 24 tonne/h of steam @ 105 m/s. The exit velocity of steam is 324 m/s. The inlet pipe is located 2 m above the exhaust pipe. Using Steady Flow Energy Equation, calculate the change in enthalpy in kJ/kg. **04**

(c) Explain first law of thermodynamics for a cyclic process. A gas at 500 kPa, 227 ^{o}C occupying 0.25 m3 volume is cooled isobarically to 67 ^{o}C. Calculate the following: **07**

(a) Heat transferred in kJ.

(b) Work done and its direction.

(c) Change in internal energy.

Mention the direction of each of the above changes.

Q.4 **(a)** Assume that two Carnot engines are working in series between temperatures 600K and 400K. Both the engines are coupled in a manner to develop same power. Calculate the intermediate temperature at which the first one rejects heat. **03**

(b) What is a heat engine? State its salient characteristics. Briefly describe the working of a thermal power plant with the help of a schematic diagram and write energy balance equations. How do you measure its index of performance? **04**

(c) State and explain Kelvin-Plank and Clausius statements of second law of thermodynamics. Explain their equivalence by justifying your answer with mathematical justification. **07**

OR

Q.4 **(a)** Explain the concept of entropy. A refrigerator is operating between 2 ^{o}C and 40 ^{o}C providing a COP of 70% of the maximum possible COP. If it is removing 3.5167 kW of heat from the refrigerated space, calculate the power requirement and the heat it rejects to the sink. **03**

(b) Explain Clausius inequality. Show that for any thermodynamic process (1→2), $(\Delta s)_{1-2} \geq \int_1^2 (\frac{dQ}{T})$. **04**

(c) State and explain Carnot theorems. What do you understand by PMM1 And PMM2? Explain Carnot cycle showing various state points and processes and explain the significance of this cycle. **07**

Q.5 **(a)** Establish the following for a pure substance undergoing an infinitesimal reversible process: **03**

(i) dU = TdS – PdV

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

(b) Explain the following briefly: **04**

(i) Critical point

(ii) Dryness fraction of steam

Using steam tables find out the values of saturation temperature, specific volume of steam having 80% quality at 2 bar pressure

(c) Explain the following: **07**

(i) Sensible heating

(ii) Dew point temperature

(iii) Cooling and dehumidification

(iv) Specific humidity

For a certain location the following data are available for the atmospheric air:

Temperature = 35 ^oC

Barometric Pressure = 760 mm Hg and

Relative humidity = 50%.

Using Psychrometric Chart determine:

(i) Dew point temperature in ^oC

(ii) Wet bulb temperature in ^oC

(iii) Mass of moist air in kg/kg d.a

OR

Q.5 **(a)** Establish the following for a pure substance undergoing an infinitesimal reversible process: **03**

(i) dH = TdS + VdP

(ii) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$

(b) Explain the following briefly: **04**

(i) Saturated steam

(ii) Quality of steam

Using steam tables find out the values of saturation pressure, specific volume of steam having 75% quality at 140 ^oC.

(c) Explain the following: **07**

(i) Wet bulb temperature

(ii) Relative humidity

(iii) Heating and dehumidification

(iv) Sensible cooling

For a certain location the following data are available for the atmospheric air:

Barometric Pressure = 760 mm Hg

Relative humidity = 60%.

DPT = 20 ^oC

Using Psychrometric Chart determine:

(i) DBT in ^oC

(ii) Wet bulb temperature in ^oC

(iii) Specific humidity of moist air in kg/kg d.a

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