



University of Fort Hare
Together in Excellence

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF FORT HARE, ALICE CAMPUS
PAC 324: PHYSICAL CHEMISTRY
NOVEMBER 2018 MAIN EXAMINATION

STUDENT NO.

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SEAT NUMBER:

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DURATION: 3 HOURS

TOTAL MARKS: 100

External Examiner

Prof I Bahadur
North West University

Internal Examiner:

Dr. Z. Tywabi-Ngeva
University of Fort Hare

QUESTION NO.	1 (42 Marks)	2 (18 Marks)	3 (40 Marks)	Total (100 Marks)
INTERNAL MARK				
EXTERNAL MARK				

INSTRUCTIONS

1. **Non programmable calculators** may be used but **all working must be shown**.
2. You must write legibly in **black** or **blue** ink. **Pencils and Tipp-Ex are not allowed**.
3. This question paper consists of **22 pages** (including the cover page) and **3 questions**. Please check that you have them all.
4. Your answers must be written on the question paper in the spaces provided. The left-hand pages may be used for extra space or for rough work.
5. A **periodic table** and a **data sheet** are provided.

QUESTION 1 (42 marks)

1.1 State the *Gibbs Phase Rule* and give the meanings of the terms that appear in it.

(4)

1.2 Ammonium bromide is placed into an empty vessel and allowed to dissociate into ammonia and hydrogen bromide until an equilibrium is established. Determine the degrees of freedom for this system. (4)

1.3 The temperature/composition data below was obtained for a mixture of two liquids **A** and **B** at 1.00 atm, where x is the mole fraction in the liquid and y is the mole fraction in the vapour at equilibrium.

$T / ^\circ\text{C}$	125	130	135	140	145	150
x_A	0.91	0.65	0.45	0.30	0.18	0.098
y_A	0.99	0.91	0.77	0.61	0.45	0.25

The boiling points of **A** and **B** are 124 °C and 155 °C respectively.

- i. Sketch the temperature-composition diagram consistent with the data given in the table.
- ii. What is the composition of the vapour in equilibrium with the liquid of composition $x_A = 0.67$?
- iii. Using the Lever Rule, give the compositions of and the amounts of the phases present at 140 °C and $x_A = 0.50$. (10)

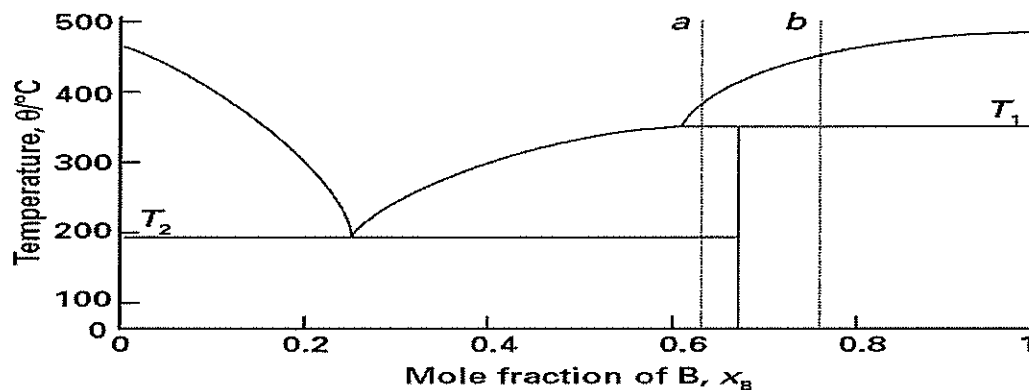
1.4 Trouton's Rule is an empirical rule which shows that standard entropy of vaporization ($\Delta_{\text{vap}}S^\circ$) for a wide range of liquids is approximately $85 \text{ J K}^{-1}\text{mol}^{-1}$.

- i. Give a brief explanation of this rule.
- ii. Given that for water, $\Delta_{\text{vap}}S^\circ = 109 \text{ J K}^{-1}\text{mol}^{-1}$, explain why water does not obey Trouton's Rule. (6)

1.5 Calculate the pressure that must be applied to melt ice at $-10\text{ }^{\circ}\text{C}$. Take the molar volumes of ice and liquid water to be $19.7\text{ cm}^3\cdot\text{mol}^{-1}$ and $18.0\text{ cm}^3\cdot\text{mol}^{-1}$, respectively, and $\Delta H_{\text{fus}} = +6.008\text{ kJ}\cdot\text{mol}^{-1}$. (5)

1.6

Figure.1



- Label the regions of the phase diagram in **Fig. 1** above
- State what substances exist in each region. Mark each phase in each region as solid, liquid, or gas.
- Mark the eutectic point on the diagram. What is the composition of the eutectic mixture and at what temperature does it melt? (8)

1.7 Describe fractional distillation.

(5)

Question 2 (18 marks)

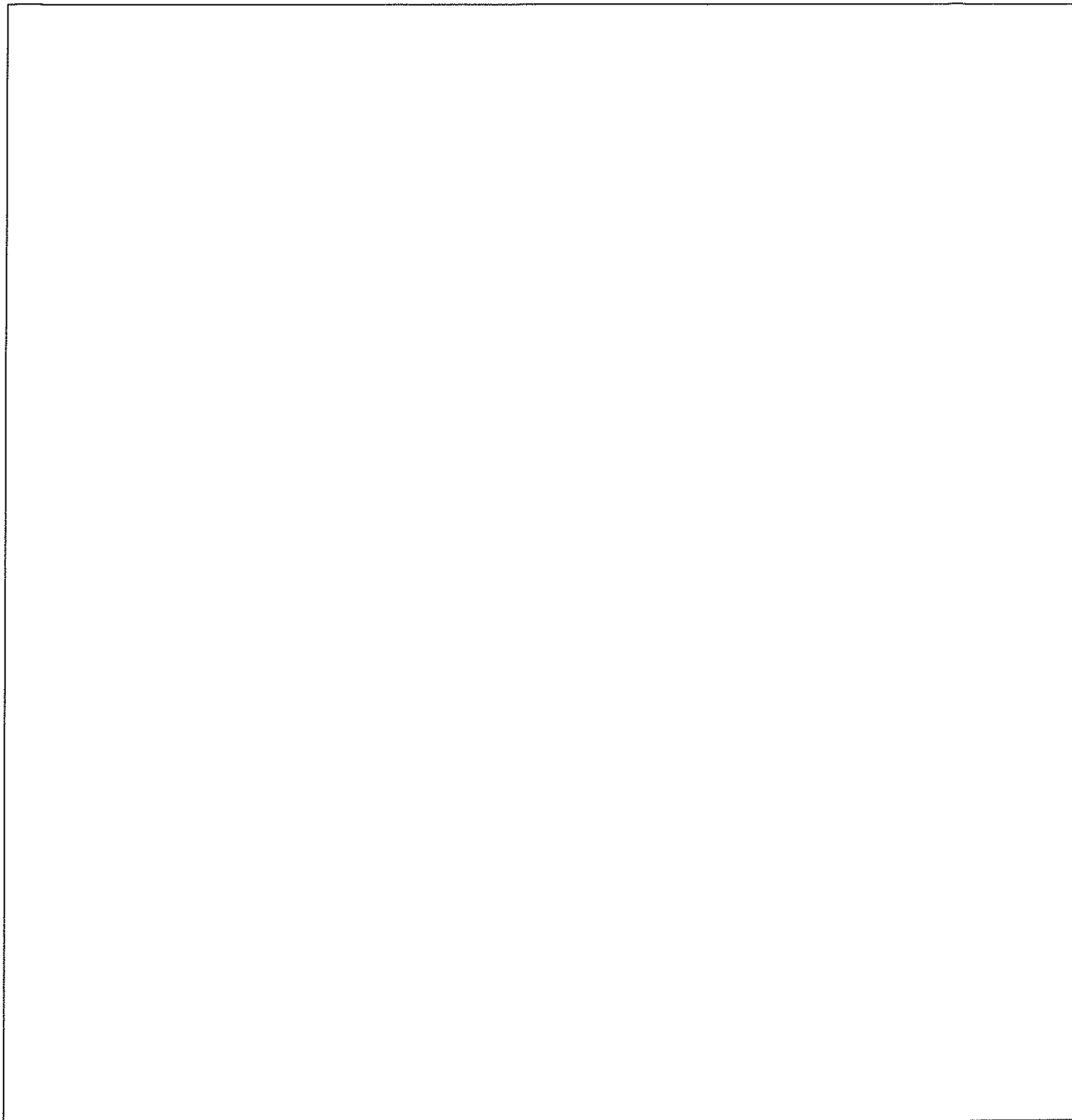
- 2.1 The vapour pressures of two pure liquids, **M** and **N**, at 300 K is 76.7 kPa and 520 atm, respectively. The two liquids are mixed to form an ideal solution in equilibrium with its vapour. Given that the mole fraction of **M** in the vapour is 0.350, find:
- The composition of the liquid mixture, and
 - The total vapour pressure. Show all working clearly.
 - The mixture described above is distilled. What will be composition of the first drop of distillate collected? (8)

2.2 Eugenol, the active ingredient in cloves, has a formula, $C_{10}H_{12}O_2$. What is the boiling point of a solution containing 0.154 g of this compound dissolved in 11.3 g of benzene? ($K_{bp} = 2.53 \text{ }^\circ\text{C m}^{-1}$ and boiling point of benzene = $80.1 \text{ }^\circ\text{C}$) (4)

2.3 Calculate the vapour pressure of a solution made by dissolving 82.4 g of Urea ($\text{NH}_2(\text{CO})\text{NH}_2$), (molar mass of 60.06 g mol^{-1}) in 212 mL of water at 35°C (vapour pressure of water @ $35^\circ\text{C} = 42.18 \text{ mmHg}$). Calculate the vapour-pressure lowering. (6)

Question 3 (40 marks)

3.1 Explain with the aid of a simple diagram the phenomenon known as "surface tension". (6)



3.2 Calculate the work needed (in Nm) to raise a wire that is 5 cm in length a height of 10 mm when its sitting on the surface of water at 20 °C. The surface tension of water at 20 °C is 72.75 mN m⁻¹. (5)

3.3 Calculate the surface tension of water at 30 °C given that at that temperature water climbs to a height of 9.11 cm in a clean glass capillary tube of internal radius 0.32 mm. The density of water at 30 °C is 0.9956 gcm⁻³.
(3)

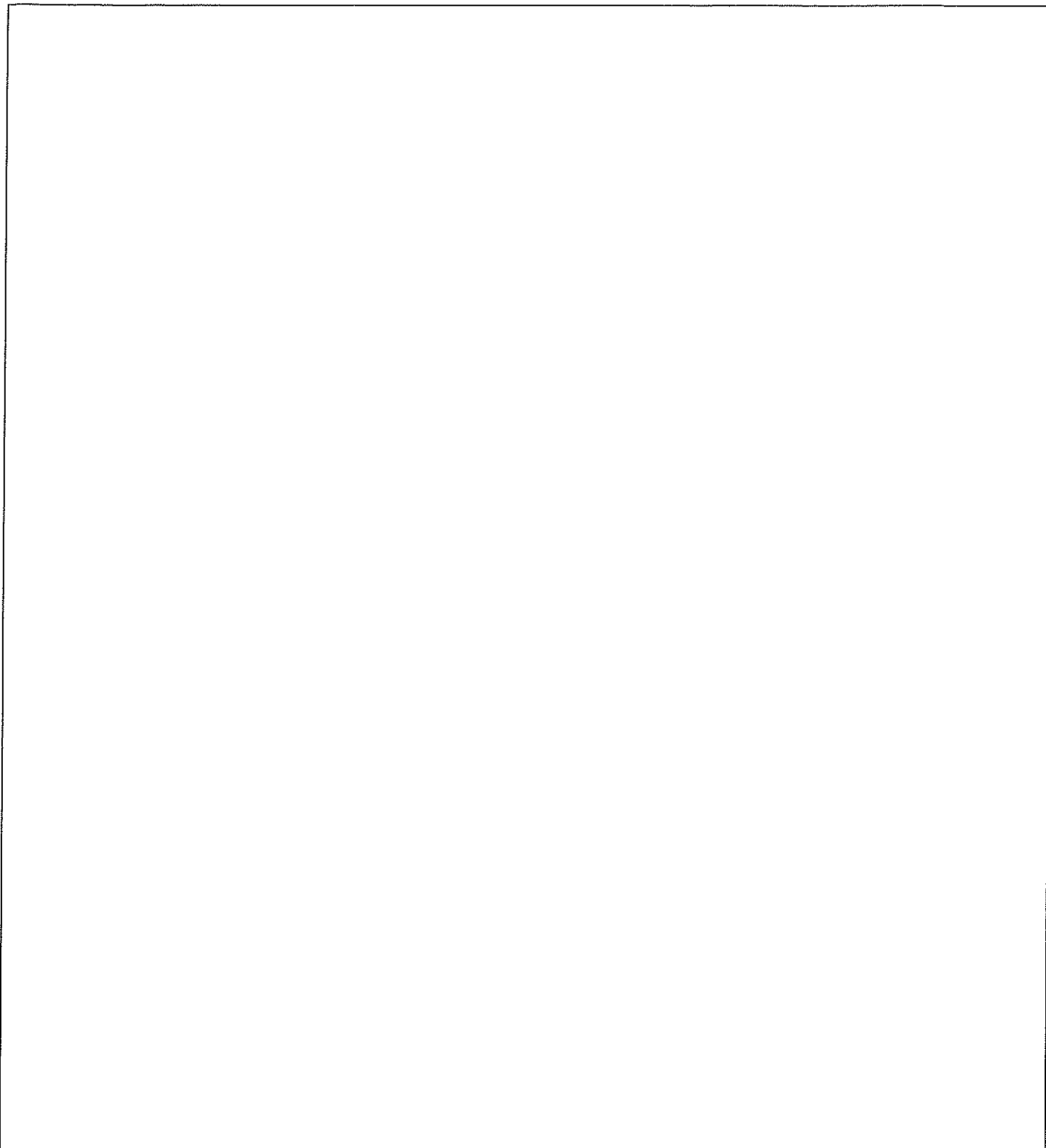
3.4 A The following data was obtained for the adsorption of hydrogen on the surface of 1.00 g of copper at 0 °C. The volume of H₂ below is the volume that the gas would occupy at STP (0 °C and 1 atm).

P/kPa	15.0	29.5	44.9	60.0	75.3	90.4
V/cm³	7.64	9.72	10.38	10.85	11.34	11.61

- i. Show graphically that the data fit the Langmuir equation
- ii. Determine the volume of H₂ necessary to form a monolayer
- iii. Estimate the surface area of 1.00 g of copper if the area occupied by a hydrogen molecule is $2.45 \times 10^{-19} \text{ m}^2$.

(12)

3.5 Discuss IN DETAIL **three** experimental techniques used to determine the surface composition of solid surfaces. (9)



3. 6 Discuss the difference between physical adsorption and chemical adsorption.

(5)

