Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:131404 **Date:09/01/2017**

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. **Steam Tables and Psychrometric chart cam be used.**

Q.1 **(a)** What are ideal gases? Explain the reasons for deviation of gases from ideal behaviour. A sealed metallic container of 400 litres volume contains nitrogen gas at a temperature of – 23 ^{o}C and 22 bar pressure. Calculate the mass of nitrogen gas in kg using **07**

(i) Ideal gas equation

(ii) Real gas equation of state incorporating compressibility factor.

[Take R = 8.314 J/mol K, z = 0.72]

(b) Explain the following in briefly: **07**

(i) Law of corresponding states

(ii) Adiabatic process

(iii) Negative Gauge pressure

(iv) Isolated system

An insulated rigid tank of 10 m^3 volume contains 30 kg of CO_2 gas at 5 bar pressure. A paddle wheel is rotated inside the tank so that its pressure increases to 10 bar. Calculate the following:

(i) Heat transfer

(ii) Change in internal energy

(iii) Work done

[Take C_p = 1.05 kJ/kgK, R = 8.314 J/mol K]

Q.2 **(a)** Stare Zeroth law of thermodynamics and explain how it can be used as a basis for temperature measurement. Explain with a neat diagram the principle and working of a mercury thermometer **07**

(b) Explain first law of thermodynamics for a closed system operating in a cycle. Prove that the work done by the system during an isentropic process is given by **07**

$$W = \frac{1}{\gamma - 1}(P_1 V_1 - P_2 V_2).$$

OR

(b) What is first law of thermodynamics? Prove that for a reversible adiabatic process $TV^{\gamma-1} =$ Constant. An ideal gas at 247 ^{o}C and 20 bar pressure expands isentropically through a volume ratio of 5:1. Calculate the work done during the process in kJ/kg. [Take C_p = 1.005 kJ/kgK, C_v = 0.715 kJ/kgK] **07**

Q.3 **(a)** What is steady flow process? Derive SFEE for a fluid stream entering and leaving a compressor in terms of work and energy transfer taking place per unit time. Support your answer with a neat control volume diagram and state the assumptions made. **07**

(b) What do you mean by Source & Sink? Explain the operation of a Carnot heat engine with the help of a schematic diagram. A heat engine is operating in a cyclic process between two constant temperature reservoirs at 500 K and 300 K to produce a work output of 10 kW. If the thermal efficiency of the engine is 80% of the maximum possible efficiency, determine the heat input and the heat rejection in kW. **07**

OR

Q.3 **(a)** Differentiate between flow work and non-flow work. Derive SFEE for a fluid stream entering and leaving a nozzle in terms of work and energy transfer per unit mass. Support your answer with a neat control volume diagram and state the assumptions made. **07**

(b) State and explain Clausius statement of second law of thermodynamics with a schematic construct. Draw P-V and T-s diagrams of a Carnot cycle showing various state points and explain the practical importance of this cycle. **07**

Q.4 **(a)** State and explain Carnot theorems. Prove that for an irreversible cyclic thermodynamic process **07**

$\int (\frac{dQ}{T}) < 0$, where dQ is kJ &T in K.

(b) Prove that for any gas undergoing a throttling process, **04**

$$\mu_{j,T} = \frac{1}{C_P}\left[T\left(\frac{\partial v}{\partial T}\right)_P - v\right]$$

(c) Explain Gibb's phase rule with examples. **03**

OR

Q.4 **(a)** Prove that $\oint (\frac{dQ}{T}) = 0$; for any cyclic reversible process. **07**

An ideal gas is undergoing a reversible process (1↔2). Show that the specific entropy change for this process is given by $(\Delta s)_{1-2} = C_v \ln\left(\frac{P_2 V_2^{\gamma}}{P_1 V_1^{\lambda}}\right)$.

(b) Prove the following: **04**

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

(c) State and explain the types of equilibrium for a thermodynamic system and conditions for its stability. **03**

Q.5 **(a)** Draw a neat phase diagram of water on P-V coordinates showing all its states. Define the terms 'triple point' and 'saturated vapours'. Using Steam Tables, calculate the specific volume and specific enthalpy of steam at 250 °C having a quality of 80%. **07**

(b) Prove that absolute humidity (ω) of moist air is given by $\omega = 0.622\left(\frac{P_w}{P - P_w}\right)$. **07**

On a certain day, the atmospheric air condition of Anand city was recorded as follows:

Ambient pressure = 760 mm Hg
Ambient Temperature = 30 ^{o}C
DPT = 17 ^{o}C,
Using Psychrometric Chart, calculate % RH, WBT, Specific enthalpy and humidity of the atmospheric air.

OR

Q.5 **(a)** Explain the following briefly:
(i) Specific humidity (ii) Wet Bulb Temperature
(iii) Sensible heating (iv) Adiabatic saturation
The weather report of Anand city on the morning of 2nd October 2016 was recorded as follows:
Atmospheric pressure = 752 mm Hg,
Ambient Temperature = 26 ^{o}C,
Dew Point Temperature = 18 ^{o}C.
Calculate % RH, absolute humidity and specific enthalpy of the air.

Q.5 **(b)** Draw a neat phase diagram of water indicating all its phases and states on suitable state coordinates. Define the terms **07**
(i) Critical point
(ii) Superheated Steam
A sealed rigid container of 1.0 m^3 capacity contains 5 kg of wet steam at 3 bar pressure. Calculate its specific volume and dryness fraction. Use Steam Tables to determine its saturation temperature and enthalpy.

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