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Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

III SEMESTER B.TECH. END SEMESTER EXAMINATIONS

13 December 2022

SUBJECT: CHEMICAL ENGINEERING THERMODYNAMICS - I [CHE 2151]

REVISED CREDIT SYSTEM

Time: 3 h **Max. Marks: 50**

Instructions to Candidates:

- Answer ALL questions & missing data may be suitably assumed

1A	State the limitations of Chemical Engineering Thermodynamics.	2
1B	With an example, briefly explain the open, closed and Isolated systems.	3
1C	Water at 368 K is pumped from a storage tank at the rate of 25 m^3/hr. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. What is the temperature of the water delivered to the second storage tank? Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2 kJ/kg K.	5
2A	A man whose weight is 600 N takes 2 min for climbing up a staircase. What is the power developed in him, if the staircase is made up of 20 stairs each 0.18 m in height?	3
2B	Calculate the absolute entropy of water vapour at 473 K and 101.3 kPa above 273 K base temperature. Compare this with the value reported in the steam tables (S = 7.829 kJ/kg K). The average heat capacity of water is 4.2 kJ/kg K and that of water vapour between 373 K and 473 K is 1.9 kJ/kg K. The latent heat of vaporization at 373 K is 2257 kJ/kg.	3
2C	An electric current of 0.5 A from a 14 V supply is passed for 15 minutes through a resistance in thermal contact with saturated water at 1.1 atm. As a result, 0.978 g of water is vapourized. Assuming that the water vapour behaves ideally, calculate the molar internal energy change and enthalpy change during this process.	4
3A	Prove that, unlike energy, entropy is not conserved	2
3B	A Carnot heat engine receives 500 kJ of heat per cycle from a high-temperature heat reservoir at 652°C and rejects heat to a low-temperature heat reservoir at 30°C. Determine (i) The thermal efficiency of this Carnot engine and (ii) The amount of heat rejected to the low-temperature heat reservoir	3
3C	Using the Redlich-Kwong equation calculate the molal volume of saturated vapor of methyl chloride at 333 K. The saturation pressure of methyl chloride at 333 K is	5

-	13.76 bar. The critical temperature and pressure are 416.3 K and 66.8 bar respectively.	
4A	What are the limitations of the first law of thermodynamics? Write Kelvin–Planck and Clasius Statement of the second law of thermodynamics	**3**
4B	For a simple compressible system, prove that, $dH=Cp\,dT+(1-\beta T)VdP$	**4**
4C	The coefficient of compressibility and coefficient of volume expansion of mercury at 273 K and 1 bar are 3.9×10^{-6} bar^{-1} and 1.8×10^{-4} K^{-1} respectively. Calculate C_V for mercury. ($C_P = 0.14$ kJ/kg K; $\rho = 13.596 \times 10^3$ kg/m^3)	**3**
5A	Calculate the change in internal energy, change in enthalpy, work done, and the heat supplied in the process of an ideal gas is expanded from 5 bar to 4 bar isothermally at 600 K.	**2**
5B	With T-S and P-H diagrams, explain the working of an ordinary vapour-compression refrigeration cycle.	**5**
5C	Linde process is used for air liquefaction. The high-pressure gas leaving the compressor is at 120 bar and is cooled to 306 K (516 kJ/kg) before it is sent through the heat exchanger where it exchanges heat with low pressure gas leaving the separator at 2 bar. A 14 K approach is desired at the hot end of the exchanger so that the low-pressure gas leaving the exchanger is at 292 K (526 kJ/kg). Enthalpy of saturated liquid at 2 bar is 121 kJ/kg. Determine the fraction of the air liquefied during expansion.	**3**