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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: CHE 202

COURSE TITLE: CHEMICAL THERMODYNAMICS AND PHASE EQUILIBRIA

DATE: 31ST MAY, 2022 **TIME: 0900 – 1200 HRS**

INSTRUCTION TO CANDIDATES

- SEE INSIDE

THIS PAPER CONSISTS OF 4 PRINTED PAGES **PLEASE TURN OVER**

REGULAR - MAIN EXAM

CHE 202: CHEMICAL THERMODYNAMICS AND PHASE EQUILIBRIA

STREAM: BED (Science) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer **ALL** questions.*

ii. *Diagrams may be used whenever they serve to illustrate the answer.*

iii. *Do not write on the question paper.*

Physical Constants

Physical Constants: R=0.08206 L atm K^{-1} mol^{-1}, R=8.314 J K^{-1} mol^{-1}

Question One

a) Define the following terms;

i. Colligative Properties (1 Mark)

ii. Phase Diagram (1 Mark)

iii. Saturated vapour pressure (1 Mark)

iv. Azeotrope (1 Mark)

v. Dew Temperature and Pressure (2 Marks)

b) With an example, show that a process that is spontaneous in one direction may not be spontaneous in the opposite direction (2 Marks)

c) Calculate the entropy change for an isothermal expansion of 0.5 moles of an ideal gas from one litre to ten litres (3 Marks)

d) Explain how entropy changes under the following conditions/systems:

i. Isolated system spontaneous reactions/processes (1 Mark)

ii. Heat (1 Mark)

iii. Change of phase (1 Mark)

Question Two

a) Prove that for isothermal expansion of a perfect gas from V_i to V_f, entropy change is calculated as: (3 Marks)

$$\Delta S = nR\, ln \frac{V_f}{V_i}$$

b) Calculate the entropy change involved in the conversion of 1 mole of ice at 0°C and 1 atm to liquid at 0°C and 1 atm, the enthalpy of fusion per mole of ice is 6008 $Jmol^{-1}$ for the following:

i. System (2 Marks)

ii. Surrounding (2 Marks)

iii. For both system and surroundings (1 Mark)

c) Calculate the entropy change when 1 mole of ethanol is evaporated at 351 K. The molar heat of vaporisation of ethanol is 39.84 kJ mol^{-1}. (3 Marks)

d) Calculate the standard entropy of formation, $\Delta S°_f$ of $CO_{2(g)}$. Given the standard entropies of $CO_{2(g)}$, $C_{(s)}$, $O_{2(g)}$, which are 213.6, 5.740, and 205.0 J K^{-1}, respectively. (3 Marks)

Question Three

a) Derive the Clapeyron equation for one component liquid-vapour, liquid-liquid, solid-liquid, solid-vapour and solid-solid phase equilibria. (4 Marks)

b) Calculate the vapour pressure of a mixture containing 252 g of n-pentane (Mw = 72) and 1400 g of n-eptane (Mw = 100) at 20°C. The vapour pressure of n-pentane and n-eptane are 420 mm Hg and 36 mm Hg, respectively. (4 Marks)

c) State the assumptions made in the Clausius Clapeyron equation. (3 Marks)

d) Define the following terms:

i. Ideal solution (1 Mark)

ii. Raoult´s law (1 Mark)

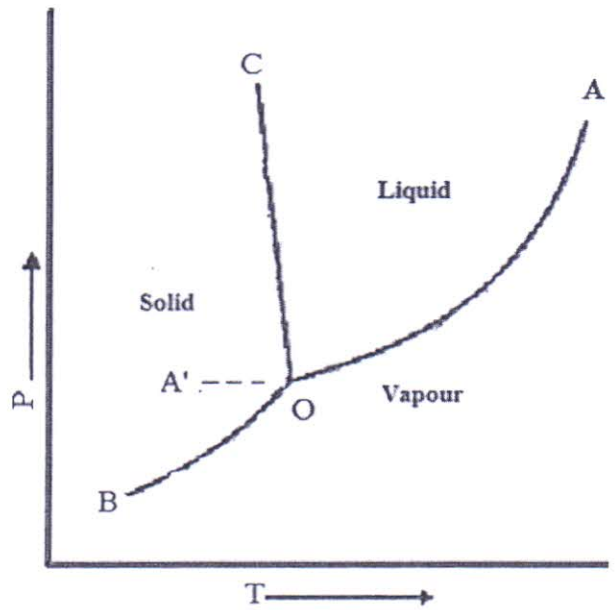
iii. When real solutions deviate from the ideality (1 Mark)

Question Four

a) Differentiate between the Clapeyron equation and the Clapeyron Clausius equation (2 Marks)

b) Define the Gibbs phase rule for a k-component, f-phase system and define all the terms. (2 Marks)

c) The diagram below shows a one component phase diagram of water system.



For each of the points indicated below, indicate the process, phase in equilibrium and degree of freedom. (8 Marks)

S/No	Point	Process	Phase in Equilibrium	Degrees of Freedom
1	Curve OB			
2	Curve OA			
3	Curve OC			
4	Area left of BOC			
5	Area AOC			
6	Area below AOB			
7	Point O			
8	Point A			

d) Define the following

i. Mixture (1 Mark)

ii. Henry's Law (1 Mark)

Question Five

a) Discuss how the following colligative properties occur/take place

i. Vapour pressure lowering (2 Marks)

ii. Boiling point elevation (2 Marks)

b) What is the effect of association and dissociation of solute particles on colligative properties? (2 Marks)

c) Give some real life practical applications of distillation colligative properties (2 Marks)

d) The vapour pressure of pure benzene at a certain temperature is 0.850 bar. A non-volatile, non-electrolyte solid weighing 0.5 g when added to 39.0 g of benzene (molar mass 78 g mol^{-1}), vapour pressure of the solution, then, is 0.845 bar. What is the molar mass of the solid substance? (3 Marks)

e) The table below shows the standard entropies of vaporization of several liquids at their boiling points.

Substance	$\Delta_{vap}H^{\theta}$/kJ mol^{-1}	θ_b/°C	$\Delta_{vap}S^{\theta}$/J K^{-1} mol^{-1}
Benzene	30.8	80.1	87.2
Carbon tetrachloride	30	76.7	85.8
Cyclohexane	30.1	80.7	85.1
Hydrogen sulfide	18.7	-60.4	87.9
Methane	8.18	-161.5	73.2
Water	40.7	100	109.1

Study and explain the deviations and show how they can be accounted for. (3 Marks)

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