Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (OLD) - EXAMINATION – SUMMER 2017

Subject Code: 131404 **Date: 07/06/2017**

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.**

Q.1 **(a)** Explain and compare the behaviour of ideal and non-ideal gases. Why do real gases deviate from ideal behavior? How did Van *der* Waal explain this deviation? Carbon dioxide gas is available in a closed tank at 327^0C. Its specific volume is 0.45 m^3/kg. Calculate the pressure exerted by the gas in bar using ideal gas equation. Take R = 8.314 J/mol K. **07**

(b) Differentiate between a nozzle and a diffuser. Dry saturated steam at 6 bar enters an adiabatic nozzle at a velocity of 2.5 m/s and leaves as dry saturated steam at 2.5 bar. Calculate the exit velocity of the steam. The enthalpies of steam at inlet and exit are 2747 kJ/kg and 2706 kJ/kg respectively. **07**

Q.2 **(a)** 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 20 ^{0}C to 30 ^{0}C by adding 75 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. [Take C_v = 735 J/kg K] **07**

(b) Draw a labeled phase diagram of a pure substance (Water) on T-s coordinates and explain the following terms: **07**

(i) Critical temperature
(ii) Triple point line
(iii) Steam quality
(iv) Sub-cooled liquid.

Using Steam Tables determine the following for saturated steam at 1.5 MPa:
(i) Saturation temperature in ^{0}C
(ii) Latent heat of vaporization (hfg) in kJ/kg
(iii) Specific volume in m^3/kg

OR

(b) Draw a labeled phase diagram of a pure substance (Water) on P-v coordinates and explain the following terms: **07**

(i) Dryness fraction of steam
(ii) Sublimation of ice
(iii) Super-heated steam

Using Steam Tables determine the following for saturated steam at 200 ^{0}C:
(i) Saturation pressure in bar
(ii) Density in kg/m^3
(iii) Entropy in kJ/kgK

Q.3 **(a)** Discuss Zeroth law of thermodynamics and explain the concept of temperature measurement and its scales. List different types of thermometers and state their working principles. Convert 32 ^{0}C in Fahrenheit, Kelvin and Rankine scale. **07**

(b) State first law of thermodynamics for a closed system undergoing a cyclic process. Ten kg of ice at ^{o}C is completely melted into water at ^{o}C at 1 atmosphere pressure. Calculate the work done and energy transferred as heat. Given that the latent heat of fusion of ice is 334 kJ/kg and the densities of the water and ice at 0^{0}C are 1000 kg/m^3 and 916 kg/m^3 respectively. **07**

OR

Q.3 **(a)** Explain first law of thermodynamics for a system undergoing isothermal process? Estimate the work done by an ideal gas if it undergoes a reversible adiabatic expansion from $P1$, $v1$, $T1$ to $P2$, $v2$, $T2$. It is given that the internal energy of an ideal gas is a function of temperature only. **07**

(b) State the Zeroth law of thermodynamics. Explain its applications. With the help of a neat diagram explain the working principle of a mercury thermometer. **07**

Q.4 **(a)** What do you mean by a heat engine? Explain its operation with the help of a block diagram. A cyclic heat engine operates between a source temperature of 600 ^{0}C and a sink temperature of 27 ^{0}C. Calculate the least rate of heat rejection per kW heat input to the heat engine? **07**

(b) With the help of a neat sketch explain Kelvin-Plank statement of second law of thermodynamics. What are PMM1 and PMM2? Briefly explain a Perpetual Motion Machine of second kind with a schematic diagram. **07**

OR

Q.4 **(a)** With the help of a neat sketch explain Claucius statement of second law of thermodynamics. Briefly explain the statement of Clausius Inequality and the criterion of the reversibility of a cycle. **07**

(b) What do you mean by a refrigerator? Explain its operation with the help of a block diagram. A cyclic refrigerator is extracting 3.5 kJ/s of heat and operates between a source temperature of 10 ^{0}C and a sink temperature of 37 ^{0}C. Calculate the Carnot COP. If the actual COP is 60% of the maximum COP, calculate the power consumption in kW. **07**

Q.5 **(a)** Explain the following: **07**
(i) Joule–Kelvin effect
(ii) Gibb's phase rule
(iii) Maxwell's equations
(iv) Types of equilibrium

(b) Show the following processes on Psychrometric Chart: **07**
(i) Sensible cooling (ii) Humidification and cooling
(ii) Sensible heating (iv) Heating and dehumidification
(v) Dehumidification and cooling
For an atmospheric air at 30 ^{0}C DBT, 1 atm pressure and 60% RH. Determine specific humidity in kg/kg d.a., specific enthalpy in kJ/kg d.a. DPT in ^{o}C and WBT in ^{0}C of the air using a standard psychrometric chart.

OR

Q.5 **(a)** Explain the following: **07**

(i) Vapour pressure.

(ii) Relative humidity.

(iii)Degree of saturation.

On a certain summer day, the weather report of a city was recorded as:

Ambient Temperature = 38 ^{0}C, RH = 70%.

Barometric pressure = 1 atmosphere

Using Psychrometric Chart, calculate the DBT, DPT, WBT and absolute humidity.

(b) Illustrate Gibb's phase rule with an example. Calculate the degrees of freedom of water at 37 ^{o}C and 1 atmosphere pressure. State the types of equilibrium for a thermodynamic system and state conditions for its stability. **03**

(c) For a pure substance undergoing an infinitesimal reversible process prove the following stating relevant assumptions: **04**

(i) $dU = TdS - PdV$

(ii) $dH = TdS + VdP$

(iii) $dA = -(PdV + sdT)$

(iv) $dG = VdP - sdT$

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