Q. Code: 481170

Reg. No. | | | | | | | | | | | | | | |

B.E / B.TECH. DEGREE EXAMINATION, MAY 2023

Fourth Semester

CH18403 – CHEMICAL ENGINEERING THERMODYNAMICS-I

(Chemical Engineering)

(Regulation 2018A)

TIME: 3 HOURS **MAX. MARKS: 100**

CO 1 Use the terminology associated with Engineering Thermodynamics and apply concepts of heat, work and energy conversion.

CO 2 Apply mass and energy balances to close and open systems

CO 3 Evaluate the properties of non-ideal gases.

CO 4 Illustrate the inter relations between measurable and non measurable properties.

CO 5 Solve problems involving liquefaction, refrigeration and different power cycles.

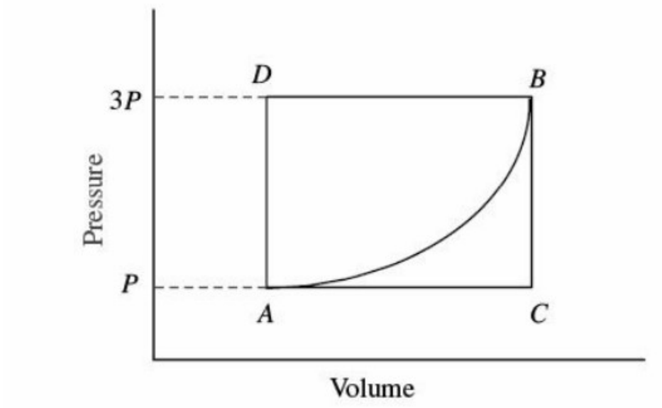
PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	State intensive properties and extensive properties? Give examples.	1	2
2.	Distinguish between heat engine and heat pump	1	2
3.	Mention the limitations of first law of thermodynamics	2	2
4.	Differentiate between flow and non-flow processes. Give examples	2	2
5.	State the principle of corresponding states.	3	2
6.	List out any four types of thermodynamic diagrams.	3	2
7.	Show the entropy-heat capacity relationships.	4	2
8.	Write the Clausius-Clapeyron equation.	4	2
9.	Give the equation for clearance volume in a compressor.	5	2
10.	Why inter-stage cooling is necessary in a multi-stage compression?	5	2

PART- B (5 x 14 = 70 Marks)

			Marks	CO	RBT LEVEL
11. (a)	**(i)**	A gas is undergoing a change of state from A to B along path ACB in which the total heat supplied to the system is 70 J and the work done by the system is 20 J. The cycle is completed by bringing the system back to the initial state along the curved path BA for which work of 60 J is done on the system.	**(7)**	1	3



Determine the following: (a) The heat transferred if the initial process were carried out along path ADB as shown in the figure. (b) The heat quantity involved in the process AD and DB, if the internal energy of the system at state D is greater than that at state A by 40 J. (c) The heat supplied or removed in the process along path BA.

(OR)

(b) **(i)** Heat is transferred to 15 kg of air which is initially at 105 kPa and 350 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following processes: (a) Constant volume process (b) Constant pressure process. Assume that air is an ideal gas for which the P-V-T relationship is PV = nRT, where n is the number of moles of the gas and R is the ideal gas constant. R = 8.314 kJ/kmol K. Take C_P = 29.099 kJ/kmol K, C_V = 20.785 kJ/kmol K and molecular weight of air = 29. **(7)** 1 3

(ii) Liquid water at 100°C and 1 bar has an internal energy (on an arbitrary scale) of 419.0 kJ kg^{-1} and a specific volume of 1.044 cm^3 g^{-1}. **(7)** 1 3

(a) Determine its enthalpy

(b) The water is brought to the vapor state at 200°C and 800kPa. where its enthalpy is 2,83S.6 kJ kg^{-1} and its specific volume is 260.79 cm^3 g^{-1}. Calculate ΔU and Δ H for the process

12. (a) Calculate the pressure developed by 1 kmol gaseous ammonia contained in a vessel of 0.6 m3 capacity at a constant temperature of 473 K by the following methods: **(14)** 2 3

(a) Using the ideal gas equation

(b) Using the van der Waals equation given that a = 0.4233 N m^4/mol^2, b = 3.73x10^{-5} m^3/mol

(c) Using the Redlich–Kwong equation given that P_C = 112.8 bar; T_C = 405.5 K.

(OR)

(b) Calculate the compressibility factor and molar volume for methanol vapour at 600 K and 10 bar by using the following equations. Experimental values of virial coefficients are, B = – 2.19x10 –4 m^3/mol; C = – 1.73x10 –8 m^6/mol^2. The critical temperature and pressure of methanol are 412.6 K and 91 bar. (a) Truncated form of virial equation (b) Redlich–Kwong equation. **(14)** **2** **3**

13. (a) Hydrocarbon oil is to be cooled from 425 K to 340 K at a rate of 6000 kg/h in a parallel flow heat exchanger. Cooling water at a rate of 11,000 kg/h at 295 K is available. The mean specific heats of the oil and water are respectively 2.5 kJ/kg K and 4.2 kJ/kg K. (a) Determine the total change in entropy. Is the process reversible? (b) If a reversible Carnot engine is to be operated receiving the heat from the oil and rejecting the heat to the surroundings at 295 K, how much work would be available. **(14)** **3** **3**

(OR)

(b) A reversible refrigerator absorbs heat from water at 273 K in order to produce ice at the same temperature and rejects heat to the surroundings at 300 K. The work requirement of the refrigerator is to be met by a reversible heat engine operating between a heat source at 425 K and surroundings at 300 K. For 2500 kilo joule of heat received by the engine, calculate: (a) The heat removed from water (b) The heat rejected to the surroundings. **(14)** **3** **3**

14. (a) Prove the following **(14)** **4** **3**

i) $du = C_V dT + \frac{a}{v^2 dv}$

ii) $C_p - C_v = -T\,(\partial V/\partial T)_P{}^2\,(\partial P/\partial V)_T$

(OR)

(b) Find out the internal energy, enthalpy, entropy and free energy for one mole of nitrogen at 773 K and 110 bar assuming that nitrogen behaves as an ideal gas. The molal heat capacity of nitrogen at 1 bar is given as $C_P = 27.3 + 4.2 \times 10^{-3}T$, where T is in K and C_P is in J/mol K. Enthalpy of nitrogen is zero at 273 K and 1 bar. The entropy of nitrogen is 192.4 J/molK at 298 K and 1 bar. **(14)** **4** **3**

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15. (a) A heat pump is used to maintain the temperature inside a building at 305 K by pumping heat from the outside air at 275 K. The unit has an overall efficiency of 35%. The pump is driven electrically and the electric power is generated by the combustion of certain fuel gas. The heat of combustion of the fuel is 890.9 kJ/mol. It is estimated that only 33% of the heat of combustion of the fuel is converted into electricity. Determine the amount of fuel burned for delivering 100 MJ of heat to the building. **(14)** **5** **3**

(OR)

(b) A Diesel engine operates with a compression ratio of 15. The pressure and temperature at the beginning of the compression stroke are 105 kPa and 310 K. Heat is transferred at the rate of 500 kJ/kg of the working fluid per cycle. Determine: (a) The pressure and temperature at each stage of the cycle (b) The work done per kg air (c) The thermal efficiency (d) The mean effective pressure Take the specific heats of air as C_P = 1.005 kJ/kg K and C_V = 0.718 kJ/kg K. **(14)** **5** **3**

PART- C (1 x 10 = 10 Marks)

(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	Show that for a gas obeying Vander Waals equation of state $C_P - C_V = R/\{[1 - 2a(V - b)^2]/[RTV^3]\}$	**(10)**	**3**	**3**