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Draw a cross through the box (X) if you have NOT written in this booklet

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SCHOLARSHIP EXEMPLAR



Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2023 Chemistry

Time allowed: Three hours
Total score: 32

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

Pull out Resource Booklet 93102R from the centre of this booklet.

Show ALL working.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–24 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (AREA NOT TO WRITE). This area may be cut off when the booklet is marked.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE
END OF THE EXAMINATION.**

QUESTION ONE

- (a) The solubility constants for three compounds are given below. Lead(II) hydroxide is a white solid, whilst the two iodide compounds are both yellow in appearance.

$$K_s(\text{PbI}_2) = 8.00 \times 10^{-9} \quad K_s(\text{AgI}) = 8.30 \times 10^{-17} \quad K_s(\text{Pb(OH)}_2) = 8.00 \times 10^{-17}$$

- (i) A student pipetted 25.0 mL of 0.00167 mol L⁻¹ potassium iodide solution, KI(aq), into each of two beakers. They then added 35.0 mL of 0.0225 mol L⁻¹ lead(II) nitrate solution, Pb(NO₃)₂(aq), to one beaker and added 35.0 mL of 0.0143 mol L⁻¹ silver nitrate solution, AgNO₃(aq), to the other.

Carry out calculations to predict what the student observed in each beaker.

beaker 1: $[\text{KI}] = \frac{25}{60} \times 0.00167 = 6.96 \times 10^{-4} \text{ mol L}^{-1}$

$[\text{Pb(NO}_3)_2] = \frac{35}{60} \times 0.0225 = 0.0131 \text{ mol L}^{-1}$

$$\begin{aligned} \text{PbI}_2 \quad \text{IP} &= [\text{Pb}^{2+}][\text{I}^-]^2 \\ &= 0.0131 \times (6.96 \times 10^{-4})^2 \\ &= 6.35 \times 10^{-9} \end{aligned}$$

$\text{PbI}_2 \quad K_s = 8.00 \times 10^{-9}$

$\text{IP} < K_s$

so no PbI₂ precipitate forms

$[\text{OH}^-] = 1 \times 10^{-7}$

$$\begin{aligned} \text{Pb(OH)}_2 \quad \text{IP} &= [\text{Pb}^{2+}][\text{OH}^-]^2 = 0.0131 \times (1 \times 10^{-7})^2 \\ &= 1.31 \times 10^{-16} \end{aligned}$$

$\text{IP} > K_s$ so Pb(OH)₂ precipitate

forms (white solid observed forming)

beaker 2: $[\text{KI}] = 6.96 \times 10^{-4} \text{ mol L}^{-1}$

$[\text{AgNO}_3] = \frac{35}{60} \times 0.0143 = 8.34 \times 10^{-3} \text{ mol L}^{-1}$

$$\begin{aligned} \text{AgI} \quad \text{IP} &= [\text{Ag}^+][\text{I}^-] = (8.34 \times 10^{-3}) \times (6.96 \times 10^{-4}) \\ &= 5.80 \times 10^{-6} \end{aligned}$$

$\text{IP} > K_s$

so AgI precipitate forms (yellow)

- (ii) Explain why, when preparing the lead(II) nitrate solution for the experiment described in (i), it is necessary that the measured mass of $\text{Pb}(\text{NO}_3)_2(s)$ is first dissolved in a small volume of dilute nitric acid, before dilution with distilled water.

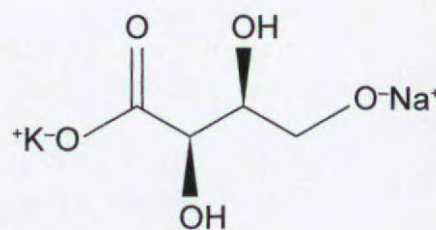
to acidify it otherwise it won't react

- (b) A reaction between hydrogen peroxide solution, $\text{H}_2\text{O}_2(aq)$, and potassium sodium tartrate solution, $\text{KNaTar}(aq)$, is commonly used in schools to demonstrate the effect of reaction conditions on the rate of a reaction.

The two colourless solutions are mixed and heated to 70 °C. No obvious reaction is observed at this point. A small amount of a pale pink cobalt(II) chloride solution, $\text{CoCl}_2(aq)$, is then added, and changes begin to be observed.

First the solution turns green as the pale pink Co^{2+} ions are oxidised into green Co^{3+} ions by the hydrogen peroxide. Once the solution has changed colour, large volumes of CO_2 gas are quickly produced as the tartrate ions react with the hydrogen peroxide. The colour of the solution remains green during the reaction. Once the hydrogen peroxide is consumed, no further gas is produced.

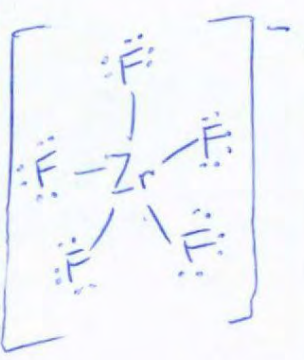
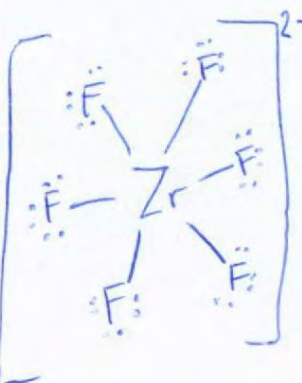
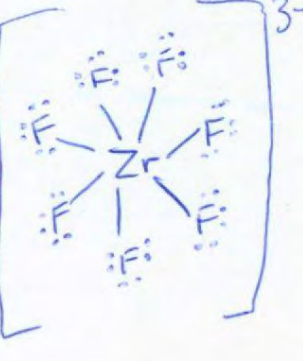
Elaborate on the various reaction conditions required for this demonstration to work according to plan, with clear reference to particle collision theory and the role of Co^{3+} ions.



(c) Zirconium forms fluorine-containing compounds and polyatomic ions.

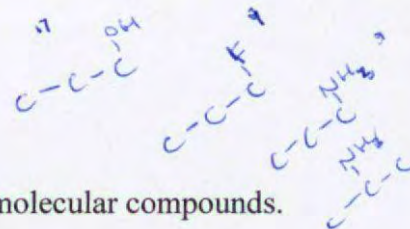
(i) Draw Lewis structures for the following fluorides of zirconium.

Use your existing knowledge to predict logical shapes for each ion, and give estimated bond angles.

Ion	ZrF_5^-	ZrF_6^{2-}	ZrF_7^{3-}
Lewis structure			
Shape	trigonal bipyramidal	octahedral	
Bond angles	90° and 120°	90°	90° and 109°

(ii) Explain the bond angles for one of the ions.

ZrF_5^- , one atom goes straight up, another straight down, creating the 90° bond angles, the other three are spaced evenly around the middle of the Zr atom creating the 120° bond angles.



QUESTION TWO

- (a) The following is a selection of boiling points for different molecular compounds.

-2.50 °C 31.7 °C 48.5 °C 97.2 °C

- (i) Match the following compounds to the boiling points provided.

propan-1-ol	1-fluoropropane	1-aminopropane	2-aminopropane
97.2 °C	2.50 °C	48.5 °C	31.7 °C

Justify your choices.

all four compounds are polar ~~are~~ so they all have temporary and permanent dipoles. 1-fluoropropane is the only compound that doesn't have an H atom bonded to an atom of high electronegativity, so all of the compounds have hydrogen bonding except 1-fluoropropane. As hydrogen bonding is the strongest type of intermolecular attraction and 1-fluoropropane only has temporary and permanent dipoles, 1-fluoropropane has the lowest boiling point as its intermolecular forces are most easily overcome. (-2.50 °C) Propan-1-ol has a higher molar mass than the remaining two compounds. It has a molar mass of 60 g mol⁻¹ whilst 1-aminopropane and 2-aminopropane have a molar mass of 52 g mol⁻¹. Because propan-1-ol has the highest molar mass it has the largest electron cloud to create an uneven distribution of charge and therefore has the strongest temporary dipoles. So propan-1-ol has the highest boiling point of 97.2 °C as its intermolecular forces are hardest to overcome. Out of the two compounds left 1-aminopropane has the slightly higher boiling point of 48.5 °C as it is a more linear molecule

than 2-aminopropane so the intermolecular forces between 1-aminopropane molecules ~~are~~ can hold them closer together and ~~are~~ therefore require more heat energy to overcome.

- (ii) Heptane has a boiling point of 98.4°C .

Explain why the boiling point of heptane is higher than any of the boiling points of the compounds in (i).

even though heptane is a nonpolar molecule and only has temporary dipoles it has a much higher molar mass (100g mol^{-1}) than any of the compounds in (i) so it has a much larger electron cloud to create an uneven distribution of charge and it has much stronger temporary dipoles so its intermolecular forces require the most heat energy to overcome.

- (b) (i) A complex organic reaction in a university laboratory yielded a mixture that contained two different organic compounds. Mass analysis determined that they had different molar masses. They were given the provisional labels **Compound X** and **Compound Y**.

Compounds **A**, **B**, and **C** were made from chemical treatments of the mixture of **X** and **Y** and were each subsequently isolated and analysed using spectroscopic techniques.

Use the mass analysis data provided below, and the IR and ^{13}C NMR spectra provided in the resource booklet, to determine the structures and names of Compounds **A**, **B**, and **C**.

$$M(\text{A}) = 59 \text{ g mol}^{-1} \quad M(\text{B}) = 72 \text{ g mol}^{-1} \quad M(\text{C}) = 88 \text{ g mol}^{-1}$$

Compound A	Compound B	Compound C
Name:	Name:	Name:
Structure:	Structure:	Structure:

- (ii) Compounds **A**, **B**, and **C** were isolated after the following chemical treatments:

A sample of the mixture of **X** and **Y** was heated with dilute NaOH solution, forming three products. TWO of these could be distilled from the reaction mixture and separated, and they were labelled Compounds **A** and **B**.

A second sample of the mixture of **X** and **Y** was heated with dilute HCl solution, and three products were formed. TWO of these could be distilled from the reaction mixture and separated. One was identified as Compound **B**, but the other product was new, and was subsequently labelled Compound **C**.

Use the mass analysis data provided below, and your knowledge of Compounds **A**, **B**, and **C**, to determine the structures of Compounds **X** and **Y**.

$$M(\text{X}) = 142 \text{ g mol}^{-1} \quad M(\text{Y}) = 129 \text{ g mol}^{-1}$$

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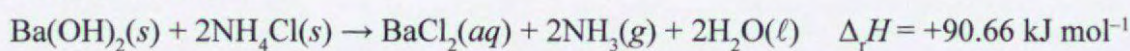
Compound X	Compound Y
Structure:	Structure:

- (iii) Why could only two of the three products from each treatment process be distilled from the reaction mixtures?

- (c) A mixture of barium hydroxide, $\text{Ba}(\text{OH})_2(\text{s})$, and ammonium chloride, $\text{NH}_4\text{Cl}(\text{s})$, was made in a glass beaker weighing 90.72 g. A spontaneous reaction occurred between the two solids, producing ammonia gas, $\text{NH}_3(\text{g})$.

The ammonia gas was extracted and reacted with 100.0 mL of hydrochloric acid solution, $\text{HCl}(\text{aq})$. The pH of the HCl solution was initially 0.50. After the addition of $\text{NH}_3(\text{g})$, the pH of the mixture had increased to 1.21.

- (i) Predict, by calculation, the temperature change of the $\text{NH}_4\text{Cl}/\text{Ba}(\text{OH})_2$ beaker once the reaction is complete.



$$c(\text{glass}) = 0.753 \text{ J } ^\circ\text{C}^{-1} \text{ g}^{-1}$$



before $[\text{H}_3\text{O}^+] = 10^{-0.5} = 0.316 \text{ mol L}^{-1}$

$$n(\text{HCl}) = 0.316 \times 0.1 = 0.0316 \text{ mol}$$

after $[\text{H}_3\text{O}^+] = 10^{-1.21} = 0.0617 \text{ mol L}^{-1}$

$$n(\text{HCl}) = 0.0617 \times 0.1 = 6.17 \times 10^{-3} \text{ mol}$$

$$n(\text{NH}_3) = 0.0316 - 6.17 \times 10^{-3} = 0.0255 \text{ mol}$$

$$q = -\Delta_r H \times n$$

$$q = -90.66 \times 0.0382$$

$$q = -3.46 \text{ kJ}$$

$$Q = -3460 \text{ J}$$

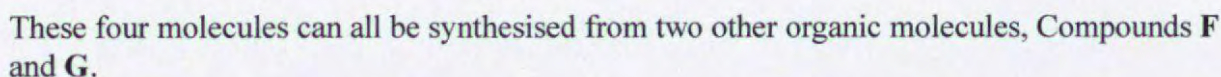
$$\Delta T = \frac{-3460}{90.72 \times 0.753}$$

$$= -0.0507^\circ\text{C}$$

- (ii) Briefly outline thermodynamic factors that contribute to the overall spontaneity of the reaction occurring in the beaker.

even though it is an endothermic reaction so the entropy of the surroundings decreases, the increase in entropy of the system is ~~positive~~ large enough to make the total change in entropy positive, so the reaction is spontaneous. This is because there are more moles of product allowing for more random arrangement of molecules and both of the products are large solids whilst the reactants are smaller molecules in much less ordered states (gaseous and liquid/aqueous) so there is a significant increase in disorder and therefore entropy of the system.

(a) Valinomycin is an antibiotic which can be obtained from several different bacteria of the *Streptomyces* genus. Four molecules are the building blocks for the structure of valinomycin, and they are given the labels Compounds **W**, **X**, **Y**, and **Z**. Their structures are as follows:

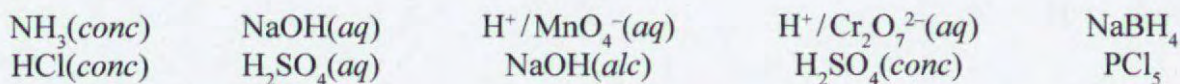


- Compound **F** has the molecular formula $\text{C}_3\text{H}_5\text{OCl}$. It does not produce steamy fumes when added to water, it does not form a silver mirror when added to Tollens' reagent, and it does not decolourise $\text{Br}_2(\text{aq})$.
- Compound **G** has the molecular formula $\text{C}_5\text{H}_{10}\text{O}$. It has a branched chain structure, and it exists as a pair of geometric isomers.

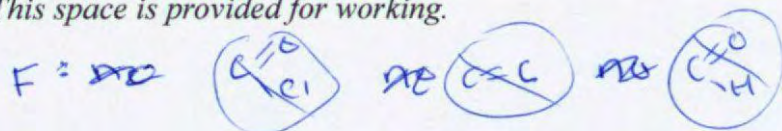
You may only select from the reagents provided below.

You can assume you would be able to separate and isolate specific compounds or isomers as required for successive steps.

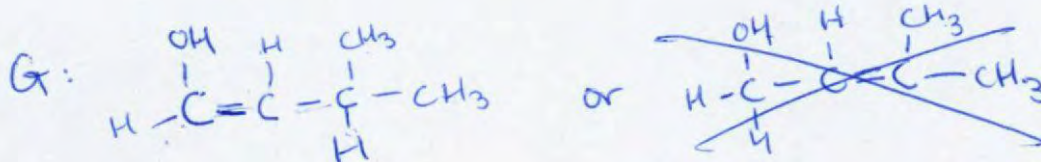
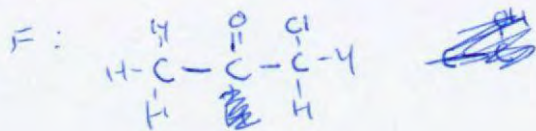
Reagents available:



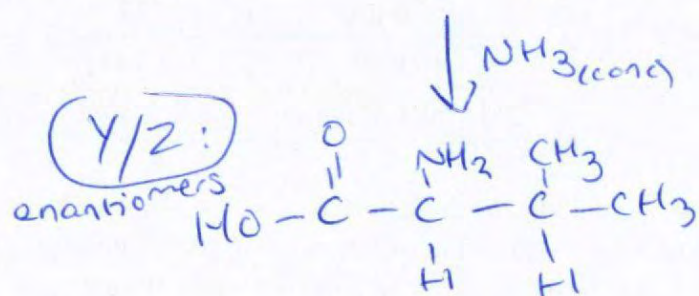
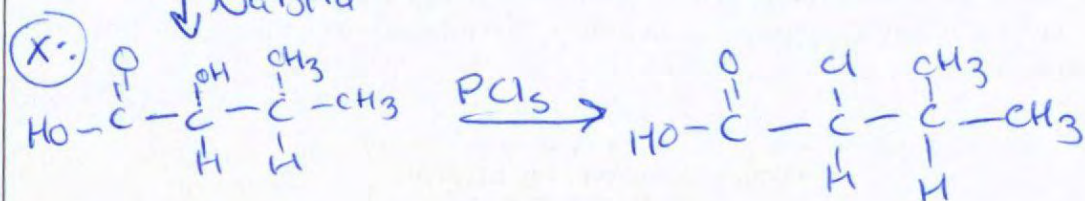
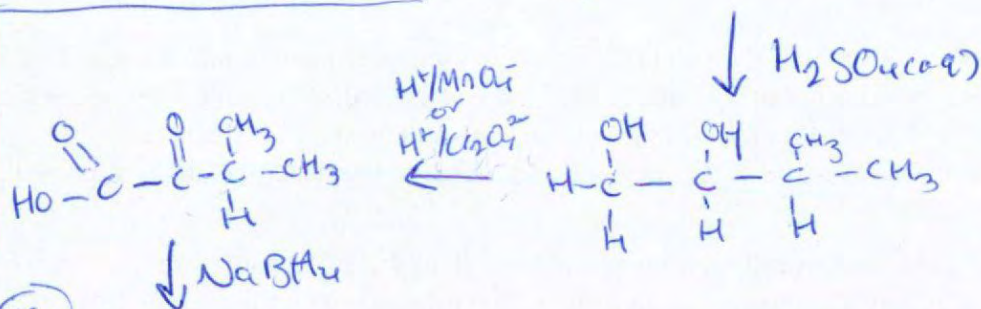
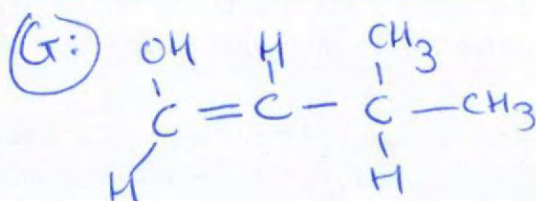
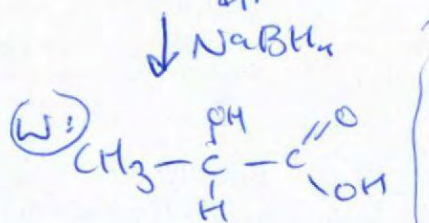
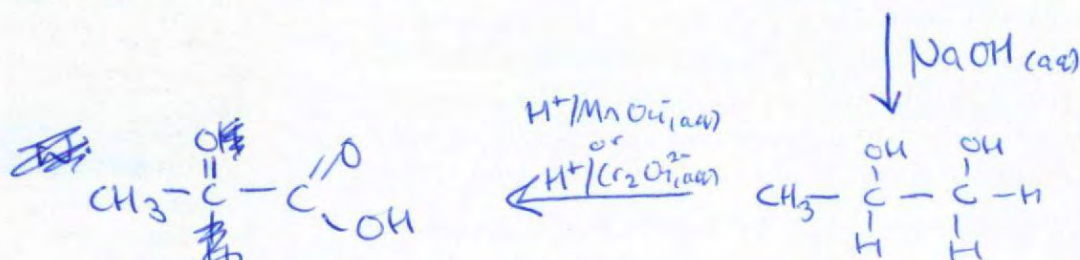
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G: $C=C$ branched



Reaction schemes:



- (b) Vitamin C ($\text{C}_6\text{H}_8\text{O}_6$) is known to degrade over time in aqueous solutions due to reaction with oxygen that is also dissolved in the water. Dry powders are less prone to degradation and can be used to prepare drinks with more reliable and consistent levels of the vitamin.

To investigate the extent of degradation of Vitamin C due to oxygen exposure, an 80.0 g sachet of an orange drink powder was emptied into a 1.00 L volumetric flask, filled to the mark using distilled water, and briefly mixed until all the solids had dissolved. The nutritional information on the drink powder packaging stated that the sachet should contain 130 mg of Vitamin C.

Two halves of the solution, and a blank control, were analysed using an iodometric titration procedure. The primary standard used in the titration was a potassium iodate solution, $\text{KIO}_3(\text{aq})$. This solution was prepared by dissolving 0.132 g into 1.00 L of distilled water in a volumetric flask.

The first half of the drink was analysed immediately. The second half of the drink was stirred in the open air then left uncovered for 24 hours, before being analysed. The control solution also analysed contained only water.

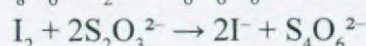
In each titration, a 20.0 mL aliquot of the solution being analysed was pipetted into a conical flask. This was followed by addition of 150 mL of distilled water, 5 mL of 1 mol L⁻¹ hydrochloric acid, $\text{HCl}(\text{aq})$, 5 mL of 1% potassium iodide solution, $\text{KI}(\text{aq})$, and 20.0 mL of the potassium iodate standard solution. This resulted in the formation of iodine in the flask, which then reacted with any Vitamin C present.

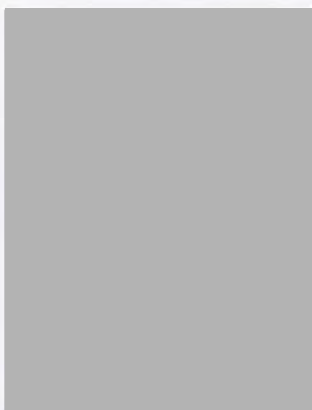
The remaining iodine in the flask was then titrated with a sodium thiosulfate solution, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$, and the titration was repeated with further 20.0 mL aliquots until average titres could be determined.

Solution	Average titre/mL
Control	27.20
Drink (fresh)	16.10
Drink (24 hours)	18.35

- (i) Carry out calculations to determine the concentration of the sodium thiosulfate solution used, whether the nutritional information on the sachet was accurate, and the percentage of Vitamin C remaining in the drink after 24 hours of atmospheric exposure.

$$M(\text{Vitamin C}) = 176.1 \text{ g mol}^{-1} \quad M(\text{KIO}_3) = 214 \text{ g mol}^{-1}$$





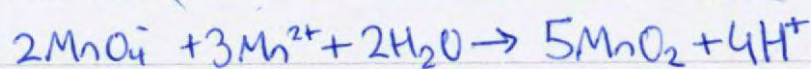
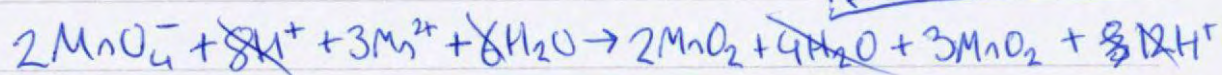
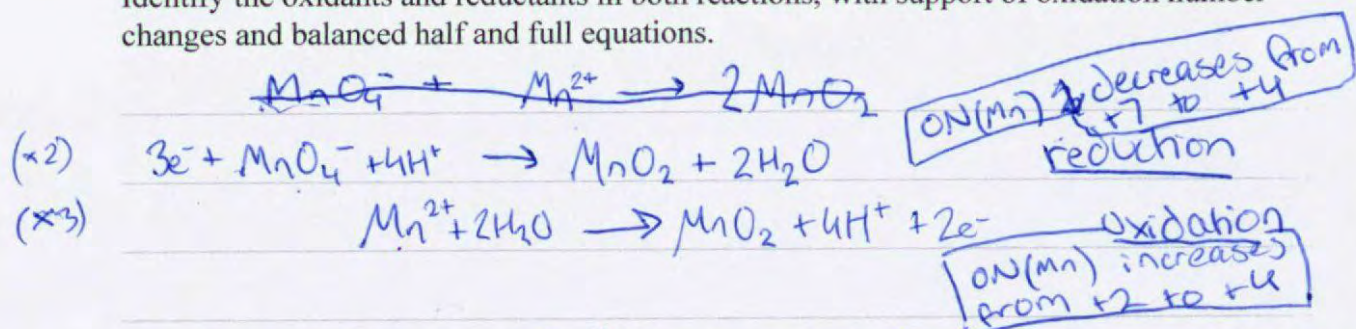
www.woolworths.
com.au/shop/
productdetails/264554/
raro-sweet-navel-orange-
flavoured-beverage-mix

- (ii) In the reaction below, the iodine-containing reactants react by electron-transfer to give the same product.

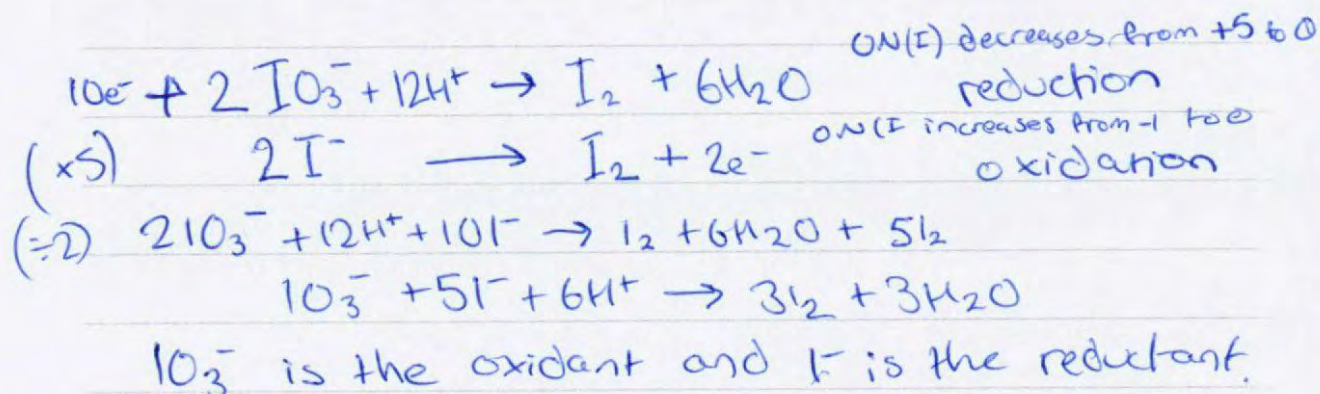


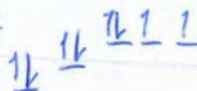
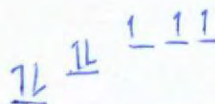
A similar reaction occurs when potassium permanganate solution, $\text{KMnO}_4(\text{aq})$, reacts with manganese(II) sulfate solution, $\text{MnSO}_4(\text{aq})$, in neutral conditions to produce manganese(IV) oxide, $\text{MnO}_2(\text{s})$.

Identify the oxidants and reductants in both reactions, with support of oxidation number changes and balanced half and full equations.



MnO_4^- is the oxidant and Mn^{2+} is the reductant





QUESTION FOUR

(a) There are various periodic trends observed between elements in the periodic table. These trends are fundamentally due to the protons and electrons within the different atoms.

(i) Justify the differences in **first ionisation enthalpy** for nitrogen and oxygen.

Give a clear definition for the term, and include references to electron arrangements where appropriate.

First ionisation enthalpy is the amount of energy required to remove a valence electron from one mole of gaseous atoms.

Usually ionisation enthalpy increases across a period because there are no new shells but there is an increased number of protons, so therefore a greater nuclear charge and the valence electrons require more energy to remove as they are held tighter to the nucleus. but even though N and O are both in the same period and O has one more proton, the first ionisation enthalpy of O is lower than N, this is because oxygen's 8th electron is paired with another in the 2p-subshell, creating extra electron-electron repulsion, and making it easier to remove than ~~the~~ N's valence electron, as all electrons in N's 2p-subshell are unpaired.

- (ii) Explain any similarities or differences in the radii of the following three particles.



all three particles are in the same row and have the same number of electrons (as N^{3-} and O^{2-} have gained electrons to fill their outer shell.). They all have the same number of shells so there are no differences in shielding and same number of electrons so no difference in electron repulsion. Ne will have the smallest radius as it has the largest number of protons (10) and therefore the greatest nuclear charge so the electrostatic attraction between the nucleus and valence electrons is stronger and they are drawn closer to the nucleus. N^{3-} will have the smallest radius as it has the lowest number of protons (7) so the smallest nuclear charge.

- (b) Vanadium is a transition metal that exists in different oxidation states, and can form ions and compounds with different colours. These include the ions shown below.

VO_2^+
Yellow

VO^{2+}
Blue

V^{3+}
Green

V^{2+}
Violet

For an experiment, a student added powdered silver, $\text{Ag}(s)$, to a solution containing VO_2^+ ions, and stirred until no further changes were observed. They then repeated the experiment twice more, but using powdered tin, $\text{Sn}(s)$, for the second, and powdered zinc, $\text{Zn}(s)$, for the third.

Use cell potential calculations to identify the **final** colour and oxidation number for vanadium in each experiment, following addition of the powdered metal.

You may assume that Zn^{2+} , Sn^{2+} , and Ag^+ are all colourless and do not form any insoluble precipitates.

$$\begin{aligned} E^\circ(\text{VO}_2^+/\text{VO}^{2+}) &= +1.00 \text{ V} \\ E^\circ(\text{Zn}^{2+}/\text{Zn}) &= -0.76 \text{ V} \end{aligned}$$

$$\begin{aligned} E^\circ(\text{VO}^{2+}/\text{V}^{3+}) &= +0.34 \text{ V} \\ E^\circ(\text{Sn}^{2+}/\text{Sn}) &= -0.14 \text{ V} \end{aligned}$$

$$\begin{aligned} E^\circ(\text{V}^{3+}/\text{V}^{2+}) &= -0.26 \text{ V} \\ E^\circ(\text{Ag}^+/\text{Ag}) &= +0.80 \text{ V} \end{aligned}$$

$$E_{\text{cell}}^{\circ} = E_{\text{red}}^{\circ} - E_{\text{ox}}^{\circ}$$

Ag: experiment one

$$E_{\text{cell}}^{\circ} = 1.00 - 0.80$$

$$= +0.20 \text{ V (spontaneous)}$$

so VO_2^+ is ~~reduced~~ reduced to VO^{2+}

$$E_{\text{cell}}^{\circ} = 0.34 - 0.80$$

$$= -0.46 \text{ (not spontaneous)}$$

VO^{2+} will not be reduced to V^{3+}

Final colour and ON for vanadium is blue and +4

Sn: experiment two

$$E_{\text{cell}}^{\circ} = 1.00 + 0.14$$

$$= +1.14 \text{ V (spontaneous)}$$

so VO_2^+ is reduced to VO^{2+}

$$E_{\text{cell}}^{\circ} = 0.34 + 0.14 = +0.48 \text{ V (spontaneous)}$$

VO^{2+} will be reduced to V^{3+}

$$E_{\text{cell}}^{\circ} = -0.26 + 0.14 = -0.12 \text{ V (not spontaneous)}$$

V^{3+} not reduced to V^{2+}

Final colour: green Final ON: +3

Zn: experiment three

$$E_{\text{cell}}^{\circ} = 1.00 + 0.76 = +1.76 \text{ V (spontaneous)}$$

so VO_2^+ is reduced to VO^{2+}

$$E_{\text{cell}}^{\circ} = 0.34 + 0.76 = +1.10 \text{ V (spontaneous)}$$

so VO^{2+} is reduced to V^{3+}

$$E_{\text{cell}}^{\circ} = -0.26 + 0.76 = +0.50 \text{ V (spontaneous)}$$

so V^{3+} is reduced to V^{2+}

Final colour: violet Final ON: +2

(c) Two acid-base titrations were carried out in a school chemistry laboratory.

- In the first titration, $0.0886 \text{ mol L}^{-1}$ sodium hydroxide solution, $\text{NaOH}(aq)$, was added to 30.0 mL of hydrochloric acid, $\text{HCl}(aq)$, which had an initial pH of 1.04 .
- In the second titration, $0.0886 \text{ mol L}^{-1}$ sodium hydroxide solution, $\text{NaOH}(aq)$ was added to a 30.0 mL solution of hypochlorous acid, $\text{HOCl}(aq)$, which had an initial pH of 4.16 .

(i) Carry out calculations to determine key points on the titration curve for each experiment.

Use these points to draw the two predicted curves on the graph space provided.

Key values may include: the initial concentrations of the two acids, the volume and pH at the equivalence point, the pH at halfway to the equivalence point, and the pH after 10 mL of excess base has been added.

$$\text{p}K_a(\text{HOCl}) = 7.53$$

HCl and NaOH (strong acid / strong base)

$$[\text{H}_3\text{O}^+] = 10^{-1.04} = 0.0912 \text{ mol L}^{-1}$$

$$\text{initial } [\text{HCl}] = 0.0912 \text{ mol L}^{-1}$$

$$n(\text{HCl}) = 0.0912 \times 0.03 = 2.74 \times 10^{-3} \text{ mol}$$

at E.P. $n(\text{NaOH}) = 2.74 \times 10^{-3}$

$$V(\text{NaOH}) = (2.74 \times 10^{-3}) \div 0.0886 = 0.0309 \text{ L (30.9 mL)}$$

$$\text{total volume at E.P.} = 60.9 \text{ mL}$$

pH at E.P. = 7 as all acid/base has reacted

pH after 10 mL excess base

$$n(\text{NaOH}) = 0.0886 \times 0.01 = 8.86 \times 10^{-4} \text{ mol}$$

$$C(\text{NaOH}) = (8.86 \times 10^{-4}) \div 0.0709 = 0.0125 \text{ mol L}^{-1}$$

$$[\text{OH}^-] = 0.0125 \text{ mol L}^{-1}$$

$$\text{pOH} = 1.90 \quad \boxed{\text{pH} = 12.1}$$

HOCl and NaOH (strong base / weak acid)

$$[\text{H}_3\text{O}^+] = 10^{-4.16} = 6.92 \times 10^{-5} \text{ mol L}^{-1}$$

$$[\text{HOCl}] = [\text{H}_3\text{O}^+]^2 \div K_a$$

$$K_a = 10^{-7.53} = 2.95 \times 10^{-8}$$

$$[\text{HOCl}] = (6.92 \times 10^{-5})^2 \div (2.95 \times 10^{-8})$$

$$[\text{HOCl}] = 0.162 \text{ mol L}^{-1}$$

$$n(\text{HOCl}) = 0.162 \times 0.03 = 4.87 \times 10^{-3} \text{ mol}$$

at EP $V(\text{NaOH}) = (4.87 \times 10^{-3}) \div 0.0886 = 0.0549 \text{ L}$
(= 54.9 mL)

total vol at $\bar{E}P = 84.9 \text{ mL}$

$$n(\text{OCl}^-) = 4.87 \times 10^{-3} \quad V(\text{OCl}^-) = 84.9 \text{ mL}$$

$$C(\text{OCl}^-) = \frac{4.87 \times 10^{-3}}{0.0849} = 0.0573 \text{ mol L}^{-1}$$

at $\bar{E}P$ $[\text{OH}^-] = \sqrt{K_b \times [\text{OCl}^-]}$

$$K_b = \frac{1 \times 10^{-14}}{2.95 \times 10^{-8}} = 3.39 \times 10^{-7}$$

$$[\text{OH}^-] = \sqrt{(3.39 \times 10^{-7}) \times 0.0573}$$

$$= 1.39 \times 10^{-4} \text{ mol L}^{-1}$$

$$p\text{OH} = 3.86$$

$$pH \text{ at } \bar{E}P = 10.1$$

pH halfway to $\bar{E}P = 7.53$ because at midpoint of buffer

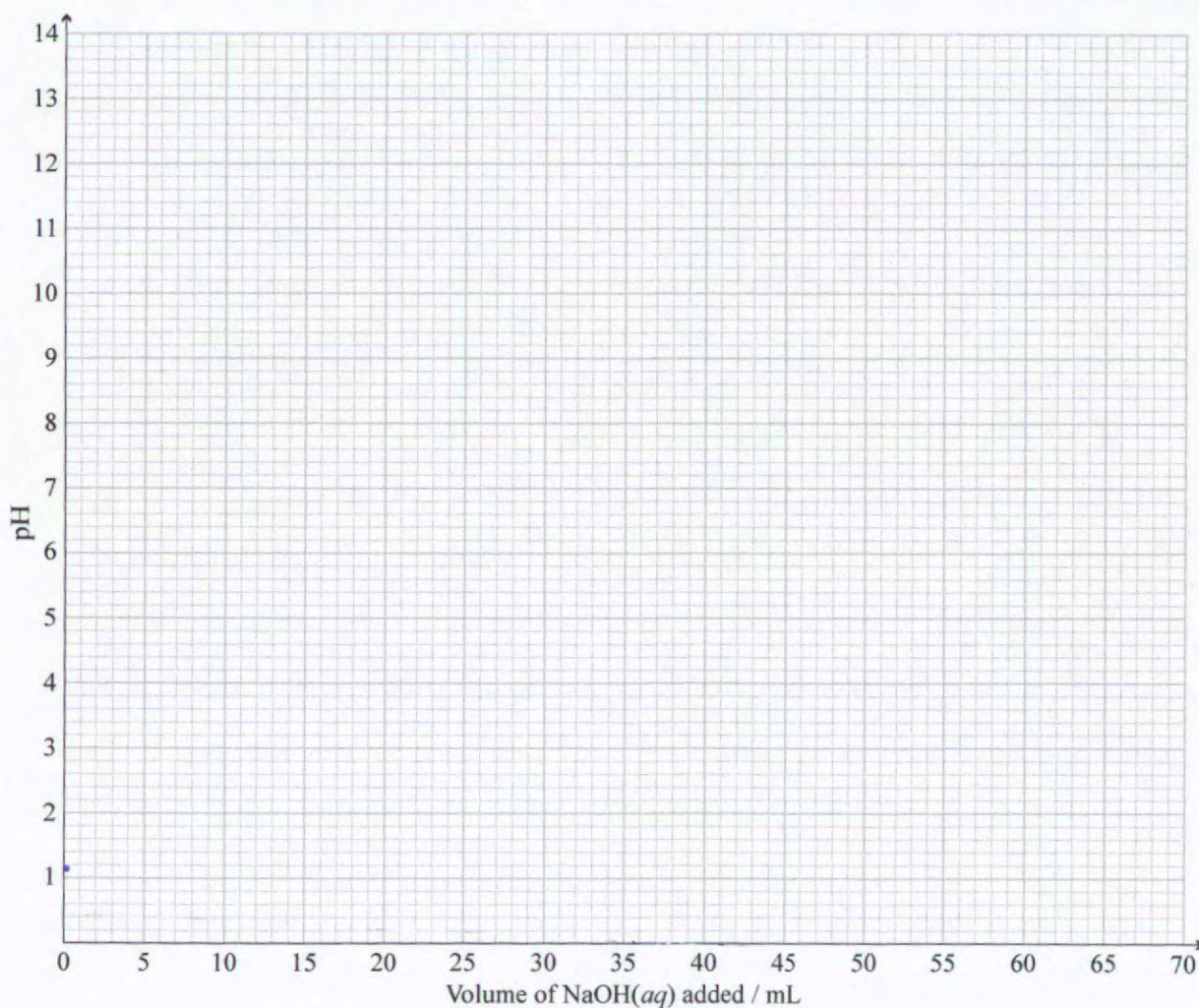
$$pH = pK_a$$

pH after 10 mL excess base

$$C(\text{NaOH}) = (8.86 \times 10^{-4}) \div 0.0949$$

$$= 9.34 \times 10^{-3} \text{ mol L}^{-1}$$

$$p\text{OH} = 2.03 \quad \boxed{pH = 12.0}$$



Question Four continues
on the following page.

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

93102

Scholarship

Subject: Chemistry

Standard: 93102

Total score: 20

Q	Score	Marker commentary
1	04	a) Calculates two Q values and correctly compares these with K_s to predict observations. b) No response. c) Drew three Lewis diagrams and correctly named two shapes.
2	04	a) Correctly identifies boiling points of molecules but limited discussion of intermolecular forces. b) No response. c) Calculates the number of moles of NH_3 and describes the changes in the entropy of the system and surroundings.
3	05	a) Draws structures for F and G and develops a scheme for the process to change F to W. b) No response. c) Writes half equations and fully balances equations for both reactions and uses oxidation numbers to identify the oxidant and reductant.
4	07	a) Defines first ionisation energy and explains why the ionisation energy of O is lower than that of N. Identifies that the number of protons determines the relative size of the particle for 2 of 3 particles. b) Calculated all the E_{cell} values (both positive and negative) to determine the end point of a series of redox reaction. Included the colour and oxidation number of the final vanadium ion for each reaction. c) Calculates the volume at the equivalence point for both titration curves and values of pH required but does not complete the drawing of the curves.