



KISII UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF
THE DEGREE OF MASTER OF SCIENCE IN ANALYTICAL CHEMISTRY
SECOND SEMESTER 2021/2022
(FEBRUARY-JUNE, 2022)

CHEM 817: ADVANCED CHEMICAL THERMODYNAMICS

STREAM: Y1 S2

TIME: 3 HOURS

DAY: MONDAY, 9.00 AM – 12.00 PM

DATE: 30/05/2022

INSTRUCTIONS:

- 1. Do not write anything on this question paper.***
- 2. Attempt only SIX Questions***

Question One

- A gas at 250 K and 15 atm has a molar volume 12 per cent smaller than that calculated from the perfect gas law. Calculate (a) the compression factor under these conditions and (b) the molar volume of the gas. Which are dominating in the sample, the attractive or the repulsive forces? (3 marks)
- If sulphur dioxide were an ideal gas, the pressure at 0.0°C exerted by 1.00mole occupying 22.4 L would be 1.0 atm. Use the Van der Waals equation to estimate the pressure of this volume. (3 marks)

Question Two

- i. A 10.0 L cylinder contains 500 g of methane. Calculate its pressure to two significant figures at 27°C using the (i.) Ideal gas law (2 marks) (ii.) Van der Waals equation. (3 marks)
- ii. Using a phase diagram explain the critical point and triple point and their conditions. (2 marks)
- iii. Explain the advancement in Bertholot Equation from Clausius equation using an equation (5 marks)

Question Three

- i. The Van der Waals constants for hydrogen chloride gas are $a=3.67 \text{ atm lit}^{-2}$ and $b=40.8 \text{ ml mol}^{-1}$. Find the critical temperature and critical pressure of the gas. (5 marks)
- ii. The entropy of a gas at 300°C and 30 bar was 25J/mol.K. At 250°C and 1.0 bar, the gas was ideal and its entropy was 45J/mol.K. What is the departure entropy at 300°C and 30 bar? The ideal heat capacity of the gas is 30J/mol.K (5 marks)

Question Four

- i. With the help of a diagram, explain the deviations from Raoult's law. (4 marks)
- ii. Explain the advantages and limitations of applying Phase rule (4 marks)
- iii. with an equation explain compressibility factor of a gas. (2 marks)

Question Five

- i. Use the Van der Waals equation to calculate the pressure of 1.00 mole ethane (C_2H_6) that has a volume of 22.41 L at 0.0°C. Compare the result with the value predicted by ideal gas (5 marks)

- ii. Calculate ionic strength, mean ionic activity coefficient γ_{\pm} , and the mean ionic molality m_{\pm} for a 0.02 molal aqueous solution of zinc chloride, ZnCl_2 (5 marks)

Question six

- i. Calculate the effective concentration of a 0.0992 M solution of NaCl at 25°C for which activity coefficient is 0.782. (5 marks)
- ii. Explain the Gibbs phase rule listing the degrees of freedom (5 marks)

Question Seven

- i. Explain the deviations in Raoult's law using a diagram (7 marks)
- ii. Using equations derive the Henry's Law of dilute solutions (3 mark)

Question Eight

- i. With the help of an illustration explain the three dimensional diagram (5 marks)
- ii. Derive the Gibbs energy of a pure substance (5 marks)