

P525/2
CHEMISTRY
Paper 2

Sept./Oct. 2022
2 $\frac{1}{2}$ hours.

S.6

THE CHEMISTRY DEPARTMENT

2022

CHEMISTRY

TEST TWO , TERM III, Paper 2

2 hours 30 minutes

INSTRUCTIONS:

*Answer **five** questions including **three** questions from section A and any **two** from section B.*

Write the answers in the answer booklet(s) provided.

Begin each question on a fresh page.

Mathematical tables and graph papers are provided.

Non-programmable scientific calculators may be used.

Use equations where necessary to illustrate your answers.

Where necessary, use the following:

$$\left[\begin{array}{l} H = 1, \quad C = 12, \quad O = 16 \\ \text{Molar gas volume is } 22.4 \text{ dm}^3 \text{ at stp} \end{array} \right]$$

SECTION A : (60 MARKS)

Answer **three** questions from this section.

1. (a) Write the electronic configuration of manganese.
(Atomic number of manganese= 24). (01 mark)
- (b) Explain why manganese:
(i) is a transition element (01 mark)
(ii) has variable oxidation states. (02 marks)
(iii) has a higher melting point (1890°C) than calcium(860°C). (03 marks)
- (c) Describe the reaction(s) of manganese with:
(i) water (2 $\frac{1}{2}$ marks)
(ii) sulphuric acid (4 $\frac{1}{2}$ marks)
- (d) Aqueous sodium hydroxide solution was added to manganese(II) sulphate solution dropwise until in excess and the resultant mixture allowed to stand.
(i) State what was observed. (1 $\frac{1}{2}$ marks)
(ii) Write equation(s) for the reaction(s) that took place. (03 marks)
(iii) Write equation for the reaction between trimanganese tetroxide and aluminium. (1 $\frac{1}{2}$ marks)
2. The table below shows the variation in pH of the solution when 30 cm³ of 0.2M ammonia solution was titrated with hydrochloric acid.

Volume of hydrochloric acid(cm ³)	0	4	8	12	16	19	19.4	19.8	20.2	20.6	21	22	26	28
pH	10.8	9.9	9.4	9.1	8.7	8.0	7.8	7.3	3.9	3.5	3.2	2.9	2.5	2.4

- (a) Plot a graph of pH against volume of hydrochloric acid. (04 marks)
- (b) Using the graph in (a) to determine the:
(i) pH and volume at endpoint. (02 marks)
(ii) molarity of hydrochloric acid. (02 marks)

- (ii) hydrolysis constant of ammonium chloride formed at the endpoint. (3 $\frac{1}{2}$ marks)
- (iii) ratio of $[NH_4Cl]:[NH_3]$ when 10 cm^3 of hydrochloric acid has been added to ammonia solution. (2 $\frac{1}{2}$ marks)
- ($K_b = 1.8 \times 10^{-5}$ and $K_w = 1 \times 10^{-14}$ at 25°C)
- (c) Explain the shape of the graph. (05 marks)
- (d) Which of the indicators below is suitable for the titration? Give a reason for your answer.

Indicator	pH range
Thymol blue	1.2 – 2.8
Methyl orange	3.1 – 4.4
Methyl red	4.2 – 6.3
Phenolphthalein	8.3 – 10.0

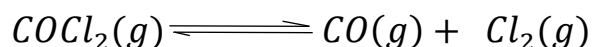
3. When 7.5g of an organic compound **Q** was burnt completely in excess oxygen, 11.2 dm^3 of carbon dioxide and 4.5g of water were formed at s.t.p.
- (a) (i) Calculate the empirical formula of **Q**. (3 $\frac{1}{2}$ marks)
 (ii) Determine the molecular formula of **Q**. (02 marks)
- (Density of **Q** is 5.357 g dm^{-3} at s.t.p.)
- (b) **Q** burns with a sooty flame and forms a yellow precipitate with 2,4-dinitrophenylhydrazine and also forms a pale yellow precipitate with iodine solution in sodium hydroxide solution. Identify **Q**. (0 $\frac{1}{2}$ mark)
- (c) Write equation and suggest a mechanism for the reaction between **Q** and:
- (i) 2,4-dinitrophenylhydrazine in acidic medium. (4 $\frac{1}{2}$ marks)
- (ii) sodium hydrogensulphite solution. (03 marks)
- (d) Using equations only, show how **Q** ;
- (i) can be synthesised from benzaldehyde. (04 marks)

- (ii) can be converted to an alkene. (2 $\frac{1}{2}$ marks)
4. (a) (i) State **Le Chatelier's principle** (01 mark)
- (ii) State **two** factors that affect equilibrium reactions apart from a catalyst (02 marks)
- (iii) Briefly describe how each of the factors you have named in (a)(ii) above affect equilibrium constant and equilibrium position. (05 marks)

(b) Given the reaction:



- (i) Write the expression for the equilibrium constants, K_c and K_p giving units in each case. (03 marks)
- (ii) What is the effect on position of equilibrium of adding a catalyst. (01 mark)
- (c) Phosgene, or carbonyl dichloride, $COCl_2$ dissociates according to the following equation:



- (i) At 25°C, one mole of carbonyl dichloride was placed in a 2dm³ vessel producing an equilibrium mixture with 20.25% chlorine. Calculate the value of the equilibrium constant, K_c at this temperature. (03 marks)
- (ii) At 75°C, the degree of dissociation of two moles of carbonyl dichloride in the same 2dm³ vessel was found to be 15% chlorine. Calculate the value of the equilibrium constant, K_c at this temperature. (03 marks)
- (iii) From your answers in (c)(i) and (c)(ii) above, state whether the reaction is exothermic or endothermic. Give a reason for your answer. (02 marks)

SECTION B : (40 MARKS)

Answer any **two** questions from this section

5. Describe the reactions that lead to the following conversions. No equations required.

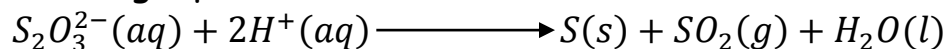
- (a) Bromobenzene from phenol (3 $\frac{1}{2}$ marks)
- (b) Propanal from chloroethane (05 marks)
- (c) Phenylamine from methylbenzene (05 marks)
- (d) Hexane from propene (2 $\frac{1}{2}$ marks)
- (e) $(CH_3)_2C = NCH_2CH_2CH_3$ from 2-iodopropane (04 marks)

6. The table below shows the hydrides of group VII elements and their boiling points.

Period number	2	3	4	5
Hydride	HF	HCl	HBr	HI
Boiling point($^{\circ}C$)	+20	-85	-67	-35

- (a) (i) Plot a graph of boiling point against period number. (04 marks)
- (ii) Explain the shape of the graph. (05 marks)
- (b) Describe briefly how the following hydrides are prepared in the laboratory. (*Illustrate your answers with equations*)
 - (i) hydrogen chloride (2 $\frac{1}{2}$ marks)
 - (ii) hydrogen iodide (2 $\frac{1}{2}$ marks)
- (c) Discuss the reactions of the hydrides with:
 - (i) sodium hydroxide
 - (ii) sulphuric acid
 - (iii) silicon dioxide (06 marks)

7. Sodium thiosulphate solution reacts with hydrochloric acid according to the following equation.



The kinetic data for the above reaction at 25°C is shown below:

Experiment No.	$[S_2O_3^{2-}]$ ($mol\,dm^{-3}$)	$[H^+]$ ($mol\,dm^{-3}$)	Initial rate ($mol\,dm^{-3}\,s^{-1}$)
1	0.40	0.20	7.00×10^{-4}
2	0.40	0.60	6.30×10^{-3}
3	0.80	0.60	1.26×10^{-2}

- (a) (i) Differentiate between **order** and **rate constant** of a reaction. (02 marks)
- (ii) Determine the order of reaction with respect to $S_2O_3^{2-}$ and H^+ ions. (03 marks)
- (iii) Write an expression for the rate law. (01 mark)
- (iv) Calculate the rate constant for the reaction at 25°C and indicate its units. ($2\frac{1}{2}$ marks)
- (b) Explain the effect of temperature on the rate constant and activation energy of the reaction. (04 marks)
- (c) Using the above reaction, describe an experiment that can be carried out to determine the order of reaction with respect to $S_2O_3^{2-}$ ions. ($7\frac{1}{2}$ marks)
8. Explain the following observations
- (a) Aluminium chloride sublimes on heating whereas sodium chloride does not. (04 marks)
- (b) When hydrogen sulphide gas was bubbled through iron(III) chloride solution, a yellow precipitate was observed. ($3\frac{1}{2}$ marks)
- (c) A mixture of water (boiling point 100°C) and chlorobenzene(boiling point 136°C) boils at 98°C at atmospheric pressure. (04 marks)
- (d) When sodium hydroxide solution was added to chromium(III) sulphate solution dropwise until in excess, followed by

hydrogen peroxide and the mixture warmed, it formed a green precipitate soluble in excess sodium hydroxide to give a green solution which turned yellow on warming with hydrogen peroxide solution. (05 marks)

- (e) When lead(IV) oxide is warmed with concentrated hydrochloric acid, effervescence of a greenish yellow gas occurs. ($3\frac{1}{2}$ marks)

END