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Total Number of Pages : 2

AR-18

B.TECH

B.TECH 3rd SEMESTER EXAMINATIONS, NOV/DEC 2019
BCHPC3030 CHEMICAL ENGINEERING THERMODYNAMICS
Chemical Engineering

Time : 3 Hours

Maximum : 100 Marks

Answer ALL Questions

The figures in the right hand margin indicate marks.

PART – A: (Multiple Choice Questions) 10 x 2=20 Mark

Q.1. Answer All Questions

- a Thermodynamic properties dependent on quantity of material are called _____ [CO1][PO1]
properties.
i. absolute
ii. partial
iii. extensive
iv. intensive
- b For incompressible fluids, the value of isothermal compressibility is _____. [CO1][PO2]
i. < 0
ii. 0
iii. 10
iv. None of these
- c If a process is reversible and adiabatic, then: [CO1][PO1]
i. $dQ^t = T$
ii. $dV^t = 1$
iii. $dH^t = \infty$
iv. $dS^t = 0$
- d Activity coefficients are functions of: [CO2][PO1]
i. vapour phase composition
ii. liquid phase composition
iii. gas density
iv. liquid density
- e Calculate $\{x_i\}$ and T, given $\{y_i\}$ and P is representing the calculations for: [CO2][PO1]
i. BUBL P
ii. DEW P
iii. BUBL T
iv. DEW T
- f Duhem's theorem is applicable to: [CO2][PO2]
i. closed system at equilibrium
ii. open system at equilibrium
iii. both i and ii
iv. none of these
- g V, U, H, S, G are examples of _____ properties. [CO3][PO1]
i. thermal
ii. pure species
iii. partial
iv. solution
- h Fugacity is applicable to: [CO3][PO2]



- i. solid
 - ii. ideal gas
 - iii. real fluid
 - iv. viscous fluid
- i The reaction proceeds to such an extent that the change in mole number of each reactant and product is equal to its stoichiometric number. This statement is valid when _____.
- i. $\Delta\varepsilon = 0$
 - ii. $\Delta\varepsilon = 1$
 - iii. $\Delta\varepsilon < 0$
 - iv. $\Delta\varepsilon > 1$
- j When standard reaction is endothermic, an increase in T results in _____ in K.
- i. decrease
 - ii. no change
 - iii. increase
 - iv. none of these

PART – B: (Short Answer Questions) 10X2=20 Marks**Q.2. Answer ALL questions**

- a Is it possible to cool your kitchen by opening the door of the electrically powered refrigerator ? Justify your answer. [CO1][PO2]
- b What are volume expansivity and isothermal compressibility ? [CO1][PO1]
- c What do you understand by isentropic process ? [CO1][PO2]
- d State Duhem's theorem. [CO2][PO2]
- e Mention the two assumptions required for Raoult's law. [CO2][PO2]
- f What is equilibrium ratio ? [CO2][PO1]
- g Define chemical potential. [CO3][PO1]
- h Define activity coefficient. [CO3][PO2]
- i What is effect of temperature on the equilibrium constant ? [CO4][PO1]
- j Explain the Phase rule for reacting systems. [CO4][PO1]

PART – C: (Long Answer Questions) 4X15=60 Marks**Answer ALL questions**

- Q.3**
- a A tank containing 20 kg water at 293.15 K is fitted with a stirrer that delivers work to the water at the rate of 0.25 kW. How long does it take for the temperature of the water to rise to 303.15 K if no heat is lost from the water ? $C_{p\text{ water}} = 4.18 \text{ kJ/kg} \cdot ^\circ\text{C}$. 3 [CO1][PO1]
 - b 1 mole of air (assumed to be ideal gas), initially at 423.15 K and 8 bar, undergoes reversible changes: expands isothermally to a pressure such that when it is cooled at constant volume to 323.15 K its final pressure is 3 bar. $C_p = 7R/2$ and $C_v = 5R/2$. Calculate: W, Q, ΔU , and ΔH . 12 [CO1][PO2]
- OR**
- c Express the volume expansivity and the isothermal compressibility as functions of density and its partial derivatives. For water at 323.15 K and 1 bar, $k = 44.18 \times 10^{-6} / \text{bar}$. To what pressure must water be compressed at 323.15 K to change its density by 1 % ? Assume that k is independent of P. 5 [CO1][PO2]



- d A vessel of 0.06 m^3 volume contains an ideal gas ($C_V = 5R/2$) at 500 K and 1 bar. If 15 kJ heat is transferred to the gas, determine its entropy change. Also, if the vessel is fitted with a stirrer that is rotated by a shaft so that 15 kJ work is done on the gas, what is the entropy change of the gas if the process is adiabatic? What is ΔS_{total} ? What is the irreversible feature of the process? 10 [CO1][PO2]
- Q.4**
- a Compared to carbon dioxide, air is inexpensive and nontoxic. But air is not used for making soda water and champagne effervescent. Using Henry's law to explain this. 3 [CO2][PO2]
- b Assuming Raoult's law to be valid, prepare a P-x-y diagram for a temperature of 363.15 K for a system of benzene(1) and ethylbenzene(2). The Antoine coefficients are:
 $A_1 = 13.7819$, $B_1 = 2726.81$, $C_1 = -55.578$,
 $A_2 = 13.9726$, $B_2 = 3259.93$, and $C_2 = -60.850$. 12 [CO2][PO2]
- OR**
- c Prove that an equilibrium liquid/vapour system described by Raoult's law cannot exhibit an azeotrope. 3 [CO2][PO1]
- d Discuss in detail the dewpoint and bubblepoint calculations with Raoult's law. 12 [CO2][PO2]
- Q.5**
- a Show that: The partial molar mass of a species in solution is equal to its molar mass. 5 [CO3][PO3]
- b Derive the partial property equations for binary solutions. 10 [CO3][PO3]
- OR**
- c Discuss in detail the ideal-solution model and the Lewis/Randall rule. 15 [CO3][PO4]
- Q.6**
- a Write about multi-reaction stoichiometry. 7 [CO4][PO1]
- b Discuss the effect of temperature on the equilibrium constant. 8 [CO4][PO1]
- OR**
- c Write briefly about fuel cells with a neat diagram. 8 [CO4][PO1]
- d A system formed initially of 2 mol CO_2 , 5 mol H_2 , and 1 mol CO undergoes the reactions:
$$\text{CO}_2 (\text{g}) + 3 \text{H}_2 (\text{g}) \rightarrow \text{CH}_3\text{OH} (\text{g}) + \text{H}_2\text{O} (\text{g})$$
$$\text{CO}_2 (\text{g}) + \text{H}_2 (\text{g}) \rightarrow \text{CO} (\text{g}) + \text{H}_2\text{O} (\text{g})$$
Develop expressions for the mole fractions of the reacting species as functions of the reaction coordinates for the two reactions. 7 [CO4][PO1]