



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: $R=0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$, $R=8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

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)

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

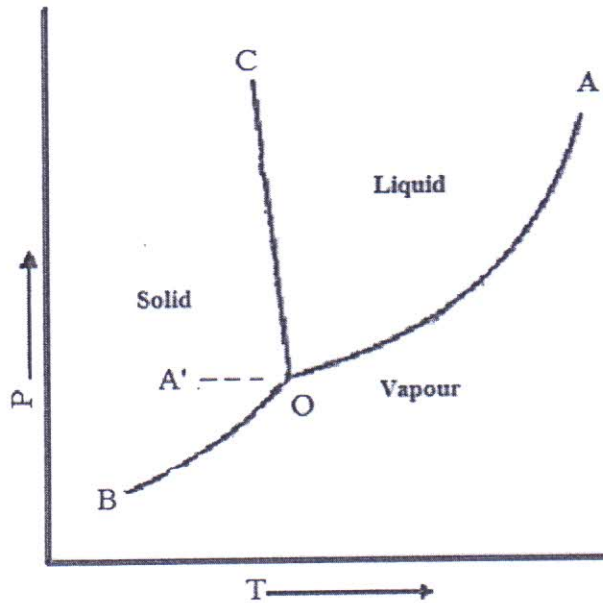
- b) Calculate the entropy change involved in the conversion of 1 mole of ice at 0°C and 1 atm to liquid at 0°C and 1 atm, the enthalpy of fusion per mole of ice is 6008 J mol^{-1} for the following:
- System (2 Marks)
 - Surrounding (2 Marks)
 - For both system and surroundings (1 Mark)
- c) Calculate the entropy change when 1 mole of ethanol is evaporated at 351 K . The molar heat of vaporisation of ethanol is $39.84 \text{ kJ mol}^{-1}$. (3 Marks)
- d) Calculate the standard entropy of formation, ΔS°_f of $\text{CO}_2(\text{g})$. Given the standard entropies of $\text{CO}_2(\text{g})$, $\text{C}(\text{s})$, $\text{O}_2(\text{g})$, 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 ($M_w = 72$) and 1400 g of n-eptane ($M_w = 100$) 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:
- Ideal solution (1 Mark)
 - Raoult's law (1 Mark)
 - 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	$\Delta_{\text{vap}}H^{\ominus}/\text{kJ mol}^{-1}$	$\theta_{\text{b}}/^{\circ}\text{C}$	$\Delta_{\text{vap}}S^{\ominus}/\text{J K}^{-1} \text{mol}^{-1}$
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)
