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SCHOLARSHIP EXEMPLAR



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MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
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Scholarship 2021 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 2–20 in the correct order and that none of these pages is blank.

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

Question	Score
ONE	
TWO	
THREE	
FOUR	
TOTAL	

ASSESSOR'S USE ONLY

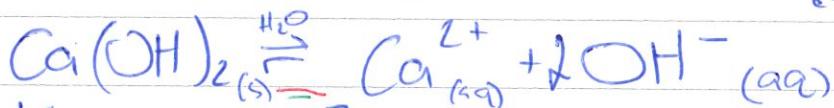
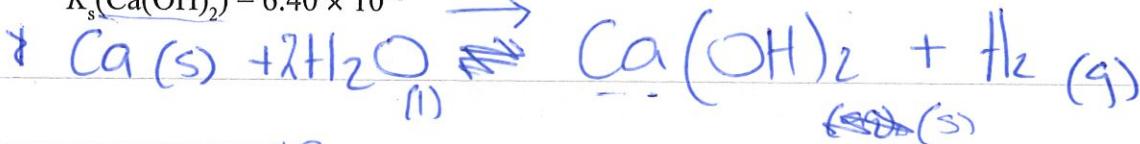
~~When conc
pacu~~

QUESTION ONE

- (a) A small 0.185 g piece of calcium metal, $\text{Ca}(s)$, was dropped into a large beaker containing 750.0 mL of distilled water at 25 °C. It spontaneously reacted, producing a colourless gas and a clear, colourless solution. When a further two pieces of calcium metal, with a combined mass of 0.396 g, were then added to the same beaker, they also spontaneously reacted to produce a colourless gas, but a cloudy white solid was observed forming in the solution as the metal pieces reacted. Addition of a small volume of dilute hydrochloric acid solution, $\text{HCl}(aq)$, caused the solution to become clear.

Justify these observations with use of calculations, balanced chemical equations, and equilibrium principles.

$$K_s(\text{Ca}(\text{OH})_2) = 6.40 \times 10^{-6}$$



$$K_s = [\text{Ca}^{2+}][\text{OH}^-]^2$$

$$n(\text{Ca}(s)) = n(\text{Ca}_{\text{aq}})$$

$$\text{Initial } n(\text{Ca}^{2+}) = \frac{0.185}{40.1} = 4.6135 \times 10^{-3} \text{ mol}$$

Initially 4.614×10^{-3} mol of $\text{Ca}(s)$ reacts

with the H_2O in the beaker which releases the colourless gas H_2 and $\text{Ca}(\text{OH})_2$, however this is initially dissolved into the solution as Ca^{2+} and 2OH^- ions

$$K_s = 6.4 \times 10^{-6}$$

$$Q_s = [4.6135 \times 10^{-3} / 0.75] \times [2 \times 4.6135 \times 10^{-3} / 0.75]^2 \\ = 9.31 \times 10^{-7}$$

As $Q_s < K_s$ the solution exists as aqueous ions dissolved in the solution as it is not yet saturated.

2) When 2 further added

$$C(\text{Ca}^{2+}) = \frac{0.396}{0.75} \times \frac{1}{40.1} = 0.01932 \text{ mol L}^{-1}$$

$$C(\text{OH}^-) = 2 C(\text{Ca}^{2+}) = 0.0386 \text{ mol L}^{-1}$$

PPT = PRECIPITATE

3

$$\text{BQ} \quad I_p = (0.01932)(0.0386)^2 \\ = 2.88408 \times 10^{-5} \\ = 2.88 \times 10^{-5}$$

As $I_p > K_s$ which is 4.4×10^{-6} after the additional Ca^{2+} is added the concentration of the Ca^{2+} and OH^- ions increased so to get back to K_s and oppose this change the backward reaction occurred producing the solid $\text{Ca}(\text{OH})_2$ or white PPT which is observed forming in the solution. The addition of HCl causes the solution to become clear ~~as~~ however as it reacted with the OH^- ions in the solution.

$\text{OH}^- + \text{HCl} \rightarrow \text{Cl}^- + \text{H}_2\text{O}$ neutralizes & removes them from the solution this resulted in a decrease of OH^- product in the reaction hence the equilibrium shifted in the forward direction to oppose this change and produce more OH^- ions resulting in the white solid $\text{Ca}(\text{OH})_2$ ppt to redissolve into the solution to get back to K_s hence the solution goes clear again. //

- (b) A pale-blue, weakly acidic copper(II) chloride solution, $\text{CuCl}_2(aq)$, was prepared by sitting a piece of copper metal, $\text{Cu}(s)$, in a beaker containing chlorine water, $\text{Cl}_2(aq)$. When pieces of aluminium foil, $\text{Al}(s)$, were added to a sample of the solution, the pieces of foil slowly disappeared as a colourless gas and brown solid were produced. When potassium permanganate, $\text{KMnO}_4(s)$, was added to a separate sample of the solution, a brown solid and pale-green gas were produced.

Using the standard electrode potentials provided in the table below, justify the reactions described above with use of balanced chemical equations and cell potential calculations.

	E° / V
$2\text{H}^+(aq) + 2\text{e}^- \rightarrow \text{H}_2(g)$	0.00
$\text{Cl}_2(g) + 2\text{e}^- \rightarrow 2\text{Cl}^-(aq)$	+1.36
$\text{Al}^{3+}(aq) + 3\text{e}^- \rightarrow \text{Al}(s)$ (oxidation)	+1.68
$\text{O}_2(g) + 4\text{H}^+(aq) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(l)$	+1.23
$\text{MnO}_4^-(aq) + 4\text{H}^+(aq) + 3\text{e}^- \rightarrow \text{MnO}_2(s) + 2\text{H}_2\text{O}(l)$	+1.69
$\text{Cu}^{2+}(aq) + 2\text{e}^- \rightarrow \text{Cu}(s)$	+0.34

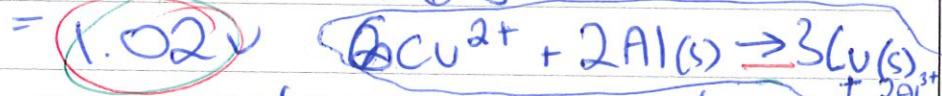


$$E^\circ_{\text{cell}} = 1.36 - (-0.34) \\ = 1.7 \text{ V}$$

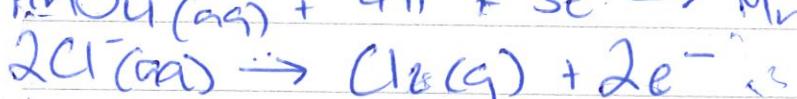
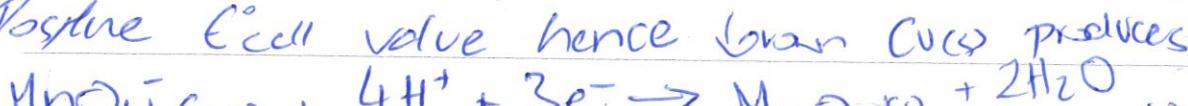
This reaction occurs as Cl_2 oxidises the $\text{Cu}(s)$ and receives 2e^- from the $\text{Cu}(s)$ which reduces the Cl_2 this reaction is spontaneous as it has a positive E°_{cell} value hence the solution of $\text{CuCl}_2(aq)$ was prepared.



$$E^\circ_{\text{cell}} = 0.34 - (-1.68)$$



This reaction is spontaneous as it has a positive E°_{cell} value hence brown $\text{Cu}(s)$ produces



Please see back of page 80m

- (c) A buffer solution with pH = 10.00 was required for an experiment. The following procedure was used to prepare this solution.

A technician began by dissolving 0.1918 g of methylammonium chloride, $\text{CH}_3\text{NH}_3\text{Cl}(s)$, into 50.0 mL of 0.0250 mol L⁻¹ methylamine solution, $\text{CH}_3\text{NH}_2(aq)$. However, when the pH of the solution was measured, it was found to be too high. To lower the pH, 10.0 mL of 0.0415 mol L⁻¹ hydrochloric acid solution, $\text{HCl}(aq)$, was added.

Calculate the pH of the initial and final buffer solutions, and decide whether the technician added a sufficient amount of hydrochloric acid to achieve the intended pH.

$$\text{CH}_3\text{NH}_3\text{Cl} \quad M(\text{CH}_3\text{NH}_3\text{Cl}) = 67.5 \text{ g mol}^{-1} \quad pK_a(\text{CH}_3\text{NH}_3^+) = 10.64$$

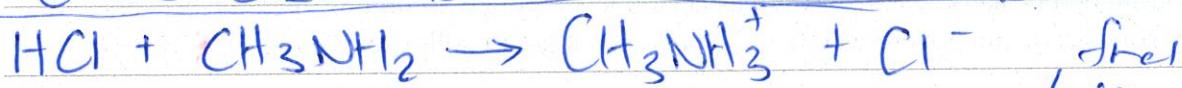
$$\frac{n}{M} = \frac{m}{M} = 2.84 \times 10^{-3} \text{ mol}$$

$$C = \frac{n}{V} = 0.0568 \text{ mol L}^{-1} = C(\text{CH}_3\text{NH}_3^+)$$

CH_3NH_2

$$n = CV = 1.25 \times 10^{-3} \text{ mol} \quad \text{initial buffer}$$

$$C = 0.025 \text{ mol L}^{-1}$$



$$n(\text{HCl}) = 10 \times 10^{-3} \times 0.0415 \\ = 4.15 \times 10^{-4}$$

$$n(\text{CH}_3\text{NH}_3^+) = \cancel{0.0568} + 4.15 \times 10^{-4} \\ = \cancel{0.05635} \quad 3.255 \times 10^{-3} \text{ mol}$$

$$n(\text{CH}_3\text{NH}_2) = \cancel{0.025} - 4.15 \times 10^{-4} \\ = 8.35 \times 10^{-4} \text{ mol}$$

$$\text{pH} = pK_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

$$\text{initial buffer solution} : \text{pH} = 10.64 + \log \frac{(0.025)}{(0.0568)} \\ = 10.28 \quad (\text{2dp})$$

final buffer solution :

$$[\text{base}] = 8.35 \times 10^{-4} / 0.06 = 0.0139 \text{ mol L}^{-1}$$

$$[\text{acid}] = 3.255 \times 10^{-3} / 0.06 = 0.05425 \text{ mol L}^{-1}$$

$$\text{pH} = pK_a + \log \frac{(0.0139)}{(0.05425)} \\ = 10.05 \quad (\text{3sf})$$

The technician needed to add slightly more HCl to decrease the pH further.

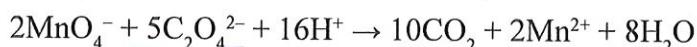


QUESTION TWO

- (a) A solution was prepared for a competition by mixing varying amounts of three compounds; ethanoic acid, $\text{CH}_3\text{COOH}(l)$, sodium chloride, $\text{NaCl}(s)$, and oxalic acid, $\text{H}_2\text{C}_2\text{O}_4(s)$, in a volume of water, $\text{H}_2\text{O}(l)$. There was no solid remaining in the final solution. Groups of students were each given 100.0 mL of the solution and were tasked with determining the mass of each of the three compounds in the sample provided.

One group of students carried out the following procedures in the laboratory.

First, the students diluted the solution by pipetting 20.00 mL into a 200.0 mL volumetric flask, and filling it to the mark with distilled water. The students then titrated 20.00 mL samples of the diluted solution with a standardised potassium permanganate solution, $\text{KMnO}_4(aq)$. The potassium permanganate solution had a concentration of 0.02960 mol L⁻¹ and required an average titre of 18.93 mL to reach the end point.



Next, the students titrated further 20.00 mL samples of the diluted solution with a standardised sodium hydroxide solution, $\text{NaOH}(aq)$, using phenolphthalein as the indicator. The sodium hydroxide solution had a concentration of 0.4790 mol L⁻¹ and required an average titre of 13.32 mL to reach the end point.

Finally, each student in the group pipetted 10.00 mL of the original undiluted solution into pre-weighed beakers. Each beaker was heated to evaporate all liquids, then the beakers and any solids remaining were weighed. The average mass of solids remaining was 2.130 g.

From these measurements, determine the final answers that the group should have submitted in the competition.

$$M(\text{NaCl}) = 58.50 \text{ g mol}^{-1} \quad M(\text{H}_2\text{C}_2\text{O}_4) = 90.00 \text{ g mol}^{-1} \quad M(\text{CH}_3\text{COOH}) = 60.00 \text{ g mol}^{-1}$$

$$n(\text{MnO}_4^-) = 0.0296 \times 18.93 \times 10^{-3} \\ = 5.60328 \times 10^{-4}$$

$$n(\text{C}_2\text{O}_4^{2-}) = 5 \times n(\text{MnO}_4^-) = 1.4008 \times 10^{-3} \text{ mol} \\ C(\text{C}_2\text{O}_4^{2-})_{\text{in titrant}} = 2 \times 1.4008 \times 10^{-3} / 20 \times 10^{-3} \text{ in } 20 \text{ mL} \\ C_2\text{O}_4^{2-} = 0.070041 \text{ mol L}^{-1}$$

$$n(\text{undiluted}) = 0.014 \text{ mol in } 20 \text{ mL sample}$$

$$C = 0.70041 \text{ mol L}^{-1}$$

$$n = CV = 0.070041$$

$$m \cancel{s} = 6.30 \text{ g (3sf) of } \text{H}_2\text{C}_2\text{O}_4$$

$$n(\text{NaOH})_{\text{calculated}} = 6.38 \times 10^{-3} \text{ mol}$$

$$n(\text{CH}_3\text{COOH}) = n(\text{NaOH}) = 6.38 \times 10^{-3} \text{ mol}$$

$$C = 0.319 \text{ mol L}^{-1} \text{ in } 20 \text{ mL sample}$$

$$n(\text{diluted}) = 0.319 \times 0.2 = 0.0638 \text{ mol}$$



$$C \text{ (20mL sample)} = 3.19014 \text{ mol L}^{-1}$$

$$n \text{ (total)} = CV = 0.319014$$

$$M = Mn = 19.1 \text{ g (3sf) of CH}_3\text{COOH}$$

$$m_{\text{total}} = 2.130 \times 10 \\ = 21.3 \text{ g}$$

$$m(\text{NaCl}) = \cancel{21.3} - \cancel{19.1} = \cancel{-0.2638} \\ = 2.14 \text{ g (3sf)} \\ = 21.3 - 19.3 \\ = 1.5 \text{ g } \cancel{\text{g}} \text{ (3sf) of NaCl}$$

this in
liquid
form so
would evaporate
off

- (b) The enthalpy of solution, $\Delta_{\text{sol}}H$, is the enthalpy change that occurs when one mol of a solid dissolves to produce a solution. The $\Delta_{\text{sol}}H$ for calcium carbonate, $\text{CaCO}_3(s)$, in water is negative, while the $\Delta_{\text{sol}}H$ for sodium chloride, $\text{NaCl}(s)$, in water is positive.

Discuss the thermodynamic factors that affect the relative solubilities of CaCO_3 and NaCl , with consideration of enthalpy and entropy changes occurring within the solute, solvent and solution.

$$K_s = [\text{Ca}^{2+}][\text{CO}_3]_s^3 \quad K_s = [\text{Na}^{+}][\text{Cl}^{-}]$$

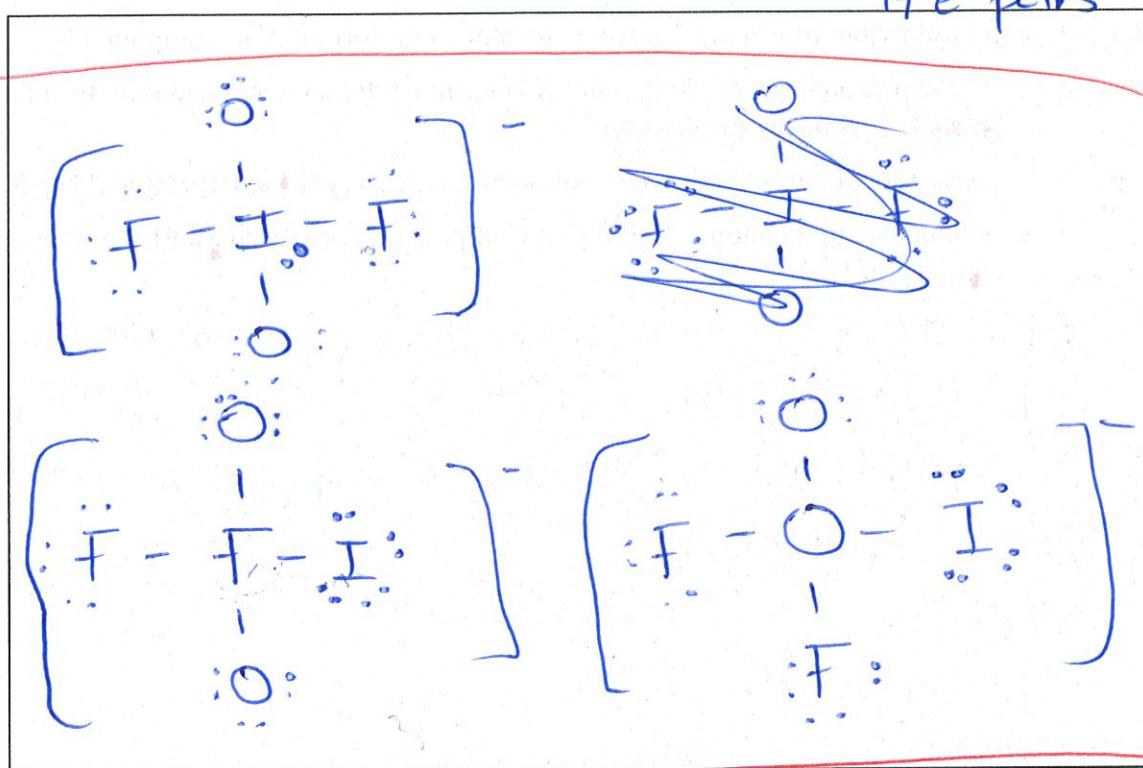
Much less soluble *disolves lots*

CaCO_3 has a much smaller solubility constant than NaCl suggesting it is much less soluble than NaCl . NaCl however has a positive enthalpy of solution suggesting that energy is required to dissolve NaCl . This in turn causes the entropy of surroundings to decrease as heat is taken from the surroundings and into the system causing the surroundings to decrease in temperature and hence become less disordered resulting in a decreasing entropy. Whereas CaCO_3 has a negative $\Delta_{\text{sol}}H$ suggesting that energy is released from the system when CaCO_3 dissolves this causes the surroundings to gain heat energy and increase in temp. resulting in the surroundings particles becoming more disordered and hence increasing in entropy. For a reaction to be thermodynamically favoured (or spontaneous) it must have a positive overall entropy. Total entropy is entropy of system + entropy of surroundings. Both ~~the~~ dissolution of NaCl and

$$+ \frac{1}{2} = 54$$

34 electrons
17 e⁻ pairs

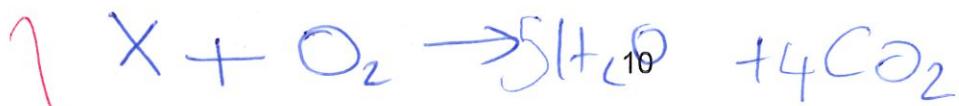
- (c) (i) Draw all potential 3-dimensional structures for the IF_2O_2^- ion.



- (ii) In VSEPR theory, it is observed that a bond from the central atom to an atom of lower electronegativity occupies more space than the bond from the central atom to an atom of higher electronegativity. Double bonds have greater electron density and, thus, greater repulsion than single bonds.

Justify the most probable positional arrangement of atoms in the IF_2O_2^- ion.

The most probable arrangement of atoms in the IF_2O_2^- ion has I as the central atom with an expand octet with ~~12~~ 5 areas of e⁻ density that arrange themselves with maximum separation to minimise repulsion creating the F geometry of a sawtooth pyramide however as only e⁻ density is a lone pair the overall shape would be seen with bond angles of 180° and 120° This is most likely the arrangement of IF_2O_2^- as F and O have greater electronegativity than I so less space is taken up //



QUESTION THREE

(a) (i) Use the following information to solve the molecular formula for Compound X.

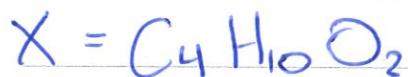
- Elemental analysis of Compound X determined that it contained only the elements carbon, hydrogen, and oxygen.
- Mass spectrometry produced a molecular ion (M^+) peak at 90 m/z for Compound X.
- Complete combustion of 4.388 g of Compound X produced 8.591 g of CO_2 and 4.410 g of H_2O .

" M^+ peak at 90m/z for compound X it must have a molar mass of 90g/mol"

$$n(CO_2) = \frac{m}{M} = 0.195 \text{ mol}$$

$$n(H_2O) = 0.245$$

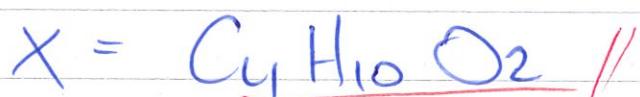
$$\frac{n(H_2O)}{n(CO_2)} = 1.25 = \frac{5}{4}$$



$$(12 \times 4) + (10) + (2 \times 16) = 90 \text{ g/mol}$$



Molecular formula of X

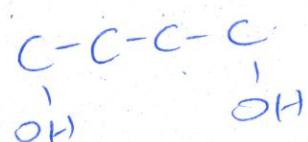
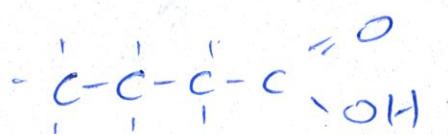
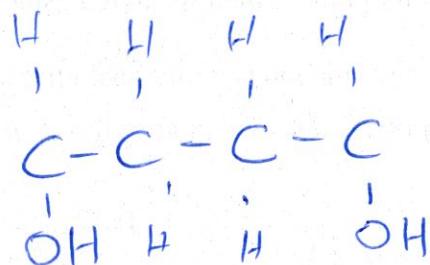


- (ii) Compound X was produced following reaction of Compound W with $\text{H}^+/\text{MnO}_4^-$.

Draw all possible structures for Compounds X and W.

You do not need to name any of the structures.

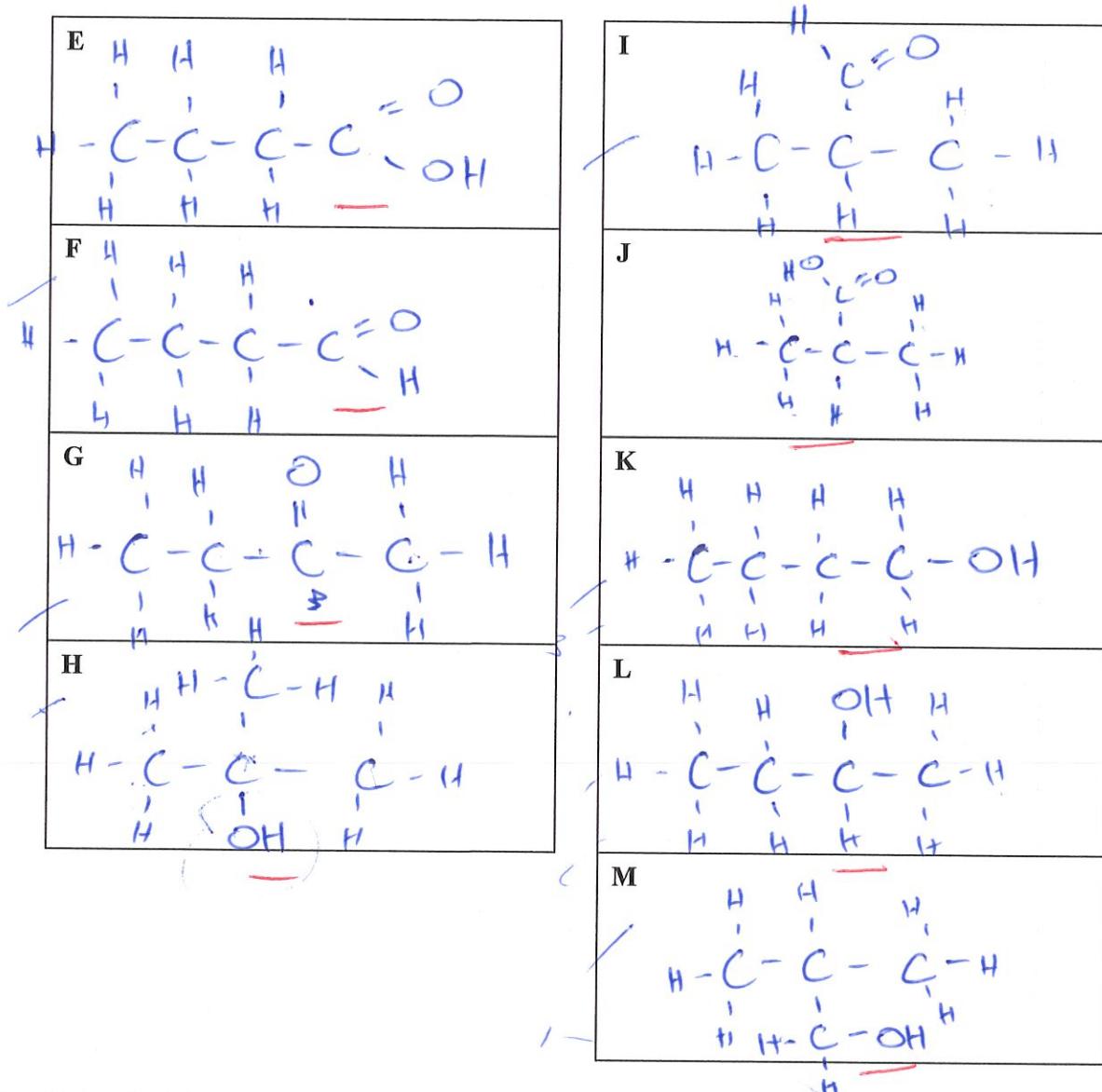
~~Oxidising agent +
carboxylic acids
& ketones~~



- (b) Compounds E–H are a group of alcohols that naturally occur in a mixture together. They are isomers with the molecular formula $C_4H_{10}O$. Addition of acidified potassium dichromate solution, $H^+/K_2Cr_2O_7(aq)$, to a sample of the mixture, followed by gentle heating, resulted in the formation of a variety of new organic compounds. In the conditions used, not all the compounds fully reacted, and the final mixture contained nine different organic compounds (E–M) with various functional groups. The mixture was then separated using distillation.

- (i) Determine a structure for each of the nine compounds in the final mixture.

The order in which you assign the compounds does not matter. You do not need to name them.



- (ii) Using the labels given to your compounds above, discuss the chemistry involved in the separation of Compounds E–M.

You should explain the predicted order in which they would separate during distillation.

During distillation F and G would evaporate first followed by I as they cannot form hydrogen bonds with other molecules. Next K and L

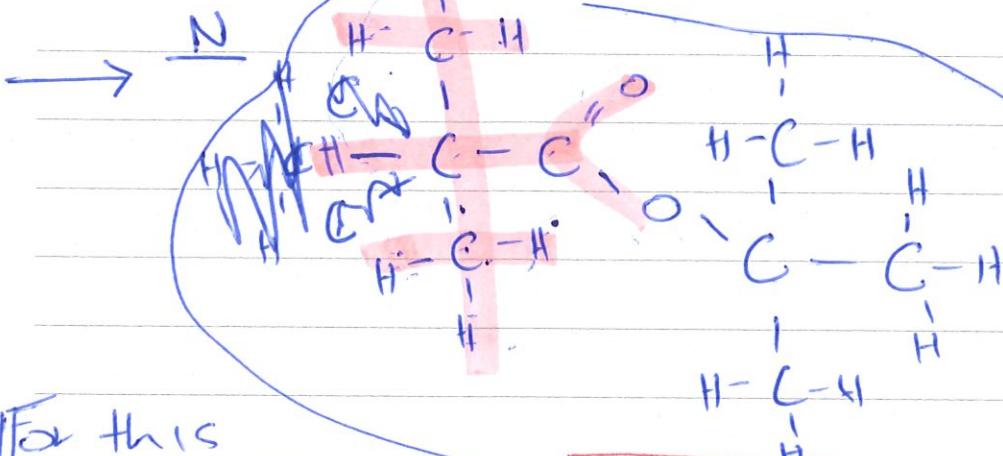
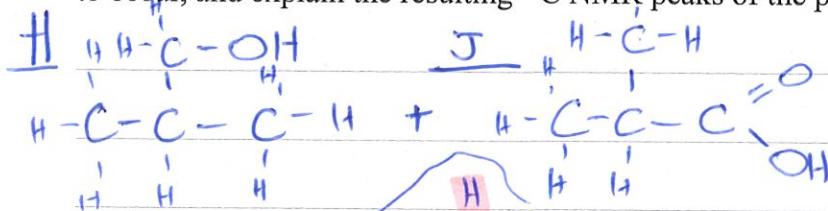
would evaporate as they can form 1 hydrogen bond due to the extremely polar OH group due to large difference in electronegativity between the O & H atoms bonds with H of other $C_4H_{10}O$ molecules. H & M would evaporate next. It evaporates after K & L due to its more globular shape allowing more electrostatic interactions the size of temporary dipoles between the molecules. F & J would be the last to evaporate due to their ability to both ^{W_H C=O} O-H bond and ^{O-H} O-C=O bond means they can form stronger attractions between the molecules so the most heat energy is required to overcome these attractions between the molecules and evaporate the compound. //

- (iii) Compound N can be synthesised using two of compounds E–M from part (i).

When analysed using ^{13}C NMR, only five peaks are detected in the spectra for this compound.

H & J

Determine the structure of Compound N, give the conditions required for the synthesis to occur, and explain the resulting ^{13}C NMR peaks of the product.



For this synthesis to occur concentrated H_2SO_4 is required to remove the small H_2O molecule between molecule H & J and form the ester link producing N as this is a condensation reaction. This shows only 5 peaks in ^{13}C NMR suggesting it has only 5 carbon environments despite having 8 carbons. This is because of the sidechains having the same environment as the other sidechains producing only 5 unique environments. These would be an aliphatic peak at around 20 ppm for the CH_3 environments a peak of around 70 ppm for the $\text{RCO}_2\text{C}_2\text{H}_5$ carbon of the alcohol group that is connected to carboxylic acid (PTO_2) → SLOM

QUESTION FOUR

- (a) Solid sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, can react with both dilute hydrochloric acid, $\text{HCl}(aq)$, and concentrated nitric acid, $\text{HNO}_3(\text{conc})$.

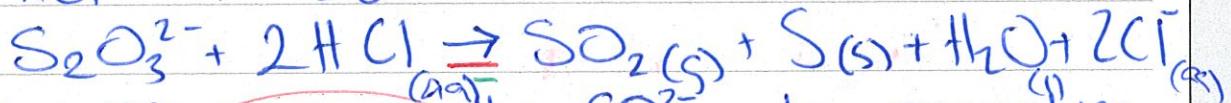
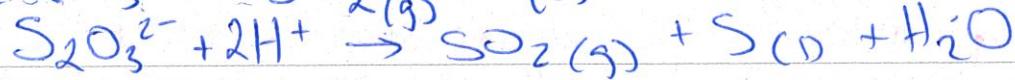
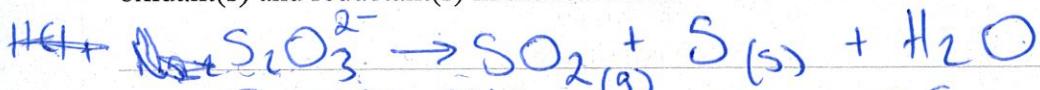
When it is reacted with dilute hydrochloric acid, $\text{HCl}(aq)$, colourless sulfur dioxide gas, $\text{SO}_2(g)$, is released from the mixture, and a yellow solid is slowly formed in the solution.

When it is reacted with concentrated nitric acid, $\text{HNO}_3(\text{conc})$, brown nitrogen dioxide gas, NO_2 , $\text{NO}_2(g)$, is released from the mixture and the same yellow solid is again observed in the solution. This second solution additionally tests positive for the presence of sulfate ions, $\text{SO}_4^{2-}(aq)$.



Account for the oxidation and reduction processes occurring in the reactions with $\text{HCl}(aq)$ and $\text{HNO}_3(\text{conc})$.

You should write balanced equations, and use changes in oxidation numbers to justify the oxidant(s) and reductant(s) in the reactions.



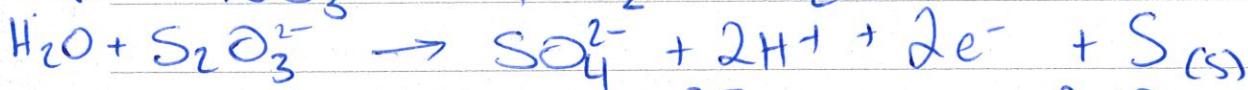
The HCl reduces the $\text{S}_2\text{O}_3^{2-}$ to produce

SO_2 and solid Sulfur yellow solid

The oxidation number of S in $\text{S}_2\text{O}_3^{2-}$

is -1 which increases to 0 in

SO_2 and S.



The NO_3^- from the HNO_3 is reduced

by the $\text{S}_2\text{O}_3^{2-}$ as it gains an electron

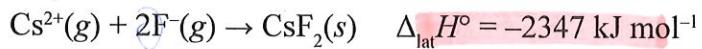
to form NO_2 the oxidation number

increases from -1 to 0 and the

$\text{S}_2\text{O}_3^{2-}$ is oxidised to produces SO_4^{2-}

as it loses e^- to form SO_4^{2-} //

- (b) Hess's law calculations use the known enthalpy changes of various reactions to calculate the enthalpy change for an overall reaction for which the enthalpy changes cannot be measured. For example, Hess's law can be used to determine lattice formation enthalpies. These are a measure of the enthalpy change when one mole of an ionic solid is formed from its ions in the gaseous state. Caesium(II) fluoride, $\text{CsF}_2(s)$, is an example of an ionic salt that does not exist, but the theoretical lattice formation enthalpy can be calculated using Hess's law and depicted as:



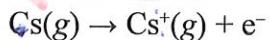
Unstabilized

- (i) Using the thermochemical information provided, calculate the theoretical enthalpy of formation, Δ_fH° , for $\text{CsF}_2(s)$, and then justify why CsF_2 does not exist, but CsF does.

Consider the position of these elements in the periodic table in your answer.



$$\Delta_fH^\circ = +76.0 \text{ kJ mol}^{-1}$$



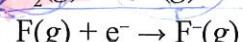
$$\Delta_fH^\circ = +382 \text{ kJ mol}^{-1}$$



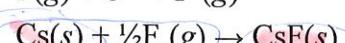
$$\Delta_fH^\circ = +2430 \text{ kJ mol}^{-1}$$



$$\Delta_fH^\circ = +158 \text{ kJ mol}^{-1}$$



$$\Delta_fH^\circ = -334 \text{ kJ mol}^{-1}$$



$$\Delta_fH^\circ = -554 \text{ kJ mol}^{-1}$$



- (ii) Justify the differences in the lattice formation enthalpies for CsF and CsF₂.

$$\Delta_{\text{lat}}H^\circ(\text{CsF}(s)) = -757 \text{ kJ mol}^{-1}$$

CsF(s) has a much smaller lattice enthalpy as Cs has one valence electron while F has 7 so in CsF they //

Question Four continues
on the next page.

- (c) Compounds A–D are constitutional isomers with a molar mass less than 100 g mol⁻¹.

¹³C NMR and IR spectra for Compounds A–D are provided in the resource booklet.

Use the spectral data provided to determine the molecular formula for the isomers A–D, then determine, name, and justify ONE possible structure for each compound.

Compound A and C both show a large peak on the IR spectra at around 3400 cm^{-1} . So this suggests these molecules have an OH group. All four molecules have a peak at around $2950-2800\text{ cm}^{-1}$ so all have C-H stretch. Compound A has 4 peaks on its ¹³C NMR spectra suggesting it has 4 carbon environments and hence a minimum of 4 carbons in the chain. Compounds D & B each show 3 peaks so while C has 2 as they are all isomers of each other this suggests that C, D & B have symmetrical elements as they have less carbon environments. They may do carbons. Molecule A, B & D all have peaks on IR at around 1700 cm^{-1} suggesting they have a C=O group while C doesn't however all A, B, C & D have a peak at around 1100 cm^{-1} suggesting a C-O-C group. A has a peak at around 210 ppm on the CNMR which suggests a C=O Ketone group giving A //

QUESTION
NUMBER

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

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$$\begin{aligned}\mathcal{E}_{\text{cell}} &= 1.69 - 1.36 \\ &= 0.33 \text{ V}\end{aligned}$$

This reaction occurs as it has a positive $\mathcal{E}_{\text{cell}}$ value meaning it is spontaneous // seen

2b

CaCO_3 will have an increase in the entropy of the system as in $\text{NaCl}_{(\text{s})} \rightleftharpoons \text{Na}^+ + \text{Cl}^{-}_{(\text{gas})}$ the NaCl in its solid lattice form produces free Na^+ and Cl^- ions which can arrange themselves in a more random manner resulting in an increase in disorder and hence an increase in entropy of the system. Similarly CaCO_3 dissolves to form Ca^{2+} ions

$\text{CaCO}_3 \xrightarrow{\text{sol}} \text{Ca}^{2+} + \text{CO}_3^{2-}$ causing an increase in disorder and random arrangement from the lattice structure of CaCO_3 to the free moving ion producing ~~as both~~ ~~CaCO_3 and NaCl go for~~ an increase in entropy of the system. This increase in entropy of system for NaCl must be greater than its decrease // seen

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

In entropy of surroundings is the reaction is thermodynamically favoured. //

3biii) another peak would be seen at around 170 for the $\text{C}=\text{O}$ that is in compound in reality it is an ester //

4c) a potential structure of $\text{H}_4\text{C}-\text{C}-\text{C}-\text{C}-\text{H}$

A) $\text{HO}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{C}-\text{H}$
The peak at 160 ppm on the CNMR spectra for B suggests it has an ester group gives B

a potential structure of $\text{H}_4\text{C}-\overset{\text{O}}{\underset{\text{H}}{\text{C}}}-\text{C}-\text{C}-\text{H}$
which has the same molecular formula B)

$\text{C}_4\text{H}_8\text{O}_2$ as A

C has a peak at 130 ppm on the CNMR which suggests it has a $\text{C}=\text{C}$ giving it the potential structure

C) $\text{HO}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}=\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{OH}$ ~~$\text{HO}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}=\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{OH}$~~

While D has a peak at 180 on the CNMR which suggests it also has an ester linkage however it has //