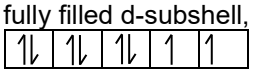
2025 Y6 H2 Chemistry Term 3 Timed Practice – Suggested Solutions

Section A

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	A	C	C	B	C	A	A	B	C	D	B	D	C	D	A

MCQ worked solutions

1 Ans: A

A	Correct. $^{63}Cu^{+}$: [Ar]$3d^{10}$. With a fully filled d-subshell, it has no unpaired electrons. $^{65}Cu^{3+}$: [Ar]$3d^{8}$ i.e.  has 2 unpaired electrons.
B	Incorrect. ^{63}Cu has 29 electrons and has the electronic configuration [Ar]$3d^{10}4s^{1}$. Hence, $^{63}Cu^{+}$ has the electronic configuration [Ar]$3d^{10}$.
C	Incorrect. No. of neutrons in $^{63}Cu^{+}$ = 63 – 29 = 34 No. of neutrtons in $^{65}Cu^{3+}$ = 65 – 29 = 36
D	Incorrect. The number of protons determine the identity of the element. Since both $^{65}Cu^{2+}$ and $^{65}Cu^{+}$ are ions of copper, they both have 29 protons.

2 Ans: C

Volume strength of 10
$\Rightarrow$ 10 dm^3 of O_2 evolved from 1 dm^3 of H_2O_2(aq)
$\Rightarrow \frac{10}{22.7}$ = 0.4405 mol of O_2 evolved from 1 dm^3 of H_2O_2(aq)
Since $2H_2O_2 \rightarrow 2H_2O + O_2$,
amt of H_2O_2 in 1 dm^3 of H_2O_2 solution
= 2(0.4405) = 0.8810 mol

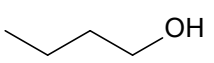
10 cm^3 of H_2O_2 contains $\frac{10}{1000}(0.8810) = 8.810 \times 10^{-3}$ mol of H_2O_2

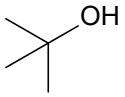
Amt of MnO_4^- reacted = $\frac{2}{5}(8.810 \times 10^{-3})$

= 3.524 x 10^{-3} mol

Volume of MnO_4^- = $\frac{3.524 \times 10^{-3}}{0.0200} = 0.176$ dm^3

3 **Ans: C**



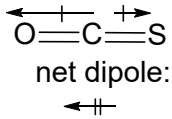
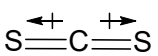
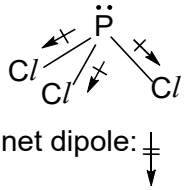
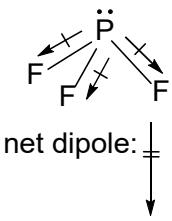
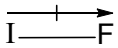
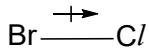
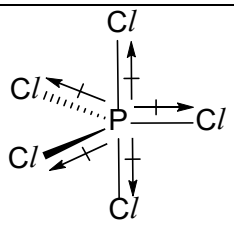


butan-1-ol ($C_4H_{10}O$) 2-methylpropan-2-ol ($C_4H_{10}O$)

Butan-1-ol is a straight-chain isomer of $C_4H_{10}O$ and has a greater surface area for instantaneous dipole–induced dipole (id-id) interactions to occur compared to 2-methylpropan-2-ol which is a branched-chain isomer of $C_4H_{10}O$.
Thus, id-id interactions are stronger in butan-1-ol than in 2-methylpropan-2-ol. (**Option 1 is correct**)

The strength of the hydrogen bonds in both molecules are the same as the hydrogen atom involved in hydrogen bonding is bonded to the same element, oxygen. The extent of hydrogen bonding is also the same as they have same number of lone pairs and number of H atoms attached to O. (**Options 2 and 3 are incorrect**)

4 **Ans: B**

	G	**H**	Remarks
A	 net dipole:	 no net dipole	**G** has a greater net dipole than **H**.
B	 net dipole:	 net dipole:	P−F bond is more polar than P−C*l* bond. **G** has a <u>smaller</u> net dipole than **H**.
C			I−F bond is more polar than Br−C*l* bond. **G** has a greater net dipole than **H**.
D	 no net dipole	 no net dipole	Both **G** and **H** do not have a net dipole.

5 Ans: C

In the second reaction, the same number of moles of reactants were used, therefore the same amount of heat, q, will be evolved.

However the total volume of solution was halved, therefore there is half the mass of solution to heat up, and the temperature increase will hence be doubled according to the equation q = mcΔT

6 Ans: A

For the process $C_6H_{12}(s) \rightarrow C_6H_{12}(l)$,

- ΔH is positive because energy is required to overcome the id-id interactions between molecules of C_6H_{12} to melt the compound.
- ΔS is positive as there is a greater disorder in the liquid state than the solid state i.e. there is an increase in disorder during melting.

7 Ans: A

By considering the slow step, the rate equation for step 2 is rate = $k_2[O\bullet][O_3]$
but O• is an intermediate, thus [O•] cannot be in the overall rate equation.

Using the equilibrium constant of step 1,

$$K_1 = \frac{[O\bullet][O_2]}{O_3}$$

$$[O\bullet] = \frac{K_1[O_3]}{[O_2]}$$

Substituting this into the rate equation from step 2,

$$\text{rate} = k_2 \frac{K_1[O_3]}{[O_2]}[O_3]$$

$$\text{rate} = k_2 K_1 \frac{[O_3]^2}{[O_2]}$$

Thus, statements 1 and 2 are correct.
Statement 3 is correct because $[O_2]$ is the denominator, thus when $[O_2]$ increases, rate decreases.

8 Ans: B

All the 4 C in the ring are sp^2 hybridised. The C in the –C≡N group is sp hybridised. Each C=C contains one π bond and the –C≡N group contains 2 π bonds.

9 Ans: C

A	The conjugate base may be a weak base. Example: CH_3COOH ($K_a = 10^{-4.75}$, a weak acid) and its conjugate base CH_3COO^- ($K_b = 10^{-9.25}$, a weak base).
B	A buffer solution contains a weak acid (or weak base) and its conjugate base (or conjugate acid). Addition of a limited amount of strong base to a weak acid will produce a buffer containing the (excess) weak acid and the conjugate base. However, if the strong base is added in excess, the weak acid will be completely reacted and the solution will not be a buffer.
C	$HA \rightleftharpoons H^+ + A^-$ $K_a = [H^+][A^-] / [HA]$ As water is added, the concentrations of HA, H^+ and A^- decrease and the reaction quotient decreases. The system will try to increase the reaction quotient by favouring the dissociation reaction until the new equilibrium is established (i.e. when reaction quotient is equal to K_a). Hence, the extent of dissociation increases with increasing dilution.
D	The dissociation of a weak acid in water is usually endothermic. As temperature increases, the system will try to counteract the increase in temperature by favouring the forward endothermic reaction in order to absorb heat. Hence, the extent of dissociation increases and K_a increases with increasing temperature.

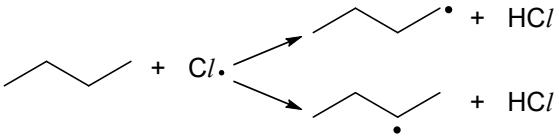
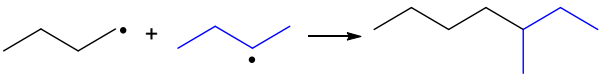
10 Ans: D

A	**Incorrect**. There are 0.015 mol of CH_3COO^- and 0.030 mol of H^+ from HC*l* i.e. H^+ is in excess. Since $CH_3COO^- + H^+ \rightarrow CH_3COOH$, the resultant mixture contains 0.015 mol of H^+ and 0.015 mol of CH_3COOH. This is not a buffer solution.
B	There are 0.020 mol of CH_3COO^- and 0.010 mol of H^+ from HC*l* i.e. CH_3COO^- is in excess. Since $CH_3COO^- + H^+ \rightarrow CH_3COOH$, the resultant mixture contains 0.010 mol of CH_3COO^- and 0.010 mol of CH_3COOH. This is a buffer solution.
C	**Incorrect**. There are 0.010 mol of CH_3COOH and 0.020 mol of OH^- from NaOH i.e. OH^- is in excess. Since $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$, the resultant mixture contains 0.010 mol of OH^- and 0.010 mol of CH_3COO^-. This is not a buffer solution.
D	There are 0.030 mol of CH_3COOH and 0.015 mol of OH^- from NaOH i.e. CH_3COOH is in excess. Since $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$, the resultant mixture contains 0.015 mol of CH_3COOH and 0.015 mol of CH_3COO^-. This is a buffer solution.

Comparing the buffer solutions in **B** and **D**, the solution in **D** contain greater amounts of the buffering species (i.e. CH_3COOH and CH_3COO^-) to react with any small amounts of acid or base added.

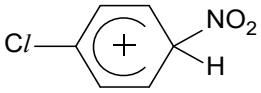
Hence, for the same amount of acid or base added, the pH change in **D** will be smaller, making it more effective in resisting pH change.

11 Ans: B

A	Incorrect. $CH_3CH_2CH_2CH_3 + Cl_2 \rightarrow CH_3CH_2CH_2CH_2Cl + HCl$ ΔH_r = bonds broken – bonds formed = BE(C–H) + BE(Cl–Cl) – [BE(C-Cl) + BE(H-Cl)] = 410 + 244 – (340 + 431) = –117 kJ mol^{-1} < 0 i.e. the reaction is exothermic.
B	Correct. In the propagation step, 2 different alkyl radicals can be formed.  In the termination step, the 2 different radicals can combine to form 3-methylheptane. 
C	Incorrect. The reaction takes place only in the *absence of water* i.e. reaction will not take place in the presence of *aqueous* chlorine.
D	Incorrect. A total of three isomers are formed (including stereoisomers) as 2-chlorobutane is chiral and exists as a pair of enantiomers.

12 Ans: D

This reaction involves the nitration of chlorobenzene.

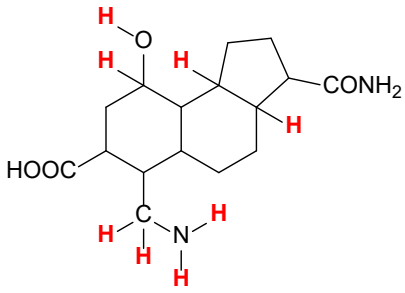
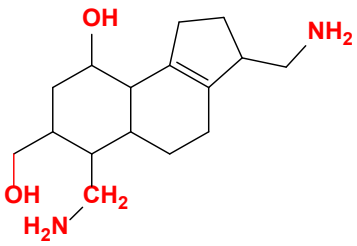
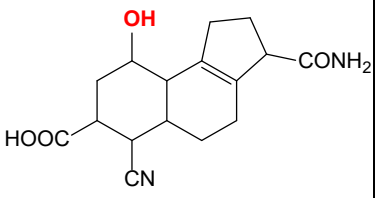
A	Incorrect. The catalyst is concentrated H_2SO_4.
B	Incorrect. The intermediate is  (or the 2-isomer).
C	Incorrect. C*l* is a deactivating group *(refer to the Data Booklet)* which makes the ring less electron rich and less reactive towards electrophilic attack. Thus a higher temperature is required for reaction compared to benzene.
D	Correct. The NO_2^+ electrophile is produced from the reaction between conc HNO_3 and conc H_2SO_4.

13 Ans: C

All three substances are conjugate bases of weak acids. Since the same amount of each substance is dissolved separately in the same volume of water, the higher the pH of the resultant solution, the stronger the base.

Note: The weaker the acid, the stronger its conjugate base.
Strength of acid: $CH_3COOH > C_6H_5OH > CH_3CH_2OH$
Strength of conjugate base: $CH_3COO^- < C_6H_5O^- < CH_3CH_2O^-$
lowest pH ⟶ highest pH

14 **Ans: D**

1	2	3
Incorrect. 8 hydrogen atoms will be incorporated since H_2, Pt reduces the ketone, alkene and nitrile. 	**Incorrect.** 2 primary amine groups will be formed as LiA/H_4 reduces the ketone, carboxylic acid, nitrile and amide but not the alkene. 	**Correct.** $NaBH_4$ can only reduce aldehydes (not present in this molecule) and ketone and only 1 secondary alcohol group is formed. 

15 **Ans: A**

Since $E^{\ominus}(NiOOH/Ni(OH)_2)$ is more positive than $E^{\ominus}(Cd(OH)_2/Cd)$, NiOOH undergoes reduction and Cd undergoes oxidation.

Cathode:
$NiOOH + 2H_2O + 2e^- \rightarrow Ni(OH)_2 + 2OH^-$
Anode:
$Cd + 2OH^- \rightarrow \underline{Cd(OH)_2} + 2e^-$

Since electrons are released at the $Cd(OH)_2/Cd$ half-cell, Cd is the negative electrode. $Cd(OH)_2$ is formed at the negative electrode.

Section B

B1(a)(i) K_{sp} of $PbBr_2 = [Pb^{2+}][Br^-]^2$

Comments:
- Generally well done.

B1(a)(ii) total amount of Br^- = 0.2 x 0.100 = 0.0200 mol
amount of Br^- in ppt = (2.57/ 367) x 2 = 0.0140 mol

total amount of Br^- = amount of Br^- in solution + amount of Br^- in ppt
0.0200 = amount of Br^- in solution + 0.0140
0.0060 = amount of Br^- in solution

conc. of Br^- in solution = 0.006/ 0.2
= <u>0.0300 mol dm^{-3}</u>

Comments:
- This question is not very well done. Many students forgot to multiply by 2 when finding the amount of Br^- precipitated in $PbBr_2$.

B1(a)(iii) Since solution is saturated,
(conc. of Pb^{2+} in solution)(conc of Br^- in solution)^2 = K_{sp} of $PbBr_2$
(conc. of Pb^{2+} in solution)$(0.03)^2 = 4 \times 10^{-5}$

conc. of Pb^{2+} in solution = 0.0444 mol dm^{-3}

initial amount of Pb^{2+} = amount of Pb^{2+} in solution + amount of Pb^{2+} in ppt
= (0.0444 x 0.2) + (2.57/ 367)
= 0.0159 mol
conc. of Pb^{2+} = 0.0159/ 0.1
= <u>0.159 mol dm^{-3}</u>

Comments:
- Some students wrongly summed the <u>concentration of Pb^{2+}</u> in solution with the no. of moles of Pb^{2+} ppt directly to find the initial amount of Pb^{2+} and dividing by the volume of 200 cm^3 to find the conc. of Pb^{2+}.
- Students are required to include the amount of Pb^{2+} in ppt when calculating the initial amount of Pb^{2+}.

B1(a)(iv) 0.159 mol dm^{-3} of Pb^{2+} = 0.159 x 207.2 g dm^{-3}
= 32.9 g dm^{-3}
= 32.9 g / 1000 g of solution
= <u>32900 ppm</u>

32900 >> 1, the sample <u>does not meet safety regulations</u>.

Comments:
- A number of students include the use of alternative calculations other than ppm to prove the safety of water.

B1(a)(v) Due to the low concentration of Ag^+, the ionic product < K_{sp} of AgBr. As such there would be no precipitation of AgBr, even though the solubility of AgBr is lower than that of $PbBr_2$.

Comments:
- Some students tried to compare the K_{sp} of AgBr vs $PbBr_2$ but failed to provide a reasonable conclusion based on the fact that $[Ag^+]$ is low and hence ionic product will not exceed K_{sp}.
- There were a handful of answers that tried to use the fact that the ionic product of AgBr only had one term of $[Br^-]$ whereas that of $PbBr_2$ had the $[Br^-]$ term squared, and concluded incorrectly that due to the squaring, a lower $[Br^-]$ was required to let the ionic product of $PbBr_2$ exceed its K_{sp}. This is not necessarily true, as the squaring of a term that is less than 1 will result in a smaller value (e.g. $0.1^2 = 0.01$).

B1(a)(vi) Potassium salts are highly soluble / Potassium salts cannot be precipitated out.

Comments:
- Generally well done.
- Some common mistakes include:
  - "K^+ is very soluble" – An ion can be soluble (due to ion-dipole interactions etc) but its salts need not necessarily be soluble. (E.g. Pb^{2+} is soluble but form many insoluble salts)
  - "K^+ is very reactive" – K metal is very reactive in water but not its ion.

B1(b) $Ag^+(aq) + Cl^-(aq) \rightleftharpoons AgCl(s)$ ----------(1)
$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$ ----------(2)

In the presence of excess NH_3, the soluble complex $[Ag(NH_3)_2]^+$ is formed and this lowers the uncomplexed $[Ag^+]$. By Le Chatelier's Principle, position of equilibrium (1) shifts left / backward reaction is favoured causing some $AgCl$ to dissolve. When sufficient NH_3 is added, ionic product < K_{sp} of $AgCl$ and all the precipitate dissolves.

Comments:
- The reversible arrows (⇌) must be used in the balanced equations to show the equilibria that were set up. These will then aid in the subsequent explanation of position of equilibrium shifting to the left/right.
- Students need to remember that NH_3 forms a soluble complex with Ag^+ ions. Some mistook $NH_3(aq)$ as acting as a base in the dissolution of the $AgCl$ precipitate and provided an equation for the formation of AgOH. If this had indeed been formed, then the precipitate should still remain as AgOH is also sparingly soluble.
- Please take note to remember the formula of the complex ion, $[Ag(NH_3)_2]^+$, formed between Ag^+ and NH_3.

B2(a)(i) $C_6H_5NH_3^+ + H_2O \rightleftharpoons C_6H_5NH_2 + H_3O^+$

Comments:
- Many students wrongly used the irreversible arrow to represent the reaction. Note that $C_6H_5NH_3^+$ is a weak acid that undergoes partial dissociation in water.
- Some common mistakes include:
  - Writing the equation for the ionisation of the weak base phenylamine
  - Reacting $C_6H_5NH_3^+$ with OH^- instead of water
  - Excluding water from the equation.
- Students are reminded to read the question carefully.

B2(a)(ii) $C_6H_5NH_3^+$ (aq) + H_2O (l) ⇌ $C_6H_5NH_2$ (aq) + H_3O^+ (aq)

$$K_a = \frac{[H_3O^+][C_6H_5NH_2]}{[CH_3NH_3^+]}$$

Since $C_6H_5NH_3^+$ is a weak acid with a small K_a,
$[C_6H_5NH_3^+]_{eqm} \approx [C_6H_5NH_3^+]_{initial} = 0.10$ mol dm^{-3}

$$\left[H_3O^+\right] = \sqrt{\frac{K_w}{K_b}\left[C_6H_5NH_3^+\right]} = \sqrt{\frac{1.0\times10^{-14}}{10^{-9.4}}\times0.10}$$
$$= 1.585\times10^{-3} \text{ mol dm}^{-3}$$

pH = –lg (1.585 x 10^{-3}) = <u>2.80</u>

Comments:
- The conjugate acid would hydrolyse in water to form H^+ which makes the solution acidic, as illustrated by the equation in **(a)(i)**. The pH can be calculated for this solution containing a weak acid.
- Some students thought that the solution would be alkaline and attempted to calculate pH of a weak base.
- K_a of the conjugate acid can be obtained from the given pK_b value of its conjugate base. Students should be able to manipulate the various equations involving K_a, pK_a, K_b, pK_b, K_w, pK_w, as well as pH and pOH.

B2(b)(i) (1) is an amide while (2) is a (secondary) amine.

Comments:
- This question is generally well done.
- For clarity, students should specify which functional group are (1) and (2).

B2(b)(ii) In (1), the orbital containing the lone pair of electrons on the N (1) atom overlaps with the π-electron cloud of the adjacent C=O group and the lone pair of electrons is delocalised and hence not available for co-ordination to a proton.

Comments:
- The discussion on orbital overlap was often left out or poorly written in students' answer.
- Students should use proper terminologies such as <u>lone pair</u> of electrons <u>on N atom delocalise</u> into the <u>C=O group</u>.
- Since amide is effectively neutral, the lone pair of electrons on N is <u>not available</u> for co-ordination to a proton.

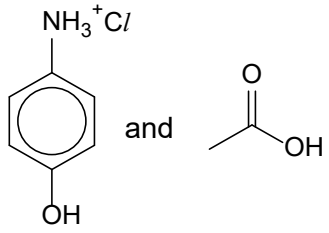
B2(c)(i) N is less electronegative than O, the lone pair of electrons on N is more available than the lone pair of electrons on O/$-NH_2$ is a stronger nucleophile than $-OH$ to act as a nucleophile.

Comments:
- This question was poorly done. Many students recognised that the $-NH_2$ is a stronger nucleophile than –OH group based on the information given in the question but did not explain why this is so by comparing the electronegativity between N and O.
- Students need to understand that the nucleophilic attack on the acyl chloride involves the lone pair of electrons on N or O being donated to the electron deficient C of the C=O group. Hence, they should focus on the availability of these lone pairs in their answer.
- The cleavage of N−H and O−H bond is not part of the rate-determining step, therefore answers related to bond strength are not accepted. Students can find parallels to commonly known examples of nucleophilic reactions in which the reactivity of a nucleophile is associated with the availability of its lone pair (and not the strength of the N–H or O–H bond).

B2(c)(ii) NaOH(aq) or Na(s)* OR HC*l*(aq) or H_2SO_4(aq)**

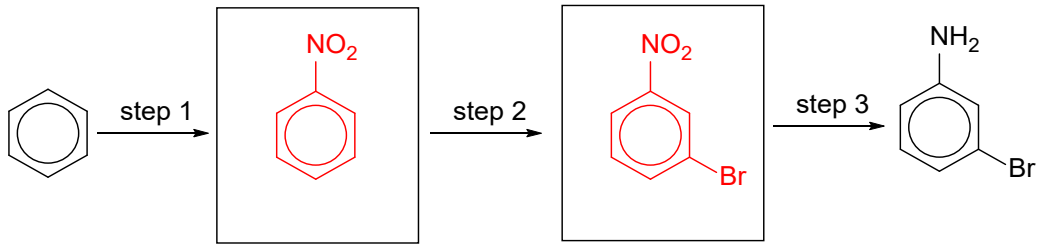
Comments:
- *The yield of **C** could be increased by first converting the phenol group into a phenoxide ion which is a stronger nucleophile. Hence, Na(s) and NaOH(aq) could be used to form the phenoxide ion before reacting with the acyl chloride.
- **Alternatively, dilute acid could be used to first protonate the basic phenylamine group to phenylammonium ion – there is no available lone pair of electrons on N of the phenylammonium ion and it cannot act as a nucleophile in the subsequent reaction with acyl chloride, decreasing the formation of **B** which in turns increases the formation of **C**.
- This is not an electrophilic substitution reaction as the reactions do not occur on the benzene ring. Thus, addition of $FeCl_3$ will not improve the yield.

B2(c)(iii)



Comments:
- Students need to recognise that the C–O bond in the ester would be broken during acidic hydrolysis. Also, since the medium is acidic, the basic phenylamine group would react in an acid-base reaction with HC*l*(aq) to give the protonated ammonium salt.
- However, many did not include the counter-anion, Cl^-, in the protonated ammonium salt product. Students should remember to include any counterion if the acid/base is specified in the question.
- Some students drew ethanoyl chloride as one of the products without realizing that it will hydrolyse under aqueous conditions.

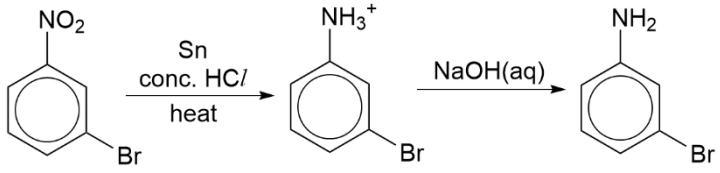
B2(d)



step 1: conc. HNO_3, conc. H_2SO_4, 55 °C
step 2: Br_2, $FeBr_3$
step 3: Sn, conc. HC*l*, heat, followed by NaOH(aq)

Comments:

- Students are expected to give the reagent and condition for each step accurately. Note that Br_2 in Step 2 cannot be (aq) since $FeBr_3$ will hydrolyse.
- Students are also reminded to consider the directing group of the substituents and hence the sequence of synthesis is not interchangable.
- The $–NO_2$ group is a deactivating group, which makes nitrobenzene less reactive towards further electrophilic substitution (compared to benzene). Hence, a Lewis acid catalyst is required in step 2 (and not just Br_2 in CCl_4).
- For step 3, the addition of NaOH(aq) after reduction under acidic condition is required to deprotonate the product, which is protonated due to the highly acidic medium.
  Step 3:



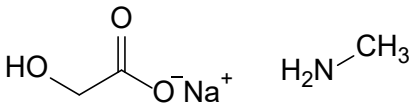
product is protonated due to presence of excess acid

B2(e)(i) From experiment 1 to 2, R_1 becomes more electron withdrawing due to the presence of C*l*, hence, the C atom in the C=O group has a larger partial positive charge/more electron deficient and it attracts nucleophiles more strongly, resulting in a faster rate of reaction.

Comments:

- Students are reminded to use proper scientific terms and be specific in their answers. A phrase such as “chlorine atom causes the carbon atom to be more electron deficient” is too ambiguous with respect to the exact carbon atom involved.
- The process of hydrolysis involves a nucleophile attacking the electron deficient carbon atom in the C=O group of the amide and the breaking of C–N bond.
- Since R_1 is covalently bonded to C atom of the C=O group, a change in the electron withdrawing nature of R_1 will directly affect the magnitude of partial positive charge on the carbon of the C=O group.
- While the increase in the electron withdrawing nature of R_1 can also cause the weakening of C–N bond due to inductive effect, this effect is less pronounced as compared to the effect on the C atom of the C=O group which R_1 is directly attached to.

B2(e)(ii)



Comments:
- Many students overlooked the nucleophilic substitution reaction of the chloroalkane in the presence of NaOH(aq) and heat.
- Some students did not realise that the carboxylic acid functional group will react with NaOH(aq) to form the carboxylate salt.
- Some students incorrectly left their answers using "R_1" and "R_2".

B2(e)(iii) The twisted amide has the longest C–N bond length and hence it is the easiest to break.

Comments:
- As stated by the question, students should refer to the C–N bond lengths given in the table and do a comparison among all the data given.
- Many students were able to relate the bond length to the bond strength and ease of breaking the bond.

B2(e)(iv) The C–N bond length of the twisted amide is similar to that of the C–N bond length of the amine/the C-N bond is longer compared to other amides. This indicates the loss/absence of partial double bond character/resonance the C-N bond in the amide group.

This is because in the twisted amide, the orbital of nitrogen atom is no longer able to overlap with the π-electron cloud of the adjacent C=O group.

Comments:
- This question was poorly done.
- Many students attributed the longer C–N bond in the twisted amide to ring strain. It is inappropriate to make use of ring strain to explain this observation. Ring strain is caused by abnormal bond angles (commonly observed in 3- or 4-membered rings) which deviate significantly from the stable ideal bond angles.
- To solve this problem, students should observe from the data provided that the C–N bond length of the twisted amide is more similar to that of the C–N bond length of the first amine (methylamine) and not similar to the amides (the second and third molecules). This gives the hint that the C–N bond in Kirby's amide is more like a single C–N, without partial double bond character.
- These deductions lead to conclusions that there is no partial double bond character in the twisted amide as opposed to usual amide due to the misalignment of the orbital of N atom containing the lone pair with the π-electron cloud of C=O group.

B3(a)

Preparation of **FA 3**

- Using the pestle and mortar, crush two Vitamin C tablets into as fine a powder as possible.
- Using a 50 cm^3 measuring cylinder, measure 50 cm^3 of deionised water into a 100 cm^3 beaker.
- Transfer the crushed powder into the 100 cm^3 beaker containing deionised water.
- Stir the mixture continuously for about 2-3 min (or use a magnetic stirrer).
- Using a filter funnel, filter the suspension into another 100 cm^3 beaker. Label this beaker as **FA 3**.

Determination of order or reaction with respect to H_2O_2

1. Using a 10 cm^3 measuring cylinder, measure out 10 cm^3 of H_2O_2 (**FA 1**) into a 100 cm^3 beaker. Label this beaker as **A**.

2. Using a 3.0 cm^3 syringe, measure out 2.5 cm^3 of starch solution and add it to the H_2O_2 in **A**.
3. Using a 50 cm^3 measuring cylinder, measure out 50 cm^3 of KI (**FA 2**) into another 100 cm^3 beaker. Label this beaker as **B**.
4. Using another 3.0 cm^3 syringe, measure 2.5 cm^3 of **FA 3** and add it to the KI in **B**.
5. Transfer the contents of **B** to **A**. At the moment when all of **B** is added, start the stopwatch.
6. Swirl the mixture once and place it on a white tile. Record the time taken for the dark blue colour to appear to the nearest second.
7. Repeat steps 1 to 6 with the following volumes of solutions, using a 10 cm^3 measuring cylinder to measure the deionised water needed.

Expt	Beaker **A**			Beaker **B**		Total volume / cm^3	t / s	$\frac{1}{t}$ / s^{-1}
	Vol. of H_2O_2 / cm^3	Vol. of H_2O / cm^3	Vol. of starch / cm^3	Vol. of KI / cm^3	Vol. of **FA 3** / cm^3			
1	10	0	2.5	50	2.5	65		
2	8	2	2.5	50	2.5	65		
3	6	4	2.5	50	2.5	65		
4	4	6	2.5	50	2.5	65		
5	2	8	2.5	50	2.5	65		

Proposed graph to be plotted

Plot a graph of $\frac{1}{t}$ against volume of H_2O_2 used.

If a straight line with positive gradient passing through the origin is obtained, the reaction is first order wrt H_2O_2.

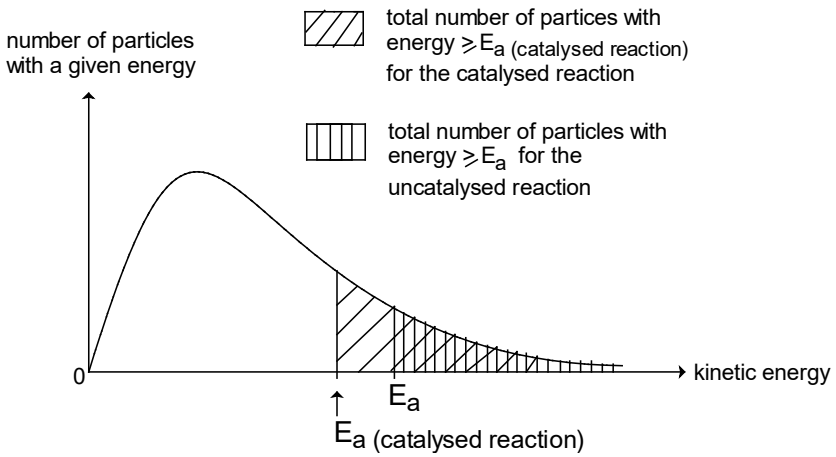
Comments:

- Most students were able to produce a powdered form of the tablets (e.g. using mortar and pestle), or employed heating, to speed up the dissolving process. The maximum volume of solvent (i.e. 50 cm^3) should be used to extract the maximum amount of Vitamin C from the tablets *before* filtration takes place. Addition of water directly to the filtrate *after* filtration (e.g. add water to top up to 50 cm^3) would have diluted FA3 to a concentration much lower than that specified in the question. Heating should also not be at boiling temperatures, as the (prolonged) high heat may cause some degradation to the organic Vitamin C molecules. Filtration was done to remove the insoluble components and produce a *clear* solution.
- All capacities for the apparatus used should be clearly stated, i.e. for measuring out solutions (e.g. measuring cylinders) or for containing them (e.g. beaker / conical flasks). The capacities should be based on your knowledge and experience from practical work, and not any random capacities you think are available. We will usually choose a (standard) capacity that is either equal or larger than the volume that needs to be measured so that we do not need to measure more than once, e.g. use a 50 cm^3 measuring cylinder to measure 50 cm^3, and not a 10 cm^3 measuring cylinder. To prevent contamination and reaction, we should use separate apparatus to measure out different reagents.
- FA 1 and FA 2 should be prepared in separate containers since reaction begins once H_2O_2 and KI are in contact with each other, and the stopwatch needs to be started at this moment of contact. Some students mixed all four solutions (from separate containers including syringes) and started the stopwatch *simultaneously*, which is physically challenging (i.e. to pour + squeeze syringes + start stopwatch all at the same instant) to achieve successfully without, e.g. spillage or time delay, and is hence inappropriate as a procedural step. We should also not add the starch as a step *after* FA 1 and FA 2 have already been mixed, and then start the stopwatch after adding the said starch). [In this answer, before mixing, Vitamin C was not placed in the same

container as H_2O_2 in case some degree of oxidation of Vitamin C takes place, but this was not a marking point here.]

- The decision to stop the stopwatch is based on the instant the dark blue colour appears, and *not* to "obsure" a cross placed at the bottom of the reaction vessel, nor to wait until the entire solution turns dark blue. Students should follow the details given in the question carefully, and not assume based on their memory of past work done (e.g. dark blue, not blue-black; 2.5 cm^3 of starch, not a few drops of starch).
- From the information in the question (see "first set of the series of experiments"), the total volume of the solution is already fixed at 65 cm^3 – students should not add water to this and subsequent experiments, and create their own new total volume, but refer to the given quantities in the question in this case.
- The experiment is to determine the order wrt H_2O_2, and hence only the concentration of this reagent should be varied – some students erroneously varied the [KI] instead, or [KI] simultaneously with [H_2O_2].
- Presentation-wise, a table showing the volumes used (especially H_2O_2 and water here) would be clearer and usually more efficient when describing the specific volumes to be used in the planned experiments. Just saying to "vary" the volume of FA1 is insufficient, as "vary" can mean to increase or decrease the volume.
- Some students impractically included a volume of H_2O_2 to be used as "0 cm^3", which means no reaction actually takes place when the solutions are mixed, and so the stopwatch will be stopped at time = infinity.
- For a planned experiment, when one wants to determine a *relationship* between variables, it is not scientifically sound to make a conclusion based on just two (or three) data points. Since there are no real or given contraints to the number of experiments that can be practically carried out, a *trend* should be established, rather than what many students did – to just compare two specific data points and thereafter decide that the relationship is (in)valid. Experimental error alone could have led to a correct or incorrect conclusion when only just two points are used. [Of course, in a given (non-planning) question in the exams, e.g. MCQ with a given set of data of rates and [reactant], we can go ahead and compare two experiments and determine the order mathematically or by inspection, but that is because you have no access to further data or info than what is given in the question.] Note: a rough guide: to collect (at least) 5 data points for a straight line and (at least) 7 data points for a curve.
- The "time" here is the time taken for the solution to change from faint-yellow to dark blue (i.e. time taken for the dark blue to first appear), and which is to be used in the determination of the *initial rate* of the reaction. This "time" is different from the "time" in a *continuous* experiment whereby one may start an experiment, and let the [reactant] decrease and the reaction proceed indefinitely or until the end of the experiment, e.g. refer to a [A] vs time graph. Some students mistakenly thought that the half-life concept could be applied in this question.
- The question only required you to confirm that the order was one, hence in this case, it is not really necessary for the answers to include a discussion of the cases for the orders 0 or 2. If you were instead asked to determine the order, then yes, a discussion of the 0, 1, 2 cases most would likely be required.
- Note that when discussing the first order case, the phrase "straight line passing through the origin" is sufficient and both ideas are needed.
- Common ambiguities relating to the description of the expected graph:
  - Just the words "straight line" alone could mean a horizontal line.
  - Just the words "positive gradient" alone could mean the line has a non-zero y-intercept.
  - Just the words "constant gradient" alone could mean the two cases above, or a line with a negative gradient.
- A simple sketch with the correct axes and the correct graph would make it very clear what you mean.

B3(b)



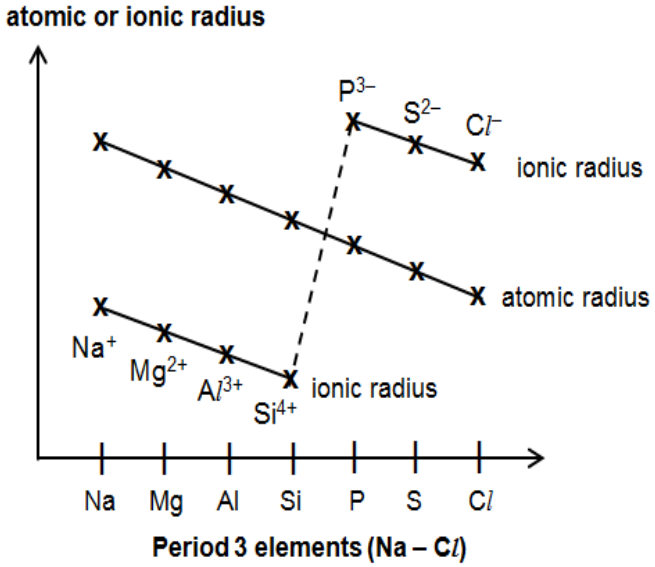
A catalyst increases the rate of a reaction by providing an alternative reaction pathway, one of lower activation energy ($E_{a\ (catalysed\ reaction)}$) than the uncatalysed reaction. As such, significantly more reactant particles have energy greater than or equal to the activation energy for the catalysed reaction. This is as shown by the larger shaded area for the catalysed reaction in the above diagram. This results in an increase in effective collision frequency and hence an increase in the rate of the reaction. An alternative reaction pathway of lower activation energy also results in a larger rate constant k and hence an increase in the reaction rate.

Comments:

- Note the following key points when drawing the Maxwell-Boltzmann distribution curve:
  - label axes and both E_a
  - curve must start from origin
  - at high kinetic energy, the curve is an asymptote (should not touch the x-axis)
- Note that increasing temperature increases the <u>frequency</u> (NOT number) of <u>effective</u> collisions.
- Some students excluded the effect on rate constant when activation energy is lowered by the use of catalyst.

Section C

C1(a)(i)



Comments:
- Generally well done.
- Some students incorrectly placed Si^{4+} to be above Si or confused these trends with other trends in Periodicity.
- Note that to avoid ambiguity, sketches should be clearly labelled and the "plots" should be aligned vertically to the respective element.
- Read the question carefully to note that Ar is not required in the sketch.

C1(a)(ii) P: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ P^{3-}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Both P^{3-} and P have the same nuclear charge. However, P^{3-} has more electrons than P leading to greater shielding and hence the electrostatic attraction between the nucleus and the outermost electron is weaker in P^{3-}, resulting in P^{3-} having a larger electron cloud size, and a larger ionic radius than P.

Comments:
- Some students incorrectly stated that P^{3-} has an extra electron shell compared to P.
- Some students did not discuss "nuclear charge" and "shielding effect" in their answers.

C1(a)(iii) Na^+: $1s^2\ 2s^2\ 2p^6$ Mg^{2+}: $1s^2\ 2s^2\ 2p^6$

Na^+ and Mg^{2+} have the same number of electrons/isoelectronic and hence their outermost electrons experience the same shielding effect. However, Mg^{2+} has a higher nuclear charge than Na^+. Consequently, the electrostatic attraction between the nucleus and outermost electrons is stronger in Mg^{2+}, hence the ionic radius of Mg^{2+} is less than that of Na^+.

Comments:
- Students should note that the same number of electron shells does not mean the same number of electrons nor the same shielding effect. E.g. F and F^- have the same number of electron shells but not the same number of electrons and their valence electrons do not experience the same shielding effect.

C1(b)(i) Energy difference between the 1st and the 2nd ionisation energies (IEs) is smaller because both involve the removal of electrons from the same outermost electron shell. The difference between the 2nd and 3rd IEs is greater because the 3rd electron to be removed is located in an inner electron shell / an electron shell of a lower principal quantum number, which is closer to the nucleus, experiencing less shielding and is attracted more strongly by the nucleus. Thus, the 3rd IE is very much higher than the 2nd IE, resulting in a much greater energy difference.

Comments:
- Some students did not explain the part relevant to the 1st and 2nd IE i.e. **same** outermost electron shell for both the first and the 2nd electrons removed.
- Some students did not discuss "shielding effect" in their answers.

C1(b)(ii) No. Element Q is from Group 1 due to the big jump in the 1st and 2nd IEs. Given that 5 IEs are given, element Q must have at least 5 electrons. Group 1 element in Period 2 (i.e. Li) has only 3 electrons.

Comments:
- A number of students confused period number with Group number, justifying that Q is not in Period 2 as it has only 1 valence electron.
- Many students were able to mention that Li only has 3 electrons, but did not mention that element Q needs to have at least 5 electrons.

C1(b)(iii) Energy required = 0.02 (420 + 3050 + 4420) = +157.8 kJ ≈ +158 kJ (3 s.f.)

Comments:
- Some students calculated the energy required for 1 mol instead of 0.02 mol of R.
- A few students wrongly used values for S instead of R in their calculations.
- A few students used only the 3rd I.E. value in their calculation, which is incorrect as the 3rd I.E. involves the loss of the 3rd electron only and not all 3 electrons.

C2(a)(i) Having a smaller charge and a larger ionic radius, Mg^{2+} has a lower charge density / polarising power than Al^{3+} and thus polarises/distorts the electron cloud of H_2O coordinated to it to a lesser extent. As a result, the extent of hydrolysis to form H^+ ions is lesser / O-H bond in water is weakened to a smaller extent for $[Mg(H_2O)_6]^{2+}$ resulting in its lower acidity and hence higher pK_a.

Comments:
- Students should state clearly that they are referring to the Mg^{2+} and Al^{3+} cations when discussing charge density and polarising power, and not $[Mg(H_2O)_6]^{2+}$ and $[Al(H_2O)_6]^{3+}$.
- A common misconception is seen in the use of the keywords "polarising power" versus "polarisability". Students are reminded that "polarisability" should be used to describe how easily the electron cloud of an anion or molecule can be distorted, while "polarising power" is used to describe how a cation is able to polarise the electron cloud of anion or molecule.
- Another common mistake in phrasing would be "polarises/distorts H_2O molecule". Students need to be aware and explicitly state that it is the electron cloud of H_2O that is being polarised.
- The conclusion should link the value of pK_a to the strength of the acid.

C2(a)(ii) The gas produced is CO_2.

To liberate CO_2 from CO_3^{2-}, the reagent added must be a stronger acid than HCO_3^- and H_2CO_3. As $[Al(H_2O)_6]^{3+}$ is a stronger acid (as shown by its smaller pK_a value) than HCO_3^- and H_2CO_3, it reacts with CO_3^{2-} to form H_2CO_3. H_2CO_3 then decomposes to form CO_2 and H_2O, resulting in effervescence being observed.

Comments:
- From the question prompt, students should use the information in Table 2.1 and the given equations and pK_a values to draw the conclusion that $[Al(H_2O)_6]^{3+}$ acts as a stronger acid than HCO_3^- and H_2CO_3. As such, $[Al(H_2O)_6]^{3+}$ reacts with CO_3^{2-} to give HCO_3^-, which further reacts to produce H_2CO_3.
- The formation of CO_2 was a result of the decomposition of H_2CO_3 produced.
- Comparison of the relative acid strengths of $[Al(H_2O)_6]^{3+}$ and $[Mg(H_2O)_6]^{2+}$ does not substantiate the reaction between $[Al(H_2O)_6]^{3+}$ and HCO_3^- / CO_3^{2-}.
- Le Chatelier's Principle cannot be used to explain the observation as both $[Al(H_2O)_6]^{3+}$ and $[Mg(H_2O)_6]^{2+}$ can hydrolyse in water to form H^+ leading to shifts in positions of equilibrium but it does not explain why effervescence is observed only for Al^{3+}.

C2(a)(iii)

precipitate formed between $Na_2CO_3(aq)$ and $Mg^{2+}(aq)$	$MgCO_3$
precipitate formed between $Na_2CO_3(aq)$ and $Al^{3+}(aq)$	$Al(OH)_3$

Comments:
- Common errors include $Mg(OH)_2$ and $Al_2(CO_3)_3$.
- Recall that $\underline{Al_2(CO_3)_3 \text{ cannot be obtained}}$ by mixing an aqueous solution containing Al^{3+} ions with an aqueous solution containing CO_3^{2-} ions. Similarly, $Fe_2(CO_3)_3$ and $Cr_2(CO_3)_3$ also cannot be obtained. (refer to Section 5.5 of Guide to Qualitative Inorganic Analysis)

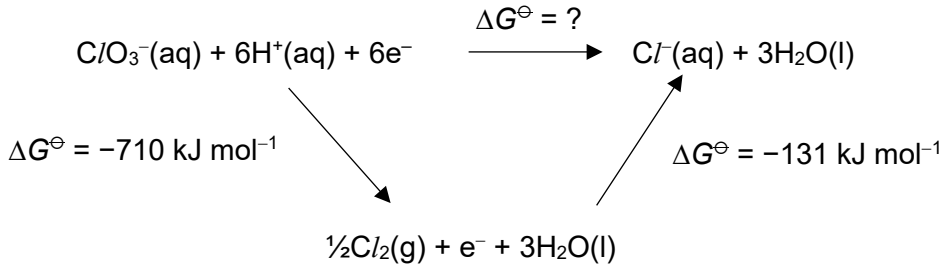
C2(b) $\Delta H_r = BE[I–Br] – ½ \{BE[I–I] + BE[Br–Br]\} = 175 – ½(151 + 193) = +3.00 \text{ kJ mol}^{-1}$

Comments:
- The question did not require the drawing of an energy cycle.
- Using an appropriate formula "sum of bond energies of bonds broken (endo) – sum of bond energies of bonds formed (exo)" will allow the ΔH_r to be calculated efficiently.

C2(c)(i) +7

Comments:
- The + sign should be in front of the number when stating oxidation number.

C2(c)(ii) $ClO_3^- + 6H^+ + 6e^- \longrightarrow Cl^- + 3H_2O$



Applying Hess Law, $\Delta G^\ominus = -710 + (-131) = -841$ kJ mol^{-1}

$\Delta G^\ominus = -nFE^\ominus$
$E^\ominus = -[-841 \times 10^3 / (6 \times 96500)] = +1.45$ V

Comments:
- The half equation carries an irreversible arrow as the question specifies that it is for the conversion of ClO_3^- to Cl^-.
- When drawing an energy cycle, state symbols should be included. The cycle must be balanced, including the number of electrons.
- Irreversible arrows should not be used in the energy cycle as the $\Delta G^\ominus$ of each process is for a specific direction of the reaction.
- When using this formula: $\Delta G^\ominus = -nFE^\ominus$, the Gibbs free energy obtained is in J mol^{-1}.

C2(c)(iii) Using Latimer diagram: $E^\ominus_{cell} = +1.45 - (+1.19) = +0.26$ V
Amt of electrons transferred = 6 mol
$\Delta G^\ominus = -(6)(96500)(+0.26) = -151$ kJ mol^{-1}

Comments:
- It is necessary to find out the electron transaction of the reaction. The oxidation involves 6 mol of electrons: $3ClO_3^- + 3H_2O \longrightarrow 3ClO_4^- + 6e^- + 6H^+$. Similarly, the reduction involves 6 mol of electrons: $ClO_3^- + 6H^+ + 6e^- \longrightarrow Cl^- + 3H_2O$. Hence n = 6.
- Some students wrongly calculated in this manner by multiplying the electron potential with the stoichiometric coefficient of the species: $E^\ominus_{cell} = +1.45 - 3(+1.19) = -2.12$ V. Do note that reduction potentials are **not** measured on a per mol basis and should **not** be multiplied by stoichiometric coefficients.

C2(d)(i) Cathode: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$
Anode: $2Br^- \longrightarrow Br_2 + 2e^-$

Comments:
- Students need to indicate whether a half equation is a cathode or anode reaction.
- When writing equations for anode or cathode reactions, you must use a '$\longrightarrow$' sign, **NOT** '$\rightleftharpoons$' sign.
- The anode is where oxidation occurs, so electrons must appear on the product side of the equation. The opposite is true at the cathode.
- Na^+ will not be reduced at the cathode as $E^\ominus(Na^+/Na)$ is less positive than $E^\ominus(H_2O/H_2)$.
- H^+ will not be reduced at the cathode, as this reaction was done in a neutral aqueous medium where the concentration of H^+ is very low.
- Some students indicated the reduction of Br_2 to Br^- for the cathode reaction when there are no Br_2 present in the system.

C2(d)(ii) $S_2O_3^{2-} + 4Br_2 + 5H_2O \longrightarrow 2SO_4^{2-} + 10H^+ + 8Br^-$

Amt of $S_2O_3^{2-} = \frac{35.60}{1000} \times 0.500 = 0.0178$ mol

$S_2O_3^{2-} + 5H_2O \rightleftharpoons 2SO_4^{2-} + 10H^+ + 8e^-$

$4Br_2 + 8e^- \rightleftharpoons 8Br^-$

Number of moles of electrons = 8 x 0.0178 = 0.142 mol

Comments:
- To construct a balanced redox equation, students are reminded to do their working of 2 half-equations (Br_2 to Br^- ; $S_2O_3^{2-}$ to SO_4^{2-}) and balancing them with the number of electrons transferred.
- The number of moles of electrons involved can be derived using either half-equations as long as the stoichiometry of the 2 reactants is balanced.

C2(d)(iii) $Cr^{n+} + ne^- \longrightarrow Cr(s)$

Amt of Cr = 3.68 / 52.0 = 0.0708 mol

n = 0.142 / 0.0708 = 2.01 ≈ 2 (whole number)

Comments:
- n has to be expressed as a whole number.
- n = amt of electrons / amt of Cr, not the other way round. This is because each chromium ion is receiving a certain number of electrons, to be reduced. An ion cannot be receiving ½ an electron. Hence, the amount of electrons should not be less than the amount of chromium ions reacted.

C3(a) Test: Add 2,4-DNPH to each compound in separate test-tubes.

EITHER Observation: Orange ppt is observed for methanal but not for methanol

Test: Add Fehling's solution to each compound in separate test-tubes and heat (in a hot water bath).

Observation: Brick-red ppt of Cu_2O is observed for methanal but not for methanol

Test: Add Tollens' reagent to each compound in separate test-tubes and heat (in a hot water bath).

Observation: Silver mirror is observed for methanal but not for methanol

Comments:
- Generally well done.
- The most common mistake is that student forgot to <u>heat</u> when using Tollens' reagent or Fehling's solution.
- $KMnO_4/K_2Cr_2O_7$, $H_2SO_4(aq)$, heat cannot be used as both the aldehyde (methanal) and methanol can be oxidised to result in the same observations.

C3(b)(i) EITHER step 1: LiA/H_4 in dry ether OR H_2, Ni, heat OR $NaBH_4$
step 3: KCN in ethanol, heat (under reflux)

Comments:
- A common mistake was to exclude heat for step 3.
- For step 3, many students were confused with the following reagents and conditions:

	RX undergo **nucleophilic substitution** to form **nitriles**.
Reaction X = Cl, Br or I	$R–X + KCN \xrightarrow{\text{ethanolic KCN}} R–CN + KX$ a nitrile
Reagents and conditions	ethanolic KCN heat (or heat under reflux)

	Carbonyl compounds undergo **nucleophilic addition** to form **cyanohydrins**.
Reaction	 e.g. aldehyde cyanohydrin
Reagents and conditions	HCN with trace amount of KCN/KOH

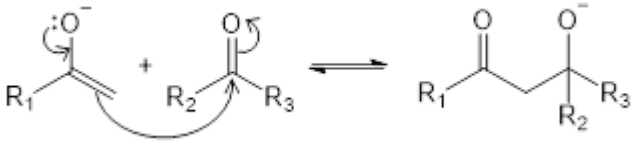
C3(b)(ii) EITHER

L

M

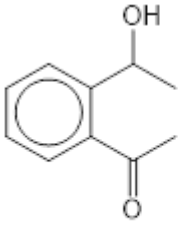
Comments:
- Generally well done.

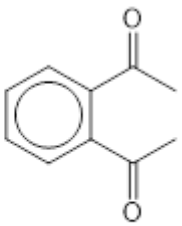
C3(c)(i) EITHER



Comments:
- The arrow from the double bond should point to the carbonyl carbon, and not R_2. This is so as the π-electrons from the double bond were used to form a bond with the carbonyl carbon and not R_2.

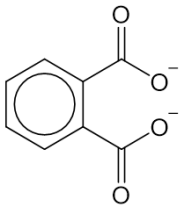
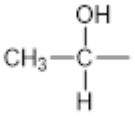
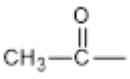
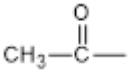
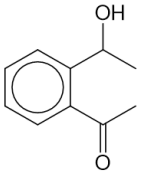
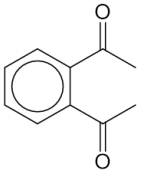
C3(c)(ii)
EITHER


H


J

Comments:

- Students have difficulty identifying that **H** contains one secondary alcohol and one ketone functional group; many drew two alcohol groups in **H**.
- Many students did not draw any structure for **K** and some drew a 6-membered ring for **K** which is incorrect.

Evidence	Explanation and Deduction
Compound **H** has a molecular formula of $C_{10}H_{12}O_2$ and contains the carbonyl functional group.	Since C:H ≈1:1, benzene ring present in **H**. (or **H** has 5 degrees of unsaturation ⇒ benzene ring and C=O bond present in **H**)
H exhibits optical activity	**H** does not have a plane of symmetry / **H** has at least one chiral C atom with non-superimposable mirror image.
H does not react with Tollens' reagent.	**H** is not an aldehyde. Since **H** contains the carbonyl functional group, **H** is a ketone.
H turns hot acidified potassium dichromate(VI) from orange to green to form **J** ($C_{10}H_{10}O_2$).	**H** undergoes oxidation with the loss of 2 H atoms. **H** is a secondary alcohol (and a ketone deduced above). *(**H** cannot be a primary alcohol as primary alcohol will be oxidised to form carboxylic acid with increase in one O atom).* **J** is a diketone / contains 2 ketone groups.
H and **J** reacts with alkaline aqueous iodine to give a yellow precipitate and the following product. 	**H** and **J** give positive iodoform test. Since **H** is both a secondary alcohol and a ketone, it must have both  and  structures. Since **J** contains 2 ketone groups, each group must have  structure.   Hence, **H** and **J** must be **H** **J** .

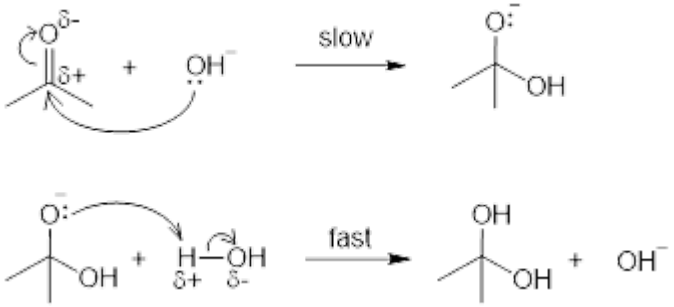
C3(a)
OR

Compared to ketone, the carbonyl carbon in aldehyde is more susceptible to nucleophilic attack due to it being

1. more electron deficient (higher $\delta+$ charge) as it has one less electron donating alkyl group
2. less sterically hindered as it has one less alkyl group

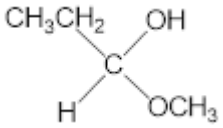
Comments:
- Generally well done.

C3(b)
OR



Comments:
- Many students used H_2O as the nucleophile in attacking the carbonyl C despite the given information that "sodium hydroxide acts as a catalyst and a nucleophile".
- Some students repeated common mistakes, such as not showing the partial charges, lone pair of electrons, slow and fast steps.
- Do revise and practise all the mechanisms covered in the syllabus.

C3(c)(i)
OR



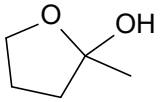
Comments:
- Generally well done.

C3(c)(ii)
OR

The mechanism involves the nucleophile (methoxide ion) attacking the $\delta+$ carbonyl carbon from either side of the trigonal plane with equal probability. Hence the product is a racemic mixture of the two enantiomers in 1:1 ratio.

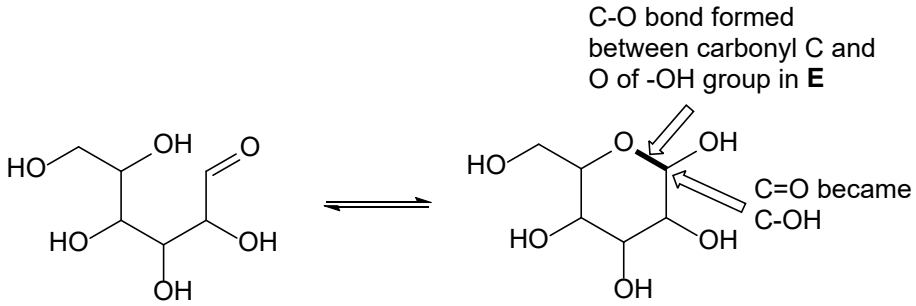
Comments:
- Most students recognised that the inability of the products to rotate plane-polarised light is due to the formation of a racemic mixture which arises from the nucleophile attacking a planar site from either side with equal probability. However, instead of recognising that the carbonyl carbon is planar, some student mistakenly attribute the planar structure to the whole propanal molecule or to a carbocation intermediate (which is not formed in nucleophilic addition mechanism).
- Note that each enantiomer is able to rotate plane-polarised light, but in opposite directions. As the two enantiomers are formed in equal amounts, the rotating power of one enantiomer exactly cancels that of the other. Hence, the racemic mixture does not rotate plane-polarised light.

C3(d)(i) OR



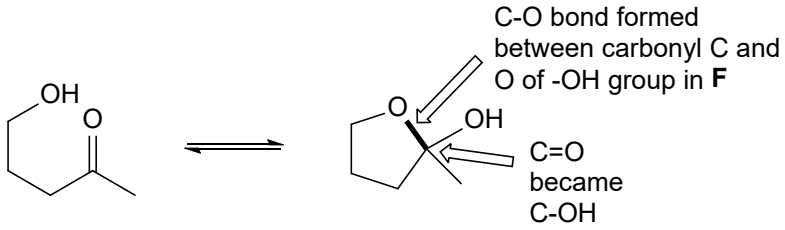
Comments:

- Some students missed out either the −OH or the $-CH_3$ group in their structures.
- To solve this question, students need to identify the differences between the reactant and product (e.g. bonds broken/formed) using the example given in Fig. 3.2:



E

Hence, for conversion of **F** to **G**:



F **G**

C3(d)(ii) OR

Test: Add I_2(aq) and NaOH(aq) to each compound in separate test-tubes and heat (in a hot water bath).
Observation: Yellow ppt of CHI_3 is observed for **F** but not for **E**.
OR
Test: Add Fehling's solution to each compound in separate test-tubes and heat (in a hot water bath).
Observation: Brick-red ppt of Cu_2O is observed for **E** but not for **F**.
OR
Test: Add Tollens' reagent to each compound in separate test-tubes and heat (in a hot water bath).
Observation: Silver mirror is observed for **E** but not for **F**.

Comments:

- Generally well done.
- Note that heating is required for iodoform, Fehling's and Tollens' tests.
- Candidates should give both the positive and negative observations.
- 2,4-DNPH cannot be used to distinguish between E and F as both compounds contain the carbonyl group which will give a positive test (orange ppt) with 2,4-DNPH.
- Similarly, hot $KMnO_4/K_2Cr_2O_7$ with H_2SO_4(aq) cannot be used as both the aldehyde (and primary and secondary alcohols) in E and the primary alcohol in F can be oxidised to result in the same observations.