

GUJARAT TECHNOLOGICAL UNIVERSITY
B. E. - SEMESTER – III • EXAMINATION – WINTER 2012

Subject code: 131404**Date: 05-01-2013****Subject Name: Food Engineering Thermodynamics****Time: 10.30 am – 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. Use of Steam Tables and Psychrometric Chart is permitted

- Q.1 (a)** Define ideal gas and explain the assumptions for ideal behaviour of gases. **07**
Give reasons why gases deviate from ideal behaviour. Write Van der Waal's equation for real gases and state S.I. units of constants a and b . Determine the volume of 64 g SO_2 gas in cm^3 at 25°C and 1.2 atmosphere. Assume ideal gas behaviour. Take $R = 8.314 \text{ J/mol K}$.
- (b)** What is meant by a heat engine and what are its characteristics? **07**
A reversible heat engine delivers 0.65 kW power and rejects energy at the rate of 0.4 kJ/s to a reservoir at 27°C . Determine the efficiency of the engine and the temperature at which energy is absorbed by the engine.
- Q.2 (a)** Define Specific heat and enthalpy. Express them in terms of state functions u , v , t , and p . Prove that $C_p - C_v = \bar{R}$ for ideal gases. Five kilogram of N_2 gas is heated reversibly and isobarically from an initial state of $[T = 320 \text{ K}, P = 1.5 \text{ bar}]$ until its volume doubles. Calculate **07**
(i) The expanded work in kJ
(ii) Change in internal energy and enthalpy in kJ.
[Take $C_p = 36 \text{ J/mol K}$, $R = 8.314 \text{ J/mol K}$]
- (b)** Draw a neat labeled P-V and T-s diagrams of a pure substance (water) **07** showing its various states. Show that the specific volume of wet steam is given by $v = v_g + (1-x) v_{fg}$. Determine the following for saturated steam at 2 atmosphere pressure:
(i) Saturation temperature in $^\circ\text{C}$
(ii) Entropy in kJ/kg K
(iii) Latent heat of vaporization in kJ/kg
(iv) Specific volume in m^3/kg
[Use Steam Tables]
- OR**
- (b)** Explain the following with the help of suitable diagrams/examples as applicable: **07**
(i) Dryness fraction of steam
(ii) Reversible and cyclic process
(iii) Vacuum and absolute pressure
(iv) Isolated and open system
(v) Extensive and intensive properties
(vi) State and path functions

(vii) Isenthalpic and isentropic process

- Q.3 (a)** What is a Carnot refrigerator? Express the coefficient of performance of a Carnot refrigerator in terms of the temperatures of the thermal reservoirs between which they operates. **07**

A domestic food freezer maintains a temperature of -15°C . The ambient air temperature is 30°C . If heat leaks into the freezer at the continuous rate of 1.75 kJ/s , what is the least power necessary to pump this heat out continuously?

- (b)** State the important consequences and practical limitations of the first law of thermodynamics and specify the most widely used sign convention for work and heat interaction. **07**

OR

- Q.3 (a)** State the first law of thermodynamics for a cyclic process. **07**

One mole of an ideal gas with $\gamma = 1.4$ initially at 300 K and 1 bar is compressed reversibly and adiabatically to 5 bar and then it is cooled at constant pressure to the original temperature. The gas is then restored to the initial state through an isothermal process. Calculate the net work and heat interaction. [Take $R = 8.314 \text{ J/mol K}$]

- (b)** What is a perpetual motion machine of the second kind? Prove that violation of Clausius statement leads to violation of the Kelvin-Planck statement of the second law of thermodynamics. **07**

- Q.4 (a)** What is a polytropic process and how does it reduce to other known processes? Show them with the help of P-v diagram. **07**

- (b)** What is the basic difference between a nozzle and a diffuser? **07**

In a nozzle air at 627°C and twice atmospheric pressure enters with negligible velocity and leaves at a temperature of 27°C . Determine velocity of air at exit, assuming no heat loss and nozzle being horizontal. [Take $C_p = 1.005 \text{ kJ/kg. K}$ for air]

OR

- Q.4 (a)** State the zeroth law of thermodynamics and explain it with help of a suitable diagrammatic representation. Name a few measurements or quantities which can be used as thermometric properties in order to quantify the temperature and corresponding thermometers which use these properties. **07**

- (b)** Define entropy. Show that $\sum \frac{Q}{T} \leq 0$ for an engine, where Q is the heat interaction, (including the sign convention), with the reservoir at temperature T . **07**

- Q.5 (a)** Differentiate between dry bulb, wet bulb and adiabatic saturation temperatures of moist air. Air at a certain location having a barometric pressure of 750 mm Hg has a temperature of 45°C . If the partial vapour pressure of water vapours present in the air is 20 mm Hg , determine the following *without* using Psychrometric Chart: **07**

- | | |
|--------------------------|----------------------------|
| (i) Dry bulb temperature | (ii) Wet bulb temperature |
| (iii) Relative humidity | (iv) Dew point temperature |

(v) Absolute humidity

(vi) Specific enthalpy of moist air

(b) Establish the following for a pure substance undergoing an infinitesimal reversible process: **07**

(i) $dU = TdS - PdV$

(ii) $dH = TdS + VdP$

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

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

OR

Q.5 (a) Show the following processes on psychrometric chart for moist air: **07**

- (i) Sensible heating
- (ii) Humidification and heating
- (iii) Cooling and dehumidification
- (iv) Dehumidification

For a certain location the following data are available for the atmospheric air: Temperature = 30°C, Barometric Pressure = 760 mm Hg and Relative humidity = 90%. Using Psychrometric Chart determine:

- (i) Dew point temperature in °C
- (ii) Wet bulb temperature in °C
- (iii) Mass of moist air in kg/kg d.a

(b) Explain the following with relevant examples: **07**

- (i) Types of equilibria and conditions of stability.
- (ii) Gibb's Phase rule
- (iii) Joule Kelvin effect.
