Q. Code: 695175

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

B.E./ B. TECH.DEGREE EXAMINATIONS, MAY 2024

Third Semester

CH22303– CHEMICAL ENGINEERING THERMODYNAMICS-I

(Chemical Engineering)

(Regulation 2022)

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

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Apply concepts of heat, work and energy conversion and mass and energy balances to close and open systems.	**3**
CO 2	Envisage the entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.	**3**
CO 3	Evaluate the properties of non-ideal gases.	**4**
CO 4	Illustrate the inter relations between measurable and non-measurable properties.	**4**
CO 5	Examine the process of liquefaction, refrigeration and different power cycles.	**4**

PART- A(20x2=40Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Relate how temperature relates to the average kinetic energy of particles in a substance.	**1**	**2**
2.	Mention the different forms of energy and their interconversion in thermodynamic processes.	**1**	**3**
3.	Infer why state functions are independent of the path taken during a thermodynamic process.	**1**	**2**
4.	Outline the significance of the phase rule in predicting the number of degrees of freedom in a thermodynamic system.	**1**	**2**
5.	Interpret Carnot's theorem and its significance in the efficiency of heat engines.	**2**	**2**
6.	Highlight how the entropy of an ideal gas changes during isothermal and adiabatic processes.	**2**	**2**
7.	State the mathematical statement of the second law of thermodynamics.	**2**	**2**
8.	Summarize the concept of lost work and its implications in thermodynamic processes.	**2**	**2**
9.	Mention the concept of corresponding states and its significance in comparing the behavior of different substances.	**3**	**2**
10.	Differentiate between standard heats of formation and reaction.	**3**	**2**
11.	Select the most appropriate equation of state for describing the behavior of a specific gas under non-ideal conditions and justify your choice.	**3**	**3**

12.	Compare the advantages and limitations of the van der Waals and virial equation of state.	**3**	**2**
13.	Interpret the meaning of negative and positive residual properties in terms of deviations from ideal behavior in real fluids.	**4**	**2**
14.	Sketch a pressure-temperature phase diagram for a pure substance undergoing a solid-liquid phase transition.	**4**	**3**
15.	State residual properties in thermodynamics.	**4**	**2**
16.	Highlight the significance of Helmholtz and Gibbs free energies in thermodynamics and their relationship to system stability and spontaneity of processes.	**4**	**3**
17.	Compare the advantages and disadvantages of vapor-compression and absorption refrigeration cycles.	**5**	**2**
18.	How does a pump differ from a compressor in terms of its operation and application.	**5**	**3**
19.	Identify the effect of compressor clearance on the performance of a reciprocating compressor.	**5**	**3**
20.	State the key assumptions made in the ideal Rankine cycle analysis.	**5**	**2**

PART- B (5x 10=50Marks)

		Marks	CO	RBT LEVEL
21. (a)	A liquid mixture containing 50 mol percent each of benzene and toluene at 313 K is to be continuously flash vaporised so that 60 mol percent of the feed is vaporised. The residual liquid product contains 35 mol percent benzene. If the enthalpies per mole of feed, distillate and the residue are respectively 5, 30 and 2 kJ/mol, Determine the heat added in kJ per mole of vapour product.	**(10)**	**1**	**3**
	(OR)			
(b)	Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 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.	**(10)**	**1**	**3**
22. (a)	**(i)** An inventor claims to have developed a refrigeration unit which maintains	**(5)**	**2**	**3**

the refrigerated space at 270 K while operating in a room where the temperature is 300 K and which has a coefficient of performance of 9.5. How do you evaluate his claim?

(ii) A new engine is claimed to be having a power output of 4.5 hp while receiving a heat input of 6.25 kW and working between the source and sink temperature limits of 1000 K and 500 K. Determine the efficiency of the proposed engine. Is the claim for the engine admissible? **(5)** 2 3

(OR)

(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 maintained 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. **(10)** 2 3

23. (a) Determine 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 X 10^{-4} m^3/mol; C=– 1.73 X 10^{-8} m^6/mol^2. The critical temperature and pressure of methanol are 512.6 K and 81 bar. (a) Truncated form of virial equation, (b) Redlich–Kwong equation. **(10)** 3 3

(OR)

(b) Determine the pressure developed by 1 kmol gaseous ammonia contained in a vessel of 0.6 m^3 capacity at a constant temperature of 473 K by the following methods: **(10)** 3 3

(a) Using the ideal gas equation.

(b) Using the van der Waals equation given that a = 0.4233 N m^4/mol^2 and b = 3.73 X 10^{-5} m^3/mol

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

24. (a) Show that for a gas obeying van der Waals equation of state, **(10)** 4 3

$$C_P - C_V = \frac{R}{1 - 2a(V-b)^2/(RTV^3)}$$

where a and b are van der Waals constants.

(OR)

(b) Develop expression for the coefficient of thermal expansion, the isothermal compressibility, Joule-Thompson coefficient and $C_P - C_V$ for **(10)** 4 3

(i) Ideal gas

(ii) Gas obeys the equation of state $[P + (a/V^2)] (V – b) = R T$.

		Marks	CO	RBT LEVEL
25. (a)	An air-refrigeration machine rated at 10 ton is used to maintain the temperature of a cold room at 261 K when the cooling water is available at 293 K. The machine operates between pressures of 1.013 bar and 4.052 bar. Assume a 5-K approach in the cooler and the refrigerator. The specific heat of air may be taken as 1.008 kJ/kg K and $\gamma = 1.4$. Determine the COP and air-circulation rate.	**(10)**	**5**	**3**
	(OR)			
(b)	The compression ratio in an air-standard Otto cycle is 8. The temperature and pressure at the beginning of the compression stroke are 290 K and 100 kPa. Heat transferred per cycle is 450 kJ/kg of air. The specific heat of air are $C_P = 1.005$ kJ/kg K and $C_V = 0.718$ kJ/kg K. Determine the following: (a) The pressure and temperature of air at the end of each process (b) The thermal efficiency (c) The work done by kg of air (d) The mean effective pressure.	**(10)**	**5**	**3**

PART- C (1x 10=10Marks)

(Q.No.26 is compulsory)

		Marks	CO	RBT LEVEL
26.	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. Evaluate the heat and work effects for each step. Assume $C_P = 29.3$ kJ/kmol K.	**(10)**	**2**	**5**

****