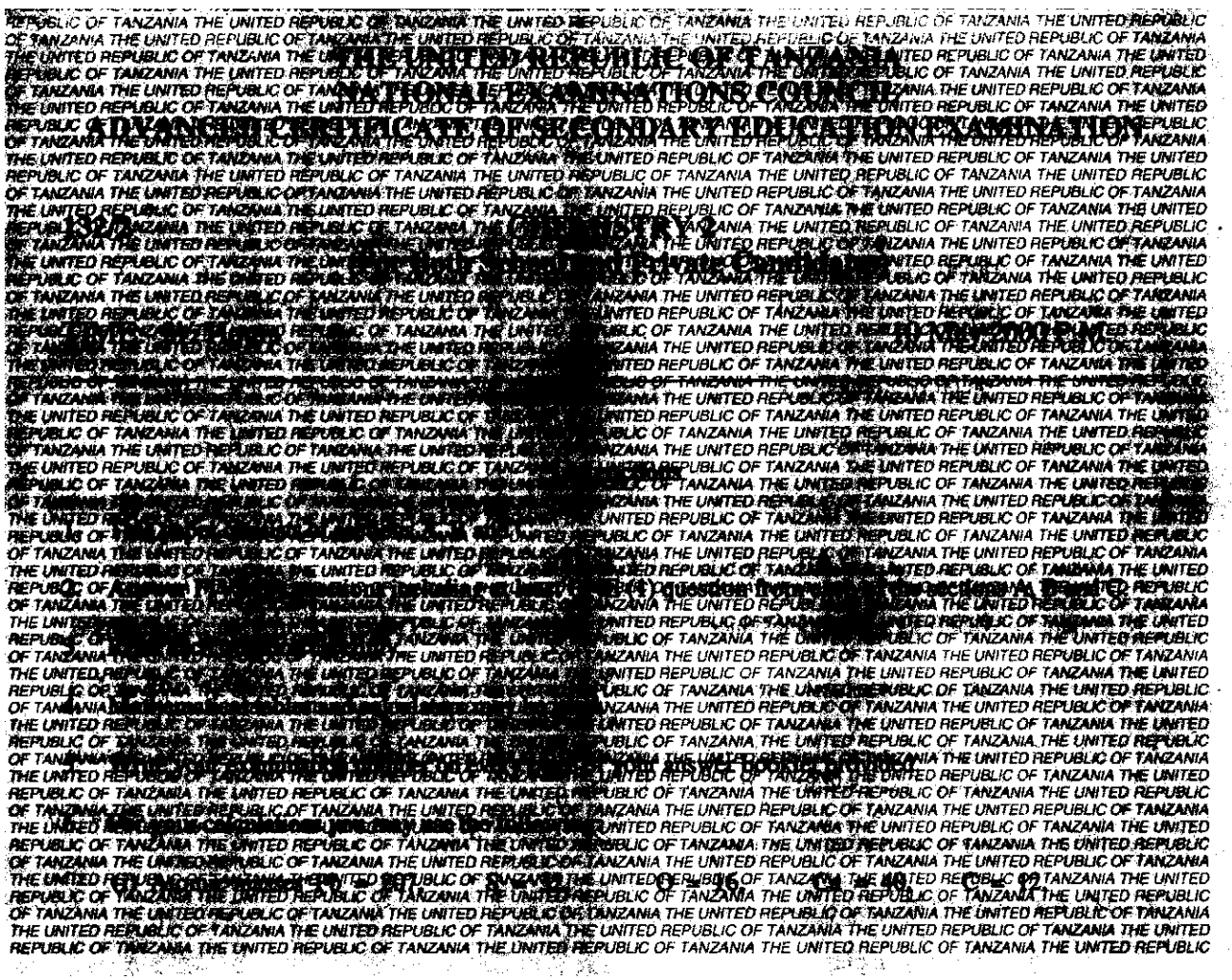


This paper consists of 7 printed pages

SECTION A

Answer at least ONE (1) question from this section

1. (a) Define the following terms

(i) Molarity

(ii) Buffer solution

(iii) Solubility product

(iv) Ionic equilibrium

(6 marks)

(b) The solubility of lead (II) sulphate at 20°C is 0.40 g/dm^3.

(i) What is its solubility product? (4 marks)

(ii) Calculate its solubility in g/dm^3 in a 0.01M sodium sulphate solution. (4 marks)

(c) Calculate the concentration of calcium carbonate precipitate in g/dm^3, if 0.1M of calcium chloride was added to 0.1M sodium carbonate solution.

(6 marks)

[The solubility product of calcium carbonate is 1.69×10^{-8} mol^2 dm^{-6}]

2. (a) What is meant by:

(i) Activated complex

(ii) Molecularity

(iii) Rate law

(iv) Zero – order reaction? (6 marks)

(b) For each of the following reactions, suggest any two properties which can be followed in measuring the rate of its reaction:

(i) $2KMnO_4(aq) + 5H_2C_2O_4(aq) \xrightarrow{6H^+(aq)} K_2SO_4(aq) + 2MnSO_4(aq) + 8H_2O_{(l)} + 10\,CO_2(g)$ (3 marks)

(ii) $CuCl_2(aq) + 2AgNO_3 \longrightarrow Cu(NO_3)_2(aq) + 2AgCl\,(s)$ (3 marks)

(c) The rate of decomposition of hydrogen peroxide was studied by titrating known volumes of the reaction mixture with potassium permanganate at different time intervals and the results obtained were as tabulated below:

Volume of $KMnO_4$ used (cm^3)	75	47	30	13	7.20
Time (minutes)	00	06	09	20	29

(i) Show that, the reaction is first order. (4 marks)

(ii) Find the rate constant. (4 marks)

3. (a) Distinguish between conductance, conductivity and molar conductivity of an electrolyte. Discuss the effect of dilution on the three quantities. (3 marks)

(b) Calculate the molar conductivity and degree of dissociation of a solution of 0.0064 Ω^{-1} cm^{-1} and molar conductivity at infinite dilution of 133.4 Ω^{-1} cm^2 mol^{-1}. The concentration of the solution is 0.005M. (4 marks)

(c) Given the following standard redox potentials at 25°C

Zn, Zn^{2+} E_θ = -0.76V
Fe, Fe^{2+} E_θ = -0.44V
Sn, Sn^{2+} E_θ = -0.14V

Compare the efficiency of zinc and tin as rust protective covering materials in iron. (5 marks)

(d) Define the term "Standard Electrode Potential". (2 marks)

(e) The following is a part of redox series

	Redox Potential E^θ at 25°C
$Li(Li^+)$	- 3.04V
$Mg(Mg^{2+})$	- 2.37V
$Zn(Zn^{2+})$	-0.76V
$Fe(Fe^{2+})$	- 0.44V
$½H_2(H^+)$	0.00V
$Cu(Cu^{2+})$	+ 0.34V
$½I_2(I^-)$	+ 0.54V
$Ag(Ag^+)$	+ 0.80V
$½Cl_2(Cl^-)$	+ 1.36V
$½F_2(F^-)$	+ 2.85V

Using the above redox series, explain giving reasons, whether the following redox reactions will take place or not.

(i) $Zn(s) + 2Ag^+(aq) \longrightarrow Zn^{2+}(aq) + 2Ag(s)$ (1½ marks)

(ii) $Cu(s) + 2H^+(aq) \longrightarrow H_2(g) + Cu^{2+}(aq)$ (1½ marks)

(iii) $Cl_2(g) + 2F^-(aq) \longrightarrow F_2(g) + 2Cl^-(aq)$ (1½ marks)

(iv) $H_2 + 2Ag^+(aq) \longrightarrow 2H^+(aq) + Ag(s)$ (1½ marks)

4. (a) Define the following terms giving one example in each case:

(i) Standard enthalpy of combustion. (2½ marks)

(ii) Standard enthalpy of formation. (2½ marks)

(iii) Lattice energy. (2½ marks)

(iv) Electron affinity. (2½ marks)

(b) State Hess's Law of constant heat summation. (2 marks)

(c) Calculate the enthalpy of formation of $Ca(OH)_2$ from the following data.

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(\ell)$ $\Delta H = -68.3$ k Cal

$CaO(s) + H_2O(\ell) \longrightarrow Ca(OH)_2(s)$ $\Delta H = -15.3$ k Cal

$Ca(s) + \frac{1}{2}O_2(g) \longrightarrow CaO(s)$ $\Delta H = -151.8$ k Cal (5 marks)

(d) Calculate ΔH for the reaction

$Fe_2O_3(s) + 3CO(g) \longrightarrow 3CO_2(g) + 2Fe(s)$ (3 marks)

given ΔHf^{θ} $Fe_2O_3(s) = -196.5$ k Cal

ΔHf^{θ} $CO(g) = -26.41$ k Cal

ΔHf^{θ} $CO_2(g) = -94.05$ k Cal

ΔHf^{θ} $Fe(s)$ $(25^{\circ}C) = 0$

SECTION B

Answer at least ONE (1) question from this section

5. (a) What is meant by:

(i) Atomic (covalent) radius

(ii) Electronegativity

(iii) Polarisation

(iv) Polarising power? (6 marks)

(b) Consider the following ions.

F^-, Na^+, N^{3-}, O^{2-} and Mg^{2+}

Arrange these in order of:

(i) increasing ionic size.

(ii) increasing polarising power.

(iii) increasing polarisability. (6 marks)

(c) Outline the unique features of nitrogen ($^{14}_{7}N$) as compared to other Group VA elements and discuss, how these features differentiate its chemistry from the chemistry of other members.

6. (a) Name the three most abundant elements in nature. (3 marks)

(b) Give the names and formulae of three common ores from which each of the following elements are extracted.

(i) Aluminium.

(ii) Manganese. (3 marks)

(c) One of the above two named elements is used in the extraction of the other. Use equations to show how this extraction occurs from a named ore. (6 marks)

(d) Compare and contrast the chemistry of these two elements in:

(i) formation and nature of ions

(ii) reaction with air or oxygen.

(iii) nature of their chlorides.

(iv) nature of their oxides. (8 marks)

7. (a) Complex compounds can sometimes exhibit isomerism. The compound $[Co(NH_3)_5 Br] SO_4$ is isomeric to compound $[Co(NH_3)_5 SO_4] Br$

(i) Give the IUPAC name for each isomer.

(ii) What ions will each isomer yield in solution?

(iii) What is the oxidation state and the coordination number of cobalt in each complex compound?

(iv) How can you distinguish the two isomers? (5 marks)

(b) Explain in terms of electronic configuration why iron (atomic number 26)

(i) Conducts electricity.

(ii) State which oxidation state is most stable and why.

(5 marks)

(c) Write the formula for each of the following complexes:

(i) Tetrammine copper (II) sulphate monohydrate.

(ii) Potassium heptaoxodichromate (VI).

(iii) Trichlorotriammine platinum (IV) chloride. (5 marks)

(d) Explain how atomic size, ionization energy and electron affinity vary along the period in the periodic table. (5 marks)

SECTION C

Answer at least ONE (1) question from this section

8. (a) Show how ethanol reacts with

(i) hydroxylamine.

(ii) phenylhydrazine.

(iii) an excess mixture of sodium hydroxide and iodine.

(iv) a mixture of amalgamated zinc and concentrated hydrochloric acid.

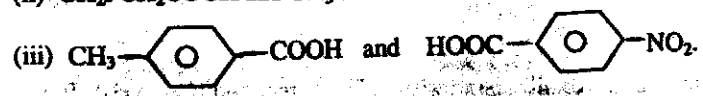
(v) sodium hydrogensulphite.

(5 marks)

(b) Identify the more acidic compound for each of the following pairs and give reasons.

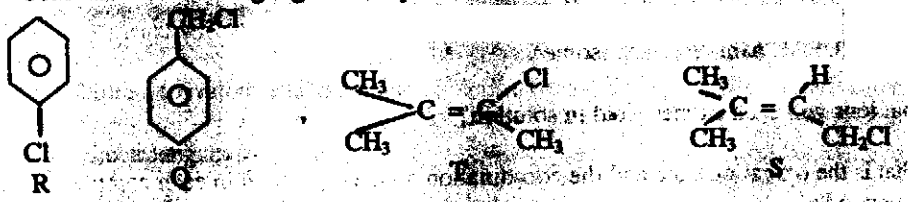
(i) $CH_2ClCOOH$ and $CH_2BrCOOH$.

(ii) CH_2FCH_2COOH and $CH_3CHFCOOH$.

(iii)  and

(5 marks)

(c) Consider the following organic compounds and answer the questions below:



Why does silver nitrate precipitate chlorine from compounds Q and S but not from compounds R and T?

(4½ marks)

(d) Explain why alkylation of nitrobenzene is much slower than that of methylbenzene. (4½ marks)

9. (a) Complete the following equations:

(i) C_6H_5MgBr $\xrightarrow[HBr]{CO_2}$

(ii) $C_6H_5COOH + PCl_5$ ⟶

(iii) CH_3CH_2COOH $\xrightarrow{LiAlH_4}$

(iv) $2C_6H_5CHO + NaOH$ ⟶

(v) $C_6H_5CH_3 + Cl_2$ ⟶

(12½ marks)

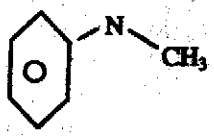
(b) Give the IUPAC names of the following compounds

(i) $H_2N(CH_2)NH_2$

(ii) $(CH_3CO)_2O$

(iii) $CH_2 = CHCN$

(iv) $CH_3-CH(NH_2)-COOH$

(v) 

(7½ marks)

16. (a) **The names below are incorrect according to the IUPAC system. Draw the structural formula for each compound named and give its correct IUPAC name.**

(i) 2,2 – Dimethyl – 3 – pentene.

(ii) 2-Methyl – 4 – heptene.

(iii) 2,2,3 – Methylbutane.

(iv) 3-Ethyl – 4 – methylpentane. (6 marks)

(b) Give the expected product(s) from the reaction of 2-butene with each of the following reagents:

(i) H^+, H_2O

(ii) H_2 / catalyst

(iii) Cl_2

(iv) HOCl

(v) O_2, flame (5 marks)

(c) An unsaturated hydrocarbon P (C_3H_6) reacts with water in the presence of acid to give compound Q (C_3H_8O). Treatment of Q with $SOCl_2$ gives R (C_3H_7Cl) which in turn gives an organomagnesium chloride S (C_3H_7MgCl) with Mg in dry ether. The reaction of S with methanol followed by hydrolysis yields alcohol T ($C_4H_{10}O$) which gives compound U ($C_4H_8O_2$) on treatment with acidified $KMnO_4$. Compound U reacts with $SOCl_2$ to yield V (C_4H_7ClO) which reacts with benzene in the presence of $AlCl_3$ giving a benzene derivative W of molecular formula $C_{10}H_{12}O$. Give the structural formulae of P, Q, R, S, T, U, V, and W. Give equations for all reactions mentioned.

(9 marks)