P P SAVANI UNIVERSITY

Fourth Semester of B. Tech. Examination

May 2022

SECH2070 Chemical Engineering Thermodynamics - I

25.05.2022, Wednesday **Time: 09:00 a.m. To 11:30 a.m.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.

SECTION – I

Q - 1 Define: **[05]**

(1) state functions

(2) Kinetic energy

(3) Pressure

(4) Adiabatic process

(5) Cyclic process.

Q - 2 (a) Derive the equation for work done for the isothermal process. **[05]**

Q - 2 (b) Derive the equation for the first law of thermodynamics for flow processes. **[05]**

OR

Q - 2 (a) A system consisting of a gas confined in a cylinder is undergoing the following series of processes before it is brought back to the initial conditions: **[05]**

Step 1 : A constant pressure process when it receives 50 J of work and gives up 25 J of heat.

Step 2 : A constant volume process when it receives 75 J of heat.

Step 3 : An adiabatic process.

Determine the change in internal energy during each step and the work done during the adiabatic process.

Q - 2 (b) Discuss: heat engine and heat pump with diagram **[05]**

Q - 3 (a) Discuss the characteristics of the reversible process with an example. **[05]**

Q - 3 (b) Using Hess's law evaluate the heat of formation of solid $CaCO_3$. The following data are available. **[05]**

(a) $Ca_{(s)} + (1/2)O_{2(g)} \rightarrow CaO_{(s)}$; $\Delta H^0_{298} = -635.77$ kJ

(b) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H^0_{298} = -393.77$ kJ

(c) $CaO_{(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)}$; $\Delta H^0_{298} = -178.15$ kJ

OR

Q - 3 (a) An ideal gas is undergoing a series of three operations: The gas is heated at constant volume from 300 K and 1 bar to a pressure of 2 bar. It is expanded in a reversible adiabatic process to a pressure of 1 bar. It is cooled at constant pressure of 1 bar to 300 K. Determine the heat and work effects for each step. Assume $C_P = 29.3$ kJ/kmol K **[05]**

Q - 3 (b) Calculate molar volume for methanol vapor at 500 K and 10 bar by using the virial equation of state. Take Virial coefficients $B = -2.19\times10^{-4}$ m^3/mol; $C = -1.73\times10^{-8}$ m^6/mol^2. **[05]**

Q - 4 **Attempt any One.** **[05]**

(i) Distinguish between intensive and extensive properties. State whether the following properties are intensive or extensive.

(1) Volume

(2) specific volume

(3) heat capacity

(4) pressure

(5) potential energy

(6) Entropy.

(ii) Write a short note on Gibbs phase rule.

SECTION – II

Q - 1 **Multiple Choice Questions / Short Questions** **[05]**

(i) Which of the following refers to the term C.O.P. of refrigeration?
a) Cooling for Performance
b) Coefficient of Performance
c) Capacity of Performance
d) Co-efficient of Plant

(ii) Discuss Carnot Principle in short.

(iii) For a system which undergoes an infinitesimal reversible process between two equilibrium states, the change in internal energy is
a) $dU = pdV - TdS$
b) $dU = TdS + pdV$
c) $dU = TdS - pdV$
d) $dU = -TdS - pdV$

(iv) If temperature is constant, internal energy does not change.
a) true
b) false

(v) The limitation of the first law is
a) does not indicate the possibility of a spontaneous process proceeding in a definite direction
b) it assigns a quality to different forms of energy
c) indicates the direction of any spontaneous process
d) none of the mentioned

Q - 2 (a) Discuss throttling process (joule–thomson expansion) and flow through compressor. **[05]**

Q - 2 (b) Oil at 500 K is to be cooled at a rate of 5000 kg/h in a counter-current exchanger using cold water available at 295 K. A temperature approach of 10 K is to be main-tained at both ends of the exchanger. The specific heats of oil and water are respectively 3.2 and 4.2 kJ/kg K. Determine the total entropy change in the process. **[05]**

OR

Q - 2 (a) Explain the Vapour-compression Cycle with diagram. **[05]**

Q - 2 (b) Calculate the change in internal energy, change in enthalpy, work done, and the heat supplied in the following processes: **[05]**
(a) An ideal gas is expanded from 5 bar to 4 bar isothermally at 600 K.
(b) An ideal gas contained in a vessel of 0.1 m3 capacity is initially at 1 bar and 298 K. It is heated at constant volume to 400 K.
(Assume that $C_P = 30$ J/mol K.)

Q - 3 (a) Define refrigeration. Explain Coefficient of Performance (COP). **[05]**

Q - 3 (b) It is required to freeze 1 kg water at 273 K by means of a refrigeration machine which operates in the surroundings at 300 K. The latent heat of fusion of ice at 273 K is 334.11 kJ/kg. Determine: (a) The minimum amount of work required and (b) The heat given up to the surroundings. **[05]**

OR

Q - 3 (a) Discuss the continuity equation and energy equation with diagram. **[05]**

Q - 3 (b) Calculate the compressibility factor and molar volume for methanol vapour at 500 K and 10 bar by using the following equations. Experimental values of virial coefficients are, $B = -2.19 \times 10^{-4}$ m^3/mol; $C = -1.73 \times 10^{-8}$ m^6/mol^2. The critical temperature and pressure of methanol are 512.6 K and 81 bar. **[05]**
(a) Truncated form of virial equation,

$$Z = \frac{PV}{RT} = 1 + \frac{B}{V} + \frac{C}{V^2} + \frac{D}{V^3} + \ldots$$

Take V Values between = 3.91 x 10^{-3} m^3 to 3.95 x 10^{-3} m^3 as trial value.

(b) Redlich–Kwong equation

$$V = \frac{RT}{P} + b - \frac{a(V-b)}{T^{0.5}\,PV(V+b)}$$

$$a = \frac{0.4278\,R^2T_C^{2.5}}{P_C}; \quad b = \frac{0.0867\,RT_C}{P_C}$$

Take V Value between V = 3.960 x 10^{-3} m^3 to 3.964 x 10^{-3} m^3

Q - 4 Discuss how Choice of Refrigerant is selected and types of refrigerant. **[05]**

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