TECHNICAL UNIVERSITY OF MOMBASA

School of Applied and Health Sciences

DEPARTMENT OF PURE AND APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY

(ANALYTICAL AND INDUSTRIAL OPTION)

BTAC 2024S.

ACH 4106: PHYSICAL CHEMISTRY 1

ORDINARY EXAMINATION

SERIES: JULY 2025 SERIES

TIME: 2 HOURS

DATE: JULY 2025

Instructions to Candidates

You should have the following for this examination

Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attemptquestion ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

PAPER 2

Question One (30 Marks)

a) Define

i. Autoprotolysis

ii. Common ion effect **(4 marks)**

b) By the help of graph and equations, state Boyle's and Charles law of gases **(4 marks)**

c) The dissociation of Litmus indicator may be represented as follows, with a reason, state the color of the indicator in

i. Alkaline solution

ii. Acidic solution. **(4 marks)**

$$HLit_{(aq)} \rightleftharpoons H^+_{(aq)} + Lit^-_{(aq)}$$

Red Blue

d) A mixture of 0.100 M NO and 0.050 M H_2 was allowed to react till equilibrium. At equilibrium the concentration of N_2 was found to be 0.019 M. Determine the value of the equilibrium constant, $K_{c,.}$ *reaction* **(4 marks)**

$$2\,NO(g) + 2\,H_2(g) \leftrightarrows N_2(g) + 2\,H_2O(g)$$

e) A buffer solution was prepared by mixing 0.20M in ethanoic acid and 0.10M in sodium ethanoate. Given dissociation constant of ethanoic acid as 1.74 x 1^{0-5} M, calculate

i. pH of buffer solution. **(3 marks)**

ii. PH change when 1ml of 1M NaOH was added to 1L of this buffer **(2 marks)**

f) Calculate the pH of a saturated solution of $Cu(OH)_2$, K_{sp} = 1.6 x 10^{-19} **(4 marks)**

g) Distinguish between

i. Arrhenius, Bronsted and Lewis concept of Acid **(3 marks)**

ii. Homogeneous from heterogeneous equilibria **2 marks**

Question Two (20 Marks)

a) A solution prepared by dissolving 5.00 g of a biomolecule in 16.0 g CCl_4 boils at 77.85 °C. . Calculate the molar mass of the biomolecule. Given boiling point constant as 5.03 °C/m, and Bp of CCl_4 is 76.50 °C. **(4 marks)**

b) At temperature above its boiling point dinitrogen tetraoxide exist in equilibrium with nitrogen dioxide, using le chatelier principle explain how the equilibrium will readjust itself if (i) Pressure is decrease (ii)Temperature is increase (iii) Concentration of $N0_2$ (g) withdrawn

$N_20_4(g) \rightleftharpoons 2N0_2$ (g) DH 57 KJ/MOL^{-1} **(3 marks)**

c) 0.25 moles of A were mixed with 0.45 moles of B and allowed to react to form C. At equilibrium there were 0.16 moles of C in 1 liter vessel. Calculate Equilibrium constant

K_x $A(g) + 2B(g) \rightleftharpoons C(g)$ **(4 marks)**

d) Using examples, explain the term conjugate acid base pair. **(4 marks)**.

e) State characteristic of partially miscible liquids **(2 marks)**

f) Define

i. vapour pressure

ii. Boiling point **(3 marks)**

Question Three (20 Marks)

a) State the postulate made in kinetic theory of gases **(3 marks)**

b) Define

(i) Amphiprotic substance

(ii) Indicators **(4 marks**

c) The following equilibrium exist at 35 ^{0}c, given equilibrium partial pressure of Ammonia, Nitrogen and Hydrogen as 2.9 X 10 $^{-4}$ atm, 8.9 X 10 $^{-1}$ atm 2.9 X 10 $^{-3}$ atm respectively Calculate;

(i) Equilibrium constant kp

(ii) Equilibrium constant k_C (R= 8.314 J **(5 Marks)**

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

d) State the success of

(i) Arrhenius theory

(ii) Bronsted theory **(4 marks)**

e) A gas mixture was prepared by blending 1.24 moles of hydrogen gas with 2.91 moles of oxygen gas under a total pressure of 104 kilopascals. Determine respective partial pressure in atmospheric. **(4 marks**

Question Four (20 Marks)

a) Calculate

i. concentration of OH^- in a solution of 2.0 X 10 $^{-3}$ M HCl **(3 Marks)**

ii. Equilibrium constant K_P for the following reaction at25°C. Given standard free energy ΔG^{O} of $CH_3OH(g)$, CO(g) and H_2 (g) as 161.9, -110.5 and 130.6 Kilojoules per mole respectively. **(5 Marks)**

$$CH_3OH(g) \rightleftharpoons CO(g) + H_2(g)$$

b) Outline the characteristic of

i. ideal solution **(3 marks)**

ii. ideal gases **(1 marks)**

iii. Double salt **(2 Marks)**

c) The density of a mixture of nitrogen and oxygen gases is 1.3393 g / L at STP. Determine the mole percentages of nitrogen and oxygen in this sample. **(4 marks)**

d) With the help of equation state Raoul's law **(2 marks)**.

Question Five (20 Marks)

a) At 29.6 °C, pure water has a vapor pressure of 31.1 torr. A solution is prepared by adding 86.8 g of "Y", a nonvolatile non-electrolyte to 350. g of water. The vapor pressure of the resulting solution is 28.6 torr. Calculate the molar mass of Y. **(4mks)**

b) Differentiate between positive and negative deviation in non -ideal solution **(4mks)**

c) Show the relationship between K_P and K_C for reaction **(4 marks)**

$$1B + 1D \rightleftharpoons 3A$$

d) A Buffer was prepared by mixing acetic acid and sodium acetate. Explain how this buffer will behave when small amount of Acid is added **(4 marks)**

e) Compare and Comment on the pressure predicted for 536 mL of 1 mole Carbon dioxide gas at 373 Kelvin. using the;

i. Ideal gas equation **(2 Marks)**

ii. Van der waals equation **(3 Marks))**

Given a = 3.61 L^2 atm mol^{-2}, b = 0.0428 L and

van der waals equation $(P + an^2/v^2)(V - nb) = nRT$.

f) The pH of A saturated solution of $Mg(OH)_2$ solution is 10.17. Calculate the K_{sp} for this compound. **(4 Marks)**