Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III(New) • EXAMINATION – WINTER 2016

Subject Code:2131404 Date:06/01/2017

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. **Standard Steam Tables and Psychrometric Chart can be used.**

Q.1 **Answer the following short questions:**

1	Define saturated steam.	**1**
2	What is triple point of water?	**1**
3	Calculate the degrees of freedom of water at its critical point.	**1**
4	Define entropy and give its SI unit.	**1**
5	If P_g = 2 bar, calculate P_{abs}.	**1**
6	Define closed system with an example.	**1**
7	Write SI unit and dimensions of specific gas constant.	**1**
8	What is a reversible process? Show it on a P-v diagram.	**1**
9	What do you mean by a steady state thermodynamic process?	**1**
10	What is compressibility factor of gases?	**1**
11	State atleast two contributions of Nicholas Sadi Carnot.	**1**
12	Comment if energy can have quality? Give example.	**1**
13	What do you understand by isentropic process?	**1**
14	What are extensive properties? Give atleast two examples.	**1**

Q.2 **(a)** State under what conditions gases deviate from ideal behavior. A vessel of 5 m^3 volume contains oxygen gas at 37 ^{0}C and 1 atmosphere pressure. The vessel is evacuated isothermally to a vacuum of 700 mm Hg. Calculate the mass of oxygen pumped out in kg. [Take R = 8.314 J/mol K] **03**

(b) What are real gases? A closed rigid container contains a gas at 300 K. Its specific volume is 0.0035 m^3/kg. Calculate the pressure of the gas by using Van *der* Waal's gas equation. Take a = 0.175 $(m^3/kg)^2$ kPa, b= 0.0014 m^3/kg, Molecular Weight of gas = 28. **04**

(c) Define C_p and C_v and state first law of thermodynamics for a closed system undergoing a state change process. A cold room is first loaded with 5 metric tons of fruits and vegetables and then its door is closed. After 8 hours an energy meter attached to the power supply shows that the cold room has consumed 40 kWh of energy and the internal energy of the system has dropped by 100 MJ. Calculate the net heat transfer from the system in MJ. **07**

OR

(c) State first law of thermodynamics for a closed system operating in a cycle. An ideal gas at 200 ^oC, 600 kPa occupying a volume of 250 liter is cooled isobarically until its temperature becomes27 ^oC. Calculate the following in SI units: **07**

(i) Heat transfer
(ii) Work done
(iii)Change in internal energy

Take Cp = 1.005 kJ/kgK

Q.3 **(a)** Draw a neat phase diagram of water on P-V coordinates indicating all its states. Define the terms **03**
(i) Sublimation
(ii) Wet Steam

(b) Prove that for a 2-phase mixture of water, the specific volume (v) is given by $v = v_f + xv_{fg}$, Using steam tables, find the temperature, density, specific enthalpy and entropy of saturated steam at 10 bar. **04**

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

(i) Dew point temperature
(ii) Wet bulb temperature
(iii) Specific enthalpy
(iv)Dry bulb temperature

The weather report of Anand city on a certain evening of October 2016 was recorded as follows:
Atmospheric pressure = 755 mm Hg,
Ambient Temperature = 25 ^oC,
Dew Point Temperature = 18 ^oC.
Calculate % RH, absolute humidity and DBT of the air.

OR

Q.3 **(a)** Define steam quality. Using steam tables find out the values of saturation pressure and specific volume of steam having 80% quality at 140 ^oC. **03**

(b) Draw a neat labeled T-s diagram of water showing its various states. One kg of wet steam at 120 ^oC containing 90% of dry steam is allowed to completely condense to water at 95 ^oC. Calculate the amount of heat released in kJ. **04**

(c) What is moist air? Define the following: **07**

i. Adiabatic saturation temperature
ii. Relative humidity
iii. Absolute humidity
iv. Dehumidification of moist air.

Using Psychrometric chart, determine % RH, DPT and specific enthalpy of moist air at 35 ^0C DBT, 1 atmosphere and 25 ^0C WBT.

Q.4 **(a)** For a reversible thermodynamic process, prove the following: **03**

i. Tds = du + Pdv

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

(b) State Zeroth law of thermodynamics. Write down the correlation between different temperature scales. During a cooling process, the temperature of a system falls by 20 ^oC. Express this rise in K and ^oF. **04**

(c) Derive SFEE for an air stream entering and leaving a compressor in terms of K.E., P.E., enthalpy, heat and work interactions per unit time. Specify each term in the equation and mention their SI units. State clearly the assumption made and specify the terminologies used. **07**

OR

Q.4 (a) For a reversible thermodynamic process, prove the following: **03**

i. Tds = dh - vdP

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

(b) Explain the working principle of a constant volume gas thermometer. The voltage-temperature relationship of a thermocouple given by **04**
e = (0.25t + 5x10^{-4} t^2) mV, where'‘t’ is in ^oC and ‘e’ is in mV.
Determine the corresponding temperatures if mV readings are 25 mV and 50 mV.

(c) Derive SFEE for a jet of steam entering and leaving a nozzle in terms of K.E., P.E., enthalpy, heat and work interactions per unit mass. Specify each term in the equation and mention their SI units. State clearly the assumption made and specify the terminologies used. **07**

Q.5 (a) What do you mean by PMM1 And PMM2? State and explain Carnot theorems. **03**

(b) State and explain Clausius statement of second law of thermodynamics. A reversible heat engine is attached between two thermal reservoirs maintained at 600 K and 310 K. The reservoir maintained at higher temperature transfers heat to the engine in steady state @ 10 kW. Calculate the power generated by the engine and the % heat rejected w.r.t. to the input. **04**

(c) Prove that “T (V)$^{\gamma -1}$ = Constant” for an ideal gas undergoing an isentropic process. An ideal gas of 1 kg mass at 4 MPa, 87 ^oC and 75 litre volume undergoes adiabatic expansion to reach a final state of 3 MPa and 100 litre volume such that the work done on the gas is 50 kJ. Calculate **07**

i. C_p and C_v of the gas in kJ /kgK

ii. Entropy change during the process in kJ/K

OR

Q.5 (a) Discuss Clausius inequality. **03**

Prove that $\oint (\frac{dQ}{T}) < 0$; for an irreversible heat engine operating in a cyclic process.

(b) State and explain Kelvin-Plank statement of second law of thermodynamics. A heat engine is operating in a cyclic process between two constant temperature reservoirs at 277 ^oC and 27 ^oC. The steady state work output generated is 20 kW. If the thermal efficiency of the engine is 77% of the maximum possible efficiency, determine the heat input and the **04**

heat rejection rate in kW.

(c) Prove that "PV^{γ} = Constant" for an ideal gas undergoing an isentropic process. A rigid vessel of 300 liter volume contains 5 kg of oxygen at 10 ^{o}C. Heat is transferred to the system so as to raise its temperature to 97 ^{o}C. Calculate **07**

i. Change in enthalpy of the system in kJ.
ii. Change in entropy of the system in kJ/K

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