THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/1 **CHEMISTRY 1**

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2009**

Instructions

1. This paper consists of sections A, B and C with total of fourteen questions

2. Each question carries ten marks.

1. (a) An electron in a hydrogen atom finds itself in the fourth energy level (n = 4).

(i) Write down a list of orbitals (subshells) that it might be in.

- The possible orbitals for n = 4 are 4s, 4p, 4d, and 4f.

(ii) What are the values of l for this energy level (n = 4)?

- The possible values of l (azimuthal quantum number) for n = 4 are:
  - l = 0 (s orbital)
  - l = 1 (p orbital)
  - l = 2 (d orbital)
  - l = 3 (f orbital)

(b) Radio isotope ${}^{14}_{6}C$ is a β-emitter with a half-life of 5568 years.

(i) Define the term half-life.

- Half-life is the time required for half of a radioactive sample to decay into its daughter elements. It is a measure of the rate of radioactive decay.

(ii) What is the atomic number, atomic mass, and name of the new atom that is formed as a result of this change?

- The decay equation is:
  ${}^{14}_{6}C$ ----> ${}^{14}_{7}N + \beta^-$
  - The atomic number increases by 1 (from 6 to 7), so the new element is nitrogen (N).
  - The atomic mass remains the same at 14.

(c) Identify the following elements:

(i) ${}^{9}_{4}X$
  - Atomic number = 4 (Beryllium, Be).

(ii) ${}^{28}_{14}X$
  - Atomic number = 14 (Silicon, Si).

(iii) ${}^{27}_{13}X$
  - Atomic number = 13 (Aluminum, Al).

(d) From which energy level do transitions in the hydrogen atom with the following spectral series arise?

(i) The first line in the Lyman series.

- The Lyman series involves transitions to n = 1, so the first line comes from n = 2 to n = 1.

(ii) The second line in the Balmer series.

- The Balmer series involves transitions to n = 2, so the second line corresponds to a transition from n = 4 to n = 2.

2. (a) Give the meaning of the following:

(i) Osmotic pressure of a solution.

- Osmotic pressure is the pressure required to prevent the flow of solvent molecules through a semi-permeable membrane from a dilute solution to a more concentrated solution. It is given by the equation:

$\pi = iMRT$, where i is the Van't Hoff factor, M is molarity, R is the gas constant, and T is temperature in Kelvin.

(ii) Van't Hoff's factor.

- Van't Hoff's factor (i) is the ratio of the observed colligative property of a solution to the expected colligative property if the solute did not dissociate. It accounts for the effect of ionization or association of solute particles in a solution.

(b) Derive an expression relating the Van't Hoff factor (i) with the degree of dissociation (α) of a molecule.

- Van't Hoff's factor is given by:

$i = 1 + (n - 1)\alpha$,

where:

- n = number of particles formed from one formula unit of solute.
- α = degree of dissociation.

- If the solute dissociates completely ($\alpha = 1$), then i = n. If there is no dissociation ($\alpha = 0$), then i = 1.

(c) 3.42 g of sodium chloride was dissolved in 100 g of water. If the atmospheric pressure of this solution at 60°C was 22680 mmHg, calculate the percentage dissociation of sodium chloride.

- Step 1: Calculate the molality of NaCl.
- Step 2: Use the Van't Hoff factor equation to determine the dissociation percentage.
- The percentage dissociation is determined by the value of α in $i = 1 + \alpha$.

3. (a) Define the following:

- Definition missing in the question. It could be "solution," "colligative property," or another fundamental term.

(b) Ethanol-water mixture is said to give a positive deviation from ideal behavior. What factors contribute to this positive deviation from ideal behavior?

- Ethanol and water molecules interact through hydrogen bonding, but mixing them disrupts these bonds, leading to weaker interactions.
- This causes an increase in vapor pressure and a decrease in boiling point compared to an ideal solution.

(c) (i) Sketch a temperature-composition curve for the water-ethanol mixture from the following data:

- Atmospheric pressure = 1 atmosphere
- Boiling point of pure water = 100°C
- Boiling point of pure ethanol = 78.4°C
- Boiling point of azeotropic mixture = 78.15°C
- Composition of azeotropic mixture = 95.6 percent by mass of ethanol

- The curve should show a minimum-boiling azeotrope at 78.15°C, with the x-axis representing ethanol composition and the y-axis representing temperature.

(ii) It is possible to separate a water-ethanol mixture into pure water but not into pure ethanol. Explain.

- Simple distillation can remove water from ethanol because water has a higher boiling point (100°C) than the azeotropic mixture (78.15°C).
- However, the azeotrope cannot be separated by simple distillation because it boils at a constant composition. Special techniques like azeotropic or extractive distillation are required to obtain pure ethanol.

(iii) Sketch a vapor pressure-composition curve for the water-ethanol mixture.

- The graph should show a positive deviation from Raoult's law, with the vapor pressure peaking at the azeotropic composition.

4. (a) Name the following complexes according to the IUPAC rules:

(i) $[Ni(H_2NCH_2CH_2NH_2)_2Cl_2]$
  - Dichlorobis(ethylenediamine)nickel(II)

(ii) $[Cr(H_2O)_4Cl_2]Cl$
  - Tetraaquadichlorochromium(III) chloride

(iii) $K_2[Co(NO_2)_4]$
  - Potassium tetranitrocobaltate(II)

(iv) $[PtCl_4]^{2-}$
  - Tetrachloroplatinate(II) ion

(b) The compound $[Co(NH_3)_5Cl]SO_4$ is isomeric with $[Co(NH_3)_5SO_4]Cl$.

(i) What ions will these two isomers yield in their aqueous solutions?

- $[Co(NH_3)_5Cl]SO_4$ ---> $[Co(NH_3)_5Cl]^{2+} + SO_4^{2-}$
- $[Co(NH_3)_5SO_4]Cl$ ----> $[Co(NH_3)_5SO_4]^{+} + Cl^{-}$

(ii) Give one positive chemical test for each isomer.

- For $[Co(NH_3)_5Cl]SO_4$: Addition of $BaCl_2$ gives a white precipitate of $BaSO_4$, confirming sulfate presence.
- For $[Co(NH_3)_5SO_4]Cl$: Addition of $AgNO_3$ gives a white precipitate of AgCl, confirming chloride presence.

(iii) What is the oxidation and coordination number of the central atom in the two isomers?

- Oxidation number of cobalt:
  - Let x be the oxidation state of Co in $[Co(NH_3)_5Cl]SO_4$.
  - $x + 0\ (NH_3) + (-1)\ (Cl) = +2$
  - $x = +3$
  - The coordination number is 6 (since cobalt is surrounded by five NH_3 and one Cl ligand).

(c) Explain why there is an increase in the maximum oxidation number from scandium to manganese, while there is a decrease in maximum oxidation number from manganese to zinc.

- From scandium to manganese, the increasing number of unpaired d-electrons allows higher oxidation states, reaching a maximum of +7 in Mn.
- From manganese to zinc, the d-orbitals begin to fill completely, reducing their ability to lose electrons, leading to a decrease in the maximum oxidation state.

5. (a) (i) What is a hydrogen bond?

- A hydrogen bond is a type of intermolecular force that occurs when a hydrogen atom, covalently bonded to a highly electronegative atom (such as fluorine, oxygen, or nitrogen), interacts with a lone pair of electrons on another electronegative atom. This interaction is responsible for many unique properties of water and biological molecules like DNA.

(ii) In the following list of compounds, identify those which form strong hydrogen bonding and those which form weak hydrogen bonding.

- Bifluoride ion (HF_2^-) – Strong hydrogen bonding due to resonance and high electronegativity of fluorine.
- Water (H_2O) – Strong hydrogen bonding because oxygen is highly electronegative and has lone pairs that strongly attract hydrogen atoms.
- 2-nitrophenol – Weak hydrogen bonding because intramolecular hydrogen bonding occurs within the same molecule, reducing intermolecular interactions.
- Hydrogen fluoride (HF) – Strong hydrogen bonding because of the high electronegativity of fluorine.

- Hydrated hydroxyl ion ($H_3O_2^-$) – Strong hydrogen bonding due to the presence of multiple hydrogen donor and acceptor sites.

(b) Classify the following compounds under inorganic covalent hydrides, ionic hydrides, and complex hydrides.

(i) NaH, KH, CaH_2
- These are ionic hydrides because they consist of metal cations (Na^+, K^+, Ca^{2+}) and hydride anions (H^-).

(ii) H_2O, H_2S, NH_3, HCl
- These are inorganic covalent hydrides because they contain hydrogen covalently bonded to non-metals.

(iii) $Li(AlH_4)$
- This is a complex hydride because it consists of a metal (Li^+) and an anionic complex (AlH_4^-).

6. The solubility product of lead (II) chloride $PbCl_2$ has a value of 1.6×10^{-5} $mol^2\ dm^{-6}$ at 298 K.

(a) Explain what is meant by this statement.

- The solubility product constant (Ksp) represents the equilibrium concentration of Pb^{2+} and Cl^- ions in a saturated solution.
- A Ksp value of 1.6×10^{-5} means that at equilibrium, the product of the molar concentrations of Pb^{2+} and Cl^- ions in solution remains constant at this value.

(b) Calculate the solubility in water of lead (II) chloride at 298 K.

- $PbCl_2$ dissociates as follows:
  $PbCl_2\ (s) \rightleftharpoons Pb^{2+}\ (aq) + 2Cl^-\ (aq)$
  Let the solubility be s. Then, at equilibrium:
  - $[Pb^{2+}] = s$
  - $[Cl^-] = 2s$
  - $Ksp = [Pb^{2+}][Cl^-]^2$
  - $1.6 \times 10^{-5} = (s)(2s)^2$
  - Solve for s to get the solubility.

(c) Calculate the solubility of the above compound in a 0.1 M solution of lead (II) nitrate at the same conditions.

- The common ion effect will reduce the solubility of $PbCl_2$ due to the presence of Pb^{2+} from $Pb(NO_3)_2$.
- Let the new solubility be s', and account for the initial Pb^{2+} concentration in the solubility equation.

7. Explain in ionic terms, the following facts with the help of a chemical equation where necessary.

(a) Silver chloride is almost insoluble in water but passes readily into solution when excess ammonia is added.

- AgCl is sparingly soluble in water due to its low solubility product (Ksp).
- In the presence of excess NH_3, a soluble complex forms:
  $AgCl\ (s) + 2NH_3\ (aq) \rightarrow [Ag(NH_3)_2]^+\ (aq) + Cl^-\ (aq)$
- The formation of this complex increases solubility.

(b) Iodine is readily soluble in a concentrated solution of potassium iodide but only sparingly soluble in water.

- Iodine (I_2) is non-polar and has low solubility in water.
- In KI solution, it forms a soluble triiodide complex:
  $I_2\ (s) + I^-\ (aq) \rightarrow I_3^-\ (aq)$
- This explains why iodine dissolves in KI solution but not in water.

(c) Lead (II) chloride is more soluble in concentrated hydrochloric acid than in water.

- In water, $PbCl_2$ has limited solubility due to its low Ksp.
- In excess HCl, Pb^{2+} forms a soluble complex:
  $PbCl_2\ (s) + 2Cl^-\ (aq) \rightarrow [PbCl_4]^{2-}\ (aq)$
- This shifts the equilibrium, increasing solubility.

(d) The addition of potassium cyanide solution to a solution of silver nitrate gives a white precipitate which then dissolves in excess of potassium cyanide solution.

- Initially, Ag^+ reacts with CN^- to form insoluble AgCN:
  $Ag^+\ (aq) + CN^-\ (aq) \rightarrow AgCN\ (s)$
- In excess CN^-, it forms a soluble complex:
  $AgCN\ (s) + CN^-\ (aq) \rightarrow [Ag(CN)_2]^-\ (aq)$

(e) When ammonia solution is added slowly to an aqueous solution of copper (II) sulfate, a pale blue precipitate is formed which dissolves in excess of ammonia to form a deep blue solution.

- Initial reaction:
  $Cu^{2+}\ (aq) + 2OH^-\ (aq) \rightarrow Cu(OH)_2\ (s)$ (pale blue precipitate)
- In excess NH_3, a soluble complex forms:
  $Cu(OH)_2\ (s) + 4NH_3\ (aq) \rightarrow [Cu(NH_3)_4]^{2+}\ (aq)$ (deep blue solution)

8. (a) Use the information in table 1 to explain the statements below:

Element	Na	Mg	Al	Si	P	S	Cl
Atomic radius (nm)	0.156	0.136	0.125	0.117	0.110	0.104	0.099
Ionic radius (nm)	0.095	0.065	0.050	X	X	0.184	0.181
1st Ionization Energy (kJ/mol)	492	743	579	591	1061	1003	1254

(i) The ionic radii of Na^+, Mg^{2+}, and Al^{3+} are less than their respective atomic radii, whereas the ionic radii of Cl^- and S^{2-} are greater than their respective atomic radii.

- Na, Mg, and Al lose electrons to form cations, reducing electron repulsion and causing their ionic radii to decrease.
- Cl and S gain electrons to form anions, increasing electron-electron repulsion and making their ionic radii larger.

(ii) The first ionization energies show a general increase from sodium to chlorine.

- Ionization energy increases across the period due to increasing nuclear charge, which pulls electrons closer to the nucleus, making them harder to remove.

(b) Identify from the following paramagnetic and diamagnetic species: Na, Mg, Cl^-, and Ca^{2+}.

- Paramagnetic species have unpaired electrons, while diamagnetic species have all electrons paired.
- Paramagnetic: Na (1 unpaired electron in $3s^1$).
- Diamagnetic: Mg (all electrons paired in $1s^2\ 2s^2\ 2p^6\ 3s^2$), Cl^- (all electrons paired in $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$), and Ca^{2+} (all electrons paired in $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$).

9. (a) Define the term hybridisation.

- Hybridisation is the process of mixing atomic orbitals of an atom to form new equivalent hybrid orbitals that have different shapes and energy levels. This concept explains the bonding properties and molecular geometries of molecules.

(b) By applying the knowledge of hybridisation explain the following:

(i) A carbon atom has got only two unpaired electrons yet, it can form four covalent bonds with chlorine atoms to form a carbon tetrachloride molecule.

- In its ground state, carbon has two unpaired electrons in the 2p orbitals. However, in the excited state, one of the 2s electrons is promoted to a 2p orbital, resulting in four unpaired electrons (one in 2s and three in 2p).

- These orbitals undergo sp^3 hybridisation to form four equivalent sp^3 hybrid orbitals, which overlap with the p orbitals of chlorine atoms to form four covalent bonds in carbon tetrachloride (CCl_4).

(ii) Beryllium has a pair of electrons in its outermost shell but it can form a beryllium molecule by means of sharing electrons with two chlorine atoms to form a beryllium chloride molecule.

- Beryllium (Be) has an electronic configuration of $1s^2\ 2s^2$, meaning it has no unpaired electrons in its valence shell.
- During bond formation, the 2s orbital of Be undergoes sp hybridisation, forming two sp hybrid orbitals.
- These orbitals overlap with the p orbitals of two chlorine atoms, forming two covalent bonds in $BeCl_2$, which has a linear geometry.

(c) Give explanations to the following observations:

(i) Anhydrous aluminium chloride does not conduct electricity but its aqueous solution does.

- In the solid state, anhydrous $AlCl_3$ exists as a covalent molecule with no free ions to conduct electricity.
- In aqueous solution, $AlCl_3$ dissociates into Al^{3+} and Cl^- ions, allowing electrical conductivity.

(ii) An aqueous solution of aluminium chloride turns blue litmus red.

- Aluminium chloride ($AlCl_3$) undergoes hydrolysis in water, forming Al^{3+} ions, which react with water molecules to produce H^+ ions:
  $Al^{3+} + 6H_2O \rightarrow [Al(H_2O)_6]^{3+}$
  - This causes the solution to be acidic, turning blue litmus paper red.

(iii) A white precipitate tends to be formed which dissolves when carbon dioxide is bubbled till excess through calcium hydroxide solution.

- When CO_2 is bubbled into $Ca(OH)_2$, an insoluble white precipitate of calcium carbonate ($CaCO_3$) forms:
  $CO_2 + Ca(OH)_2 \rightarrow CaCO_3\ (s) + H_2O$
- When CO_2 is passed in excess, the precipitate dissolves due to the formation of soluble calcium bicarbonate:
  $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2\ (aq)$

10. (a) Account for the following:

(i) Strontium in period 5 group 2 has lower ionisation energy than bromine in period 4 group 7.

- Strontium (Sr) is a group 2 metal with a larger atomic radius and weaker nuclear attraction on valence electrons, making it easier to remove an electron.
- Bromine (Br), being a group 7 element, has a smaller atomic radius and a stronger nuclear attraction, requiring more energy to remove an electron.

(ii) Phosphorus in period 3 group 5 has more non-metallic character than gallium in period 4 group 3.

- Phosphorus is in group 5 and has a higher electronegativity, making it more non-metallic.
- Gallium, being a group 3 element, has more metallic properties due to its lower electronegativity and ability to lose electrons easily.

(iii) The atomic radius of strontium in group 2 is larger than that of magnesium in group 2.

- Atomic radius increases down a group due to the addition of more electron shells, increasing the size of strontium compared to magnesium.

(iv) Bromine has more electron affinity than iodine although they belong to the same group.

- Bromine is smaller than iodine, meaning the attraction of the nucleus on an incoming electron is stronger, leading to a higher electron affinity.

(b) With reasons, arrange the following species in order of increasing size: K^+, Ar, S^{2-}, Cl^-, and Ca^{2+}.

- The correct order is $Ca^{2+} < K^+ < Ar < Cl^- < S^{2-}$.
- Ca^{2+} has the smallest size as it has lost two electrons, leading to strong nuclear attraction.
- K^+ is smaller than Ar since it has lost one electron, increasing nuclear pull.
- Ar is a noble gas with a complete shell and is neutral.
- Cl^- and S^{2-} have gained electrons, increasing their size due to electron repulsion.

11. (a) Give the IUPAC names for the following organic compounds:

(i) $CH_3-CH_2-C(CH_3)_2-COONH_2$
- 2,2-Dimethylbutanamide

(ii) $CH_3-CH(CH_3)-(CH_2)_4-COO(C_2H_5)$
- Ethyl 3-methylhexanoate

(iii) $(C_6H_5-CO)-O-(CO-C_6H_5)$
- Benzoic anhydride

(iv) C_6H_5-COCl
- Benzoyl chloride

(b) Study the following reaction:

Ethanol ----> (A) Ethanoic acid ----> (B) Ethanoyl chloride ----> (C) Ethanamide ----> (D) N-phenylethanamide

Give the names of reagents A, B, C, and D.

- A: Acidified potassium dichromate ($K_2Cr_2O_7/H_2SO_4$)
- B: Phosphorus pentachloride (PCl_5) or thionyl chloride ($SOCl_2$)
- C: Ammonia (NH_3)
- D: Aniline ($C_6H_5NH_2$)

(c) What type of reagents attack the benzene ring to form substitution products of benzene?

- Electrophilic reagents attack the benzene ring in electrophilic substitution reactions. These reagents are electron-deficient species that seek electrons from the π-system of benzene.

(d) Give the attacking reagents which are involved in the following reactions:

(i) Nitration of benzene
 - Concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4) generate the nitronium ion (NO_2^+) as the electrophile.

(ii) Alkylation of benzene
 - Alkyl halides (R-Cl) in the presence of anhydrous aluminum chloride ($AlCl_3$) as a catalyst (Friedel-Crafts alkylation).

(iii) Acylation of benzene
 - Acyl chlorides (RCOCl) or acid anhydrides $(RCO)_2O$ in the presence of anhydrous $AlCl_3$ as a catalyst (Friedel-Crafts acylation).

12. (a) Define the following:

(i) Elimination reaction
- An elimination reaction is a type of organic reaction in which two atoms or groups are removed from a molecule, typically resulting in the formation of a double or triple bond. An example is the dehydration of alcohols to form alkenes.

(ii) Addition reaction
- An addition reaction is a reaction in which two or more reactants combine to form a single product, usually involving the breaking of a double or triple bond. An example is the addition of hydrogen to ethene to form ethane.

(iii) Organic substitution reaction
- A substitution reaction is an organic reaction in which one atom or functional group in a molecule is replaced by another atom or functional group. An example is the replacement of a hydrogen atom in methane with a chlorine atom to form chloromethane.

(iv) Nucleophilic substitution reaction
- A nucleophilic substitution reaction is a type of substitution reaction in which a nucleophile replaces a leaving group in a molecule. An example is the reaction of hydroxide ions with bromoethane to form ethanol.

(v) Homologous series
- A homologous series is a group of organic compounds that have a similar structure and the same functional group, with each successive member differing by a CH_2 unit. Examples include the alkane series (methane, ethane, propane, etc.).

(b) Complete the following reactions:

(i) $CH_3CH_2CH = CH_2 + HBr$ ----> $CH_3CH_2CHBrCH_3$
- This is an example of an electrophilic addition reaction, where hydrogen bromide adds across the double bond, following Markovnikov's rule.

(ii) $CH_2 = CH_2 + KMnO_4$ ----> $CH_2(OH)$-$CH_2(OH)$
- Ethene reacts with cold, dilute potassium permanganate to form ethane-1,2-diol (glycol), a reaction known as hydroxylation.

(iii) $CH_2 = CH_2 + O_3$ ----> Zn/H_2O ----> CH_2O + HCHO
- Ozonolysis of ethene leads to the formation of formaldehyde.

(iv) CH_3-CH_2-OH ----> H_2SO_4, heat ----> CH_2=CH_2 + H_2O
- Dehydration of ethanol using concentrated sulfuric acid produces ethene.

(v) CH_3-$C(CH_3)_3 = CH_2 + H_2SO_4(aq)$ ----> CH_3-$C(CH_3)_2$-CH_2OSO_3H
- Addition of sulfuric acid to 2-methylpropene forms an alkyl hydrogen sulfate, which upon hydrolysis gives the corresponding alcohol.

13. (a) Give the chemicals and conditions, if any, which can be used to prepare aldehydes by using the following processes:

(i) Dehydrogenation
- Aldehydes can be prepared by the dehydrogenation of primary alcohols using copper at 300°C.
  CH_3CH_2OH ----> Cu, heat ----> $CH_3CHO + H_2$

(ii) Catalytic hydrogenation
- Aldehydes can be obtained by the partial reduction of acid chlorides using palladium and barium sulfate (Rosenmund reduction).
  $RCOCl + H_2$ ----> Pd/$BaSO_4$ ----> RCHO + HCl

(b) Why do aldehydes

(i) Behave like polar compounds
- Aldehydes contain a highly polar carbonyl (C=O) group, where oxygen is more electronegative than carbon, creating a dipole moment. This makes aldehydes interact with other polar molecules, giving them polar characteristics.

(ii) Have lower boiling points than alcohols of comparable relative molecular masses
- Aldehydes cannot form intermolecular hydrogen bonds like alcohols because they lack an -OH group. Alcohols form strong hydrogen bonds, leading to higher boiling points, whereas aldehydes rely only on dipole-dipole interactions, which are weaker.

(c) Complete the following chemical reactions:

(i) CH_3NC ----> H_2/Pt ----> CH_3NH_2
- Hydrogenation of methyl isocyanide forms methylamine.

(ii) $CH_3CN + [H]$ ----> $LiAlH_4$ ----> $CH_3CH_2NH_2$
- Reduction of acetonitrile using lithium aluminum hydride produces ethylamine.

(iii) $CH_3CH_2CH_2CO\text{-}NH_2$ ----> P_2O_5 ----> $CH_3CH_2CH_2CN$
- Dehydration of butanamide using phosphorus pentoxide forms butanenitrile.

(iv) $CH_3\text{-}C \equiv O + HCN$ ----> $CH_3\text{-}C(OH)\text{-}CN$
- Addition of hydrogen cyanide to acetone forms a cyanohydrin.

(v) CH_3CHO ----> H_2/Ni ----> CH_3CH_2OH
- Hydrogenation of ethanal using nickel catalyst produces ethanol.

14. (a) Give the names of four alcohols represented by the molecular formula C_4H_9OH and write their structural formulae.

- Butan-1-ol: $CH_3CH_2CH_2CH_2OH$
- Butan-2-ol: $CH_3CH(OH)CH_2CH_3$
- 2-Methylpropan-1-ol: $(CH_3)_2CHCH_2OH$
- 2-Methylpropan-2-ol: $(CH_3)_3COH$

(b) Give the products of oxidation of the alcohols in 14(a) above when acidified potassium dichromate solution was used as an oxidizing agent.

- Butan-1-ol oxidizes to butanal and further to butanoic acid.
  $CH_3CH_2CH_2CH_2OH + [O]$ ----> $CH_3CH_2CH_2CHO + [O]$ ----> $CH_3CH_2CH_2COOH$

- Butan-2-ol oxidizes to butanone.

$CH_3CH(OH)CH_2CH_3$ + [O] ----> $CH_3COCH_2CH_3$

- 2-Methylpropan-1-ol oxidizes to 2-methylpropanal and further to 2-methylpropanoic acid.
  $(CH_3)_2CHCH_2OH$ + [O] ----> $(CH_3)_2CHCHO$ + [O] ----> $(CH_3)_2CHCOOH$

- 2-Methylpropan-2-ol does not undergo oxidation under normal conditions due to the absence of a hydrogen atom on the carbon bearing the -OH group.

(c) A substance X has a molecular formula $C_5H_{10}O$. What deductions can you make for substance X from each of the following facts?

(i) X reacts with sodium metal to give hydrogen gas with the formation of compound C_5H_9ONa.

- Since X reacts with sodium metal to produce hydrogen gas, it must contain an -OH group, indicating that X is an alcohol.

(ii) On treatment of X with chromium (VI) oxide, it forms compound C_5H_8O. The compound C_5H_8O does not reduce ammoniacal silver nitrate solution but it forms a crystalline derivative with 2,4-dinitrophenylhydrazine.

- The oxidation of X to C_5H_8O suggests that X is a secondary alcohol, which forms a ketone (C_5H_8O) upon oxidation.
- The fact that C_5H_8O does not reduce ammoniacal silver nitrate means it is not an aldehyde but a ketone.
- Formation of a crystalline derivative with 2,4-DNPH confirms the presence of a carbonyl (C=O) group.
- Therefore, X is a secondary alcohol, and upon oxidation, it forms a ketone.