2411/302
INORGANIC CHEMISTRY
Oct./Nov. 2023
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

INORGANIC CHEMISTRY

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Non-programmable scientific calculator.
*This paper consists of **TWO** sections; **A** and **B**.*
*Answer **ALL** the questions in section **A** and any **THREE** questions from section **B** in the answer booklet provided.*
*Each question in section **A** carries **4** marks while each question in section **B** carries **20** marks.*
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 8 printed pages.

Candidates should check the question paper to ascertain that
all the pages are printed as indicated and that no questions are missing.

SECTION A (40 marks)

*Answer **ALL** the questions in this section.*

1. Magnesium occurs in nature in three isotopic forms as shown in table I. Calculate the atomic mass of magnesium to 2 decimal places. (4 marks)

Table I

Isotope	% Abundance	amu
^{24}Mg	78.70	23.985
^{26}Mg	11.17	25.983
^{25}Mg	10.13	24.986

2. The ionic radii of sodium and potassium ions are 102 pm and 138 pm respectively. Identify, with explanation, the compound that has the stronger ionic attraction between sodium chloride and potassium chloride. (4 marks)

3. A compound A on heating gives a colourless gas and a solid residue. The residue is dissolved in water to obtain solution B. When excess CO_2 is bubbled through the aqueous solution B, a white precipitate is initially formed, which turns into colourless solution C. Gentle heating of solution C gives back compound A. A chloride of the metal in compound A imparts a red colour to a flame.

(a) Identify compound A, as well as solutions B and C. (3 marks)

(b) Write an equation for the reaction that occurs when solution C is gently heated. (1 mark)

4. (a) Complete the equations for the following reactions:

(i) $I_2 + Cl_2 \longrightarrow$ (excess) (1 mark)

(ii) $I_2 + Cl_2 \longrightarrow$ (equimolar) (1 mark)

(b) Explain why the boiling point of the compound formed in (ii) is 40 °C higher than that of Br_2 even though the molecular size of both is nearly the same. (2 marks)

5. (a) Write electronic configuration of the following ions:

(i) Cu^{2+}; (1 mark)
(ii) Sc^{3+}; (1 mark)
(iii) Fe^{3+}. (1 mark)

(b) Identify the ions in (a) that would form a coloured complex. (1 mark)

6. Sodium -24 with a half life of 15 hours is used to study blood circulation. A patient is injected with $^{24}NaCl$ solution with an activity of 2.5×10^{9} d/s. Calculate how much activity is present in the patient's body after 4.0 days. (4 marks)

7. Silicon dioxide does not react with hydrochloric acid but reacts with sodium hydroxide.

   (a) state **one** property of silicon dioxide that can be deduced from this observation. (2 marks)

   (b) write an equation for the reaction between silicon dioxide and sodium hydroxide. (2 marks)

8. Chromium forms the two oxides CrO_3 and CrO.

   (a) Name the oxide that forms a more acidic solution. (1 mark)

   (b) Explain the answer in (a). (3 marks)

9. In aqueous solution, sodium chloride $(NaCl)$ and sodium carbonate (Na_2CO_3) can be distinguished by simple test-tube reactions using either dilute sulphuric acid or acidified silver nitrate. State the observation when dilute sulphuric acid is added to:

   (a) $NaCl_{(aq)}$; (2 marks)

   (b) $Na_2CO_{3(aq)}$. (2 marks)

10. Draw Lewis structures for the following molecules;

    (a) SO_3; (1 mark)

    (b) CH_2Br_2; (1 mark)

    (c) HCN;; (1 mark)

    (d) OF_2. (1 mark)

SECTION B (60 marks)

*Answer any **THREE** questions from this section.*

11. (a) Identify the type of bond for each of the following whether ionic, polar covalent, non-polar, covalent or metallic:

(i) S - O bond in K_2SO_4; (1 mark)
(ii) bonds in F2; (1 mark)
(iii) bonds in K_2O; (1 mark)
(iv) C - C bonds in C_3H_8; (1 mark)
(v) bonds in Ba. (1 mark)

(b) (i) State whether the following molecules are polar or non-polar:

(I) CO_2; (1 mark)
(II) $CHCl_3$. (1 mark)

(ii) Explain the answers in (i). (2 marks)

(c) For each of the following bonds, use delta notation (δ^+ and δ^+) to indicate which atom is more electronegative and an arrow to point from the less electronegative to the more electronegative atom.

(i) $C - Cl$; (1 mark)
(ii) N - O. (1 mark)

(d) Table II shows the melting points of sodium, chlorine and sodium chloride.

Table II

	Sodium	Chlorine	Sodium chloride
Melting Point (°C)	98	−101	801

(i) Draw the structure of NaCl showing the sizes of the component ions. (2 marks)

(ii) Explain why the melting point of sodium chloride is much higher than that of its constituent elements. (4 marks)

(iii) Explain why the melting point of beryllium chloride is half that of NaCl. (1 mark)

(iv) Explain why lead sulphate (PbS) is insoluble in water even though it is crystalline like NaCl. (2 marks)

$BeCl_3$ NaCl

12. (a) With the aid of a chemical equation, describe the observation made when magnesium is burned in oxygen. (4 marks)

(b) Figure 1 shows some reactions involving magnesium and its compounds.

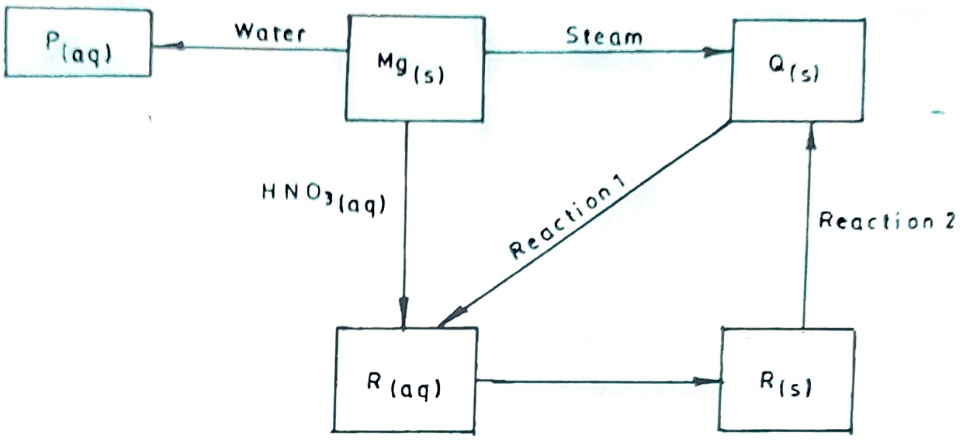

Fig.1

(i) write the formulae of the compounds:

(I) P; (2 marks)
(II) Q; (2 marks)
(III) R. (2 marks)

(ii) Name the reagent needed to convert $Q_{(s)}$ to $R_{(aq)}$ in reaction 1. (1 marks)

(iii) Write an equation for the reaction in (ii). (2 marks)

(iv) Explain how a sample of $R_{(s)}$ can be converted into $Q_{(s)}$ in reaction 2. (3 marks)

(v) Give equations for the conversion of:

(I) $Mg_{(s)}$ into $P_{(aq)}$; (2 marks)

(II) $R_{(s)}$ into $Q_{(s)}$. (2 marks)

13. (a) Explain why the isotope $^{99_m}_{43}Tc$ is used as a source of radiation for medical diagnosis. (4 marks)

(b) Explain how chemical reactions and nuclear reactions differ in terms of:

(i) magnitude of energy change; (2 marks)
(ii) effect on rate of increasing temperature; (2 marks)
(iii) effect on rate of higher reactant concentration. (2 marks)

(c) Write balanced nuclear equations for the formation of:

(i) $^{48}_{22}Ti$ through positron emission; (2 marks)

(ii) silver - 017 through electron capture. (2 marks)

(iii) polonium - 206 through $\alpha -$ decay. (2 marks)

(d) Explain whether the nuclide ^{32}S is expected to be stable or radioactive. (4 marks)

14. (a) (i) Write electronic configurations for:

(i) Cr^{3+}; (2 marks)
(ii) Mn^{2+}; (2 marks)
(iii) CO^{2+}. (2 marks)

(ii) Describe the observations made when dilute $KMnO_{4(aq)}$ is added slowly while shaking to an acidified warm solution of $FeSO_{4(aq)}$ until the $KMnO_{4(aq)}$ is in a large excess. (4 marks)

(iii) Explain the reason for the final colour change in (ii). (2 marks)

(iv) Identify the type of reaction occurring in (ii) and write the ionic equation for the reaction. (2 marks)

(b) A green solution X contains $[Fe(H_2O)_6]^{2+}$ ions. The presence of the ions can be confirmed by reacting separate samples of solutions X with aqueous ammonia and with aqueous sodium carbonate.

(i) Explain the observations made for the reaction between the ions and:

(I) aqueous ammonia; (2 marks)
(II) aqueous sodium carbonate. (2 marks)

(ii) Write equations for each of the reactions in (i).

(I) excess chloride ions; (1 mark)
(II) excess ammonia. (1 mark)

15. (a) Table III shows the variation in properties of the group VII elements.

Table III

Halogen	Melting point /°	Colour
Chlorine	−101	
Bromine	−7	
Iodine	114	

(i) Complete the table by identifying the colour of each element in its normal state at room temperature. (3 marks)

(ii) Explain why the melting points of the halogens increase from chlorine to iodine. (2 marks)

(iii) The halogens form many interhalogen compounds, including bromine monochloride, $BrCl$.

(I) give the electronic configuration of bromine and chlorine; (2 marks)

(II) draw a Lewis dot diagram of the $BrCl$ molecule. (2 marks)

(b) Chlorine and $BrCl$ each react with potassium iodide, KI.

(i) Explain the observation made when Cl_2 gas is bubbled through aqueous KI for several minutes:

(I) at the initial time; (2 marks)

(II) after several minutes. (2 marks)

(ii) Write an equation for the reaction between $BrCl$ and KI. (2 marks)

(c) Phosphorous sulphide, P_4S_3, is used in small amounts in the tip of a match stick. On striking a match stick, this compound burns.

(i) Write an equation for the reaction. (2 mark)

(ii) Both oxides formed in (i) dissolve in water to give acidic solutions. Write an equation for the reaction of each oxide with water. (3 marks)

The Periodic Table of the Elements

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (18)
																	4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	96.0 **Mo** molybdenum 42	[97] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La** * lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac** † actinium 89	[267] **Rf** rutherfordium 104	[270] **Db** dubnium 105	[269] **Sg** seaborgium 106	[270] **Bh** bohrium 107	[270] **Hs** hassium 108	[278] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[281] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

* 58 – 71 Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.3 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
† 90 – 103 Actinides	232.0 **Th** thorium 90	231.0 **Pa** protactinium 91	238.0 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103

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