

# 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]

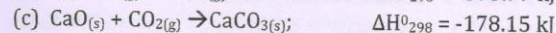
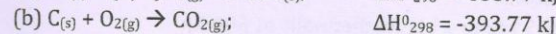
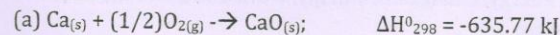
OR

- 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  $\text{CaCO}_3$ . The following data are available. [05]



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  $C_p = 29.3 \text{ kJ/kmol K}$ . [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  $B = -2.19 \times 10^{-4} \text{ m}^3/\text{mol}$ ;  $C = -1.73 \times 10^{-8} \text{ m}^6/\text{mol}^2$ . [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 m<sup>3</sup> capacity is initially at 1 bar and 298 K. It is heated at constant volume to 400 K.

(Assume that  $C_p = 30 \text{ J/mol K}$ .)

- 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,  $B = -2.19 \times 10^{-4} \text{ m}^3/\text{mol}$ ;  $C = -1.73 \times 10^{-8} \text{ m}^6/\text{mol}^2$ . The critical temperature and pressure of methanol are 512.6 K and 81 bar. [05]

(a) Truncated form of virial equation,

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

Take V Values between =  $3.91 \times 10^{-3} \text{ m}^3$  to  $3.95 \times 10^{-3} \text{ m}^3$  as trial value.

(b) Redlich-Kwong equation

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

$$a = \frac{0.4278 R^2 T_c^{2.5}}{P_c}; \quad b = \frac{0.0867 RT_c}{P_c}$$

Take V Value between  $V = 3.960 \times 10^{-3} \text{ m}^3$  to  $3.964 \times 10^{-3} \text{ m}^3$

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

[05]

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