## Mark Scheme for 2012 JC2 Preliminary Examination Paper 3

**Minus [1m] overall for P3 for lack of 3 sf. Indicate on Cover page when penalised.**

**General Comments for Q1**

**Many candidates probably left this question as their last attempted question, as they ran out of time and thus**

**(i) did not manage complete answers or**

**(ii) did not have enough time to calculate their answers or**

**(iii) made a lot of careless mistakes.**

**Marks for this question varies greatly from 4-5 to 17-20.**

**1. (a) (i)** **Anode**: $2H_2(g) \rightarrow 4H^+(aq) + 4e^-$ **[1m] s.s not penalised**

**Cathode:** $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ **[1m] s.s. not penalised**

- **Small handful of candidates still make the usual errors:**
    - **Use of reversible arrows**
    - **Use of [O] and [R]**
    - **Wrong electrodes or no labelling of electrodes**
- **A few wrote equations for alkaline medium**
- **A few chose half eqn for $H_2O_2$ instead.**

**(ii)**

- Requires a **heavy storage tank** of $H_2$ gas on board a car / takes up **more storage space** / must be **kept under high pressure**
- **Difficult to refill $H_2$ fuel** due to lack of infrastructure
- **$H_2$** gas is **MORE explosive** than fuels in internal combustion engines.
- **More expensive** due to the expensive catalysts etc
- **Explosive at high temperatures**

**[1m] for any relevant ans. Do not accept:** "explosive" only

**Common Mistakes**:

- **A few listed *advantages* instead**
- **A small handful of candidates *did not understand* what to compare e.g. thinking that the hydrogen-oxygen fuel cell is used *together* with the internal combustion engine or to supply electricity to the internal combustion engine.**

**(iii)** Using $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$, $P_1 = \left(\dfrac{P_2}{T_2}\right)T_1 = \left(\dfrac{\mathbf{3.29\times10^5}}{\mathbf{293}}\right)\mathbf{373}$

$= \underline{\mathbf{4.19\times10^5}}$ Pa

**[1m]: correct subst into formula. Accept 293.15 and 373.15**

**[1m]: correct ans, 3 s.f.**

- **Many candidates solved using PV=nRT, which is a longer method.**

**Common Mistake**:

- **Wrong units for Temperature**
- **Some gave a qualitative answer only, with no calculation.**

**1.** **(b)** **(i)** Reference electrode (cathode):

$Hg_2Cl_2$(s) + 2e $\rightarrow$ 2Hg($l$) + 2$Cl^-$(aq) **[1m] full arrow**

**(ii)** Measuring electrode (anode): $H_2$(g) $\rightarrow$ $2H^+$(aq) + 2e

Overall: $Hg_2Cl_2$(s) + $H_2$(g) $\rightarrow$ 2Hg($l$) + 2$Cl^-$(aq) + $2H^+$ (aq) **[1m] full arrow**

**Common Mistakes for (i) and (ii):**

- **Did not seem to understand Qn or were simply confused with 'Hg' and 'H' e.g.**
    - **Mixed up 'Hg' with '$H_2$' or 'Hg' with 'H' !**
    - **wrote reduction of chlorine to chloride only**
    - **wrote eqns for reaction between hydrogen and chlorine only**
- **Did not notice formula of "$Hg_2Cl_2$".**
- **Did not check their equation for balancing of charges.**

**(iii)** At a higher pH, there is lower [$H^+$], **[1m] No penalty for "E°". Just circle.**

- equilibrium in $2H^+$(aq) + 2e $\rightleftharpoons$ $H_2$(g) shifts to the left (OR eqm shifts to favour oxidation of $H_2$) and thus
- E($H^+$/$H_2$) becomes (more) negative.

Thus $E_{cell}$ becomes more positive.

**Common Mistakes:**

- **Thought "higher pH" = "higher [$H^+$]"**
- **Did not write reversible arrow for the eqm equation.**
- **Thought that a reaction between $H^+$ & $Cl^-$ will result in an eqm shift!**
- **Writing "E value" to represent E($H^+$/$H_2$).**

**(c)** **(i)**

$$E = E^0_{cell} - \frac{0.0592}{n}\log\left(\frac{[H^+]^2[Cl^-]^2}{P_{H2}}\right)$$

$$\mathbf{0.41 = 0.28 - \frac{0.0592}{2}\log\left([H^+]^2\right)}$$

**[1m] correct substitution & n=2**

~~ecf for n from (b) ← need work from both half eqns~~

$$0.41 = 0.28 - \frac{0.0592}{2} \times 2\log[H^+]$$

$$\log[H^+] = -\frac{0.13}{0.0592}$$

Solving, [$H^+$] = **$6.37 \times 10^{-3}$** **(or $6.38 \times 10^{-3}$)** mol $dm^{-3}$ **[1m] 3sf, ecf**

pH = - log($6.37 \times 10^{-3}$) = **2.20** **[1m] 3sf, ecf**

- **About half of the candidates (who attempted this part) are able to solve and calculate [$H^+$], using whatever values substituted.**

**Common Mistakes:**

- **Substituted n = amount of acid used (or any other strange number)**
- **Substituted their answer in (a)(iii) for $P_{H2}$**
- **Substituted "$1.01 \times 10^5$" for $P_{H2}$**

**1. (c) (ii)** $K_a = \frac{[H^+]^2}{c} = \frac{(6.37 \times 10^{-3})^2}{0.104}$ = **3.90 × 10⁻⁴** mol dm⁻³

**[1m] for $K_a$, 3sf, ecf**

*OR* $K_a = \frac{[H^+]^2}{c - [H^+]} = \frac{(6.37 \times 10^{-3})^2}{0.104 - 6.37 \times 10^{-3}}$ **= $4.15 \times 10^{-4}$** mol dm$^{-3}$

**(or $4.16 \times 10^{-4}$** mol dm$^{-3}$**)**

If students get [H$^+$] = $6.38 \times 10^{-3}$ mol dm$^{-3}$,

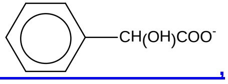
$K_a = \frac{[H^+]^2}{c - [H^+]} = \frac{(6.38 \times 10^{-3})^2}{0.104 - 6.38 \times 10^{-3}}$ **= $4.17 \times 10^{-4}$** mol dm$^{-3}$

$K_a = \frac{[H^+]^2}{c} = \frac{(6.38 \times 10^{-3})^2}{0.104}$ **= $3.91 \times 10^{-4}$** mol dm$^{-3}$

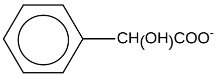
- **Most candidates earned the ecf marks.**
- **Most candidates (who got this part correct) solved for $K_a$ using** $K_a = \frac{[H^+]^2}{c}$
- **A few students got all previous calculations correct but were stuck at $K_a$. Perhaps they did not notice that mandelic acid is a monobasic acid.**

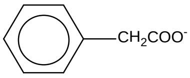
**(iii)** **Mandelic acid**, being the stronger acid, has a **larger $K_a$** value.

**[1m] Not awarded if mandelic acid is deduced as weak acid (contradiction)**

The **electron withdrawing O** atom of the - OH group **disperses the** 

**negative charge and stabilises** ,

making 

more stable than 

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**[1m] Anion must be clear**

**Accept:**
- **“electron withdrawing - OH group”**
- **“electronegative”**

**Common Mistakes:**
- **Electron donating - OH group**
- **Weaker acid has a larger $K_a$**
- **‘stabilising negative charge’**
- **‘mandelic anion’ or ‘anion’ or ‘- COO⁻ anion’**
- **Using ‘it’ to describe the acid, the anion, the - OH group (basically everything!) and thus making answers vague/unclear/misleading.**

**(iv)**
- Add **acidified $K_2Cr_2O_7$** to each of the unknowns and **heat** in a hot water bath. (**Accept “hot acidified $K_2Cr_2O_7$**)

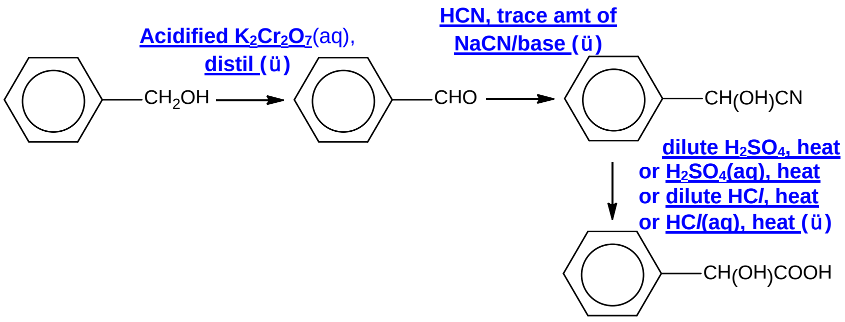
**[1m] Circle if ‘heat under reflux’ but no penalty**

- **Mandelic acid turns orange $K_2Cr_2O_7$ green but not phenylacetic acid.**

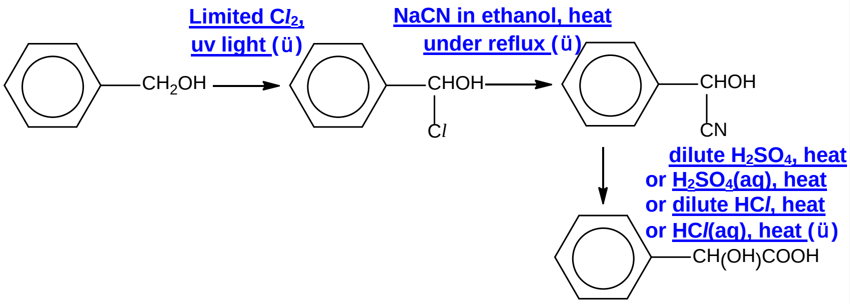
**[1m]**

**Common Mistakes:**
- **Using $KMnO_4$**
- **Using $KMnO_4$ then Brady’s reagent**
- **Using $KMnO_4$ (or $K_2Cr_2O_7$), followed by Tollens’ reagent.**
- **Using $PCl_5$**

**1. (c) (v)**



**OR the less recommended way:**



**[1m] for each correct intermediate structure**

**2(ü): 1m ; 3(ü): 2m , only awarded if corresponding structures are correct**

**Award marks proportionately, for any other long synthesis method suggested.**

**1m max for any haywire synthesis method but correct cyano-intermediate & reagent and conditions for hydrolysis to get the end product**

**- 1m** **if answers are correct but not clearly presented**

- **Have to remind students that Free Radical Substitution is *not* a recommended way of synthesis. It gives a mixture of products.**

**Common Mistakes:**

- **Some only listed the sequence of reagents & conditions required w/o giving intermediates for 'synthetic route'**
- **Suggested step to convert - OH group to - CN group ß (MANY STUDENTS)**
- **Suggested step to convert - OH group to - COOH group ß (MANY STUDENTS)**
- **Using "$KMnO_4/K_2Cr_2O_7$ and heat under reflux" to oxidise alcohol to aldehyde**
- **Confused on when to use HCN and NaCN (for nuclephilic sub & addition)**
- **Listed a mixture of two acids for hydrolysis e.g. '$H_2SO_4$, HC*l*, heat under reflux'**
- **Did not use 'dilute' or 'aq' for acid hydrolysis (i.e. simply "$H_2SO_4$, heat")**
- **Used 'conc' acid for hydrolysis.**

## General Comments for Q2

**Part (a) was generally well attempted and the average score is 7 out of 12. Students generally lost most marks in (a)(i)(ii)(vi).**

**Part (b) was poorly attempted and the average score is 3 out of 8. Students generally scored all marks in (b)(iii)(v).**

**For details, please see the comments under individual subparts.**

**2. (a) (i)** **Menthone** is expected to be **more volatile**. (or **[1m]**
**Menthol** is expected to be **less volatile**)

Less energy is required to overcome the ***weaker permanent dipole-permanent dipole interaction **between menthone molecules** than the ***stronger hydrogen bonds **between menthol molecules**. **[1m]**

**Reject:**

- **Just mention menthol has a higher boiling point.**
- **“Methanol/Menthanol” as Menthone/Menthol**

**Common mistakes:**

- **Menthone and Menthol were spelt wrongly.**
- **C=O bond is stronger than O-H bond…..**
- **….van der waals’ forces between menthone molecules**
- **“between molecules” is often missing**
- **…higher b.p…..therefore more volatile**

**(ii)** Menthol is insoluble in water due to the presence of **large/bulky** non-polar/hydrophobic cyclic **alkyl chain/group** in menthol molecule which ***prevents/hinders** effective **hydrogen bonding with water** molecules. **[1m]**

**Reject:**

- **mention “steric hindrance” without relating to the large alkyl group and hydrogen bonding.**

**Common mistakes:**

- **Menthol is non-polar/hydrophobic….cannot form ion-dipole interaction or hydrogen bonding with water ….**
- **$DH_{soln}$ is highly endothermic….**
- **Lone pair on O atom of –OH not available for hydrogen bonding as it is delocalised into the benzene ring.**

**(iii)** Step 1: **$LiAlH_4$, dry ether** or **$NaBH_4$, methanol or $H_2$, Ni, heat/200 °C** **[1m]**

Step 2: **concentrated $H_2SO_4$, heat at 170/180 °C or $Al_2O_3$, heat/350 °C** **[1m]**

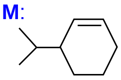
**Reject:**

- **“heat under reflux” for both steps**
- **(aq)/wrong state symbol of reagent.**
  **Except for “conc. $H_2SO_4$(aq)” (to cancel “(aq)” on student’s script)**
- **“$AlLiH_4$” as $LiAlH_4$**

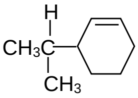
**Common mistakes:**

- **Did not state “170 °C” in step 2 when conc. $H_2SO_4$ is used.**
- **Quoted “acidified $KMnO_4$/$K_2Cr_2O_7$…” in step 1.**
- **Quoted “ethanolic KOH/NaOH, heat under reflux” in step 2.**

**(iv)** **M**:

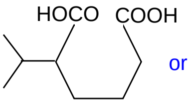


or



(or correct fully expanded structural formula) **[1m]**

**Oxidised product:**



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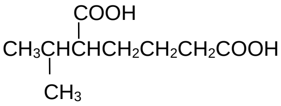


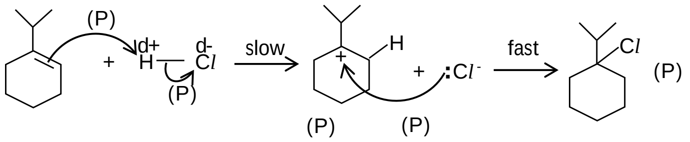
$CH_3\underset{CH_3}{CH}\overset{COOH}{CH}CH_2CH_2CH_2COOH$

**[1m]**

**Common mistakes:**

- **One missing carbon/one extra carbon atom in the oxidized product.**
- **Leave out one of more H atoms in the fully expanded structural formula of M/oxidised product.**
- **Some gave ketone/aldehyde/$CO_2$ as the oxidised product**

**2. (a) (v)**



(P) full arrow pointing from p bond to $^{d+}$H
(P) full arrow pointing from H- C*l* bond towards $^{d-}$ C*l*
*(P) correct carbocation structure
(P) full arrow pointing from lone pair on C*l*$^{-}$ towards C$^{+}$
*(P) correct addition product

3-4(P): [1m] 5(P): [2m]

**Common mistakes:**

- Leave out one or more H atoms in the expanded structural formula of 3-menthene.
- Put (d+, d-) on the C=C bond. Penalise under 1st (P).
- Dissociate H- C*l* into H$^{+}$ and C*l*$^{-}$ in the first step, then proceed with p electrons attacking the H$^{+}$ and C*l*$^{-}$ attacking the carbocation.
- Lone pair on C*l*$^{-}$ is often missing.
- Arrow point from the electrophile ($^{d+}$H) to C=C bond.

**(iv)** Stereoisomerism occurs when compounds/molecules have the same molecular formula and **same structural formula** but the ***atoms/groups of atoms** of the molecules **are directed/arranged differently in** 3-dimensional **space**. **[1m]**

3-menthene ****has no chiral centre** (or **no carbon atom with four different groups/groups of atoms attached)** and so it does not exhibit optical isomerism. **[1m]**

*****One form of the geometric isomer** (or **E-isomer/trans-isomer**) **is unstable (or does not exist) due to ring strain (or angle strain in the ring).** **[1m]**

Therefore it only exists in one stable form.

**Reject:**

- ***One form/isomer is unstable …….” without linking to geometric isomerism
- Due to ring strain, 3-menthene does not exhibit geometric isomerism
- 3-menthene has ring strain and cannot exhibit geometric isomerism

**Common mistakes:**

- For definition of stereoisomerism:
  - …molecules with 4 different groups attached to C/has chiral centre/give rise to optical isomers that rotate plane polarised light.
  - …different arrangement of molecules/functional group in space.
  - …same molecular/chemical formula but different structural formula.
- Did not use “ring strain’ but mentioned “twisting/distortion of ring and failed to relate to unstability of one geometric/trans isomer.
- No geometric isomerism as each C of C=C is bonded to the same group/due to cyclic ring.
- Mostly did not discuss both optical and geometric isomerism.

**2.** **(b)** **(i)** The **charge density of $Mg^{2+}$ is greater** than that of $Ba^{2+}$, therefore ***$Mg^{2+}$ has a** higher/greater **tendency to attract** the polar **water molecules** to itself to form hydrate as compared to $Ba^{2+}$. **[1m]**

**Reject:**

- **"...greater polarising power…."**

**Common mistakes:**

- **Many did not know what is a hydrate and discussed solubility of compound in water or reaction of compound with water instead.**
- **Discussed D$H_{hyd}$/oxidising power of $Mg^{2+}$.**
- **Discussed high polarising power of $Mg^{2+}$ and polarises the water molecule to great/greater extent.**
- **High charge density $Mg^{2+}$ favours formation of dative covalent bond with water molecules/readily accepts lone pair of electrons from water molecule to form dative covalent bond...**

**2.** **(b)** **(ii)** When white crystals of $Mg(NO_3)_2.6H_2O$ is heated in an open test-tube, **water** droplets **condense at the top** (P) of the test-tube, followed by evolution of a pungent **brown** $NO_2$ **gas/fumes** (P) and a colourless odourless $O_2$ gas which relights a glowing splint . A ***white residue/solid/powder** (P) of MgO is obtained after heating. **[1m] 3(P)**

**$Mg(NO_3)_2.6H_2O(s)$ ® $MgO(s) + 2NO_2(g) + ½ O_2(g) + 6H_2O(g)$**

**or, $2Mg(NO_3)_2.6H_2O(s)$ ® $2MgO(s) + 4NO_2(g) + O_2(g) + 12H_2O(g)$** **[1m] ignore s.s.**

**Reject:**

- ***White precipitate/ppt….**

**Common mistakes:**

- **Many thought that this was a combustion reaction and wrote**
  **- "$Mg(NO_3)_2.6H_2O(s) + O_2(g)$ ® …"**
  **- "burns with a ___________ flame"**
- **Some gave Mg (instead of MgO) as the product.**
- **Equation not balanced and "$O_2$" in the product or "$.6H_2O$" in the reactant were often missing.**
- **MgO residue is black.**
- **"Water droplets form/condense at the top" was often missing.**
- **Water vapour is seen.**

**(iii)** The **charge density of $Ba^{2+}$ is lower** than that of $Mg^{2+}$ since **$Ba^{2+}$ has a larger size/ionic radius/radius** (or **is bigger**) than $Mg^{2+}$. **[1m]**

**$Ba^{2+}$ has a lower polarising power (or *$Ba^{2+}$ has a lower ability to distort the (large) $NO_3^-$/anion**). Hence, $Ba(NO_3)_2$ is thermally more stable and requires a higher temperature to decompose than $Mg(NO_3)_2$. **[1m]**

**Reject:**

- **"polarising power/Charge density of $BaNO_3$"**
- **"atomic radius of Ba/$Ba^{2+}$/$BaNO_3$"**
- **"size/ionic radius/radius of Ba/$BaNO_3$"**
- **"Ba/$BaNO_3$...lower ability to distort/polarise anion"… etc**

**(Basically, the subject must be $Ba^{2+}$/$Mg^{2+}$, not Ba/Mg or $BaNO_3$/$MgNO_3$)**

**Common mistakes:**

- **As mentioned in "Reject".**

**(iv)** The solid residue after barium nitrate has been heated is BaO.

**BaO is soluble/dissolves/reacts** (ü) readily in water to form a strongly alkaline **solution of $Ba(OH)_2$**. (ü) Hence a colourless solution is observed.

The solid residue after magnesium nitrate has been heated is MgO. **MgO is** only **sparingly/partially/slightly soluble/not very soluble** (or **MgO dissolves to a small extent**) (ü) and reacts with water to a small extent to form a weakly alkaline solution of $Mg(OH)_2$. Hence a **white suspension of MgO** (ü) is observed.

**2-3(P): [1m]** **4(P): [2m]**

**Common mistakes:**

- **Many did not discuss solubility of MgO and BaO, but comment on solubility of $Mg(OH)_2$ and $Ba(OH)_2$.**
- **Extent of reactivity with water i.e. "BaO reacts readily/completely….. MgO reacts only to a small extent" was not discussed.**
- **MgO reacts to give $Mg(OH)_2$ which is sparingly soluble to give white $Mg(OH)_2$ suspension.**

**2.** **(b)** **(v)** Epson salt contains $SO_4^{2-}$ ions which form an insoluble $BaSO_4$ precipitate with aqueous solution containing $Ba^{2+}$.

Hence, administering of Epson salt helps ***to remove $Ba^{2+}$ ions/reduce $[Ba^{2+}]$** from the solution **through precipitation of $BaSO_4$**. **[1m]**

**Common mistakes:**

- **Many are not aware that $Ba^{2+}(aq)$ is toxic whereas insoluble barium compounds are not.**
- **Some thought that the barium poisoning is caused by the presence of Ba and discussed**
  **- reducing power of Mg/Ba**
  **- displacement reaction: $Ba + MgSO_4$ ® $Mg + BaSO_4$**
- **…form soluble $BaSO_4$ and therefore easier to remove (eg. as urine)**
- **…stronger $MgSO_4$ salt displaces out weaker $BaSO_4$ salt….**

## General Comments for Q3

**This question was one of the popular question that student would choose, however many students made a lot of careless mistakes especially in the proteins section.**

**Marks for this question varies greatly from 2-10, very few students had more than 15. (no full marks)**

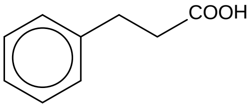
**Part (a) and (b) was generally well attempted and the average score is 5 out of 9. Students generally lost most marks in (b)(iii).**

**Part (c) was poorly attempted and the average score is 4 out of 11. Students generally scored full marks in (c)(i) only.**

**3. (a) (i)** $RCHC\mathit{l}CO_2H$ **[1m]**

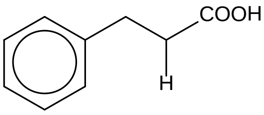
**(ii)** **substitution** **[1m]**

**(iii)** **[1m]**

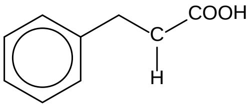


**or $C_6H_5CH_2CH_2COOH$**

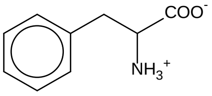
- **Accept**

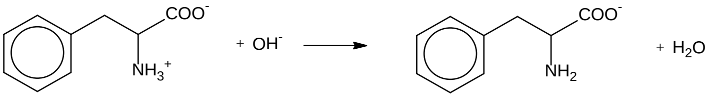


- **reject** **(incomplete structure)**



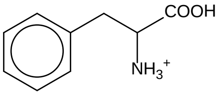
**(b) (i)** **[1m]**





**[1m]**

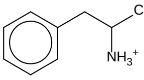
The small amount of $OH^-$ added is removed through acid-base reaction, maintaining the pH (or resisting changes in pH) of the buffer mixture.

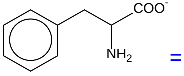
- **A few of candidates still make the usual error of using reversible arrows for the acid-base rxn.**
- **Small handful of candidates chose**  **as the species present in the buffer to remove the base added.**

**3** **(b)** **(ii)** The solution is a buffer at the start of the titration.

- When 39*x* $cm^3$ of NaOH(aq) is added

  è the buffer solution is at its maximum buffering capacity

  è Mole ratio of 

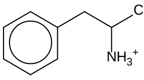
: 

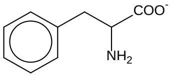
= 1: 1

- A further 41*x* $cm^3$ of NaOH(aq) is added to reach equivalence point.

  è 41*x* $cm^3$ of NaOH(aq) was required to neutralise all the acid left in the buffer at the maximum buffering capacity.

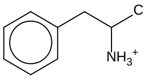
  è i.e. at max. buffering capacity,

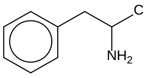
  amt of 

: 

= 41*x* : 41*x*

  è Working backwards, at start of the titration :

  Mole ratio of 

: 

$\underline{\mathbf{80\mathit{x} : 41\mathit{x} - 39\mathit{x}}}$ **[1m]**

$80x : 2x$

40 : 1 (shown)

**(iii)** In the original sample of buffer,

$$\mathrm{pH} = \mathrm{p}K_a + \lg\frac{[\mathrm{salt}]}{[\mathrm{acid}]}$$

$$\underline{\mathbf{7.4 = pKa + lg\left(\frac{1}{40}\right)}}$$

**[1m] correct substitution**

Solving, p$K_a$ = $\underline{\mathbf{9}}$.00

**[1m]** pH can be calculated directly, with clear working

Or, $\underline{\mathbf{Ka = 10^{-7.4}\left(\frac{1}{40}\right)}}$ **[1m]**

$\underline{K_a = 9.95 \times 10^{-10}}$ **[1m]**

At the maximum buffering capacity, **pH** = p$K_a$ = $\underline{\mathbf{9}}$.00 **[1m]**

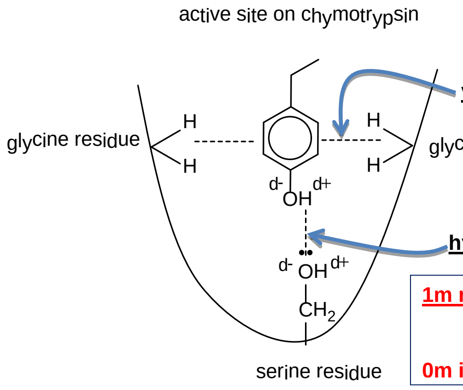
**(c)** **(i)** Since 7 amino acids are formed, 6 amide bonds were broken in peptide **G** with the release of 6 mol of $H_2O$.

$M_r$ of **G** = (2 x 181) + (2 x 204) + (3 x 165) – 6(18)

= $\underline{\mathbf{1157}}$

**[1m] no units**

**(ii)**



**van der Waals'** forces **[1m] label & drawing**

**hydrogen bond [1m] label & drawing**

**1m max if both interactions are correct but drawing is incomplete.**

**0m if drawing is complete but wrong label**

- **Majority of candidates still make the usual errors:**
  - **Drew the free –NH$_2$ and –COOH groups from the tyrosine amino acid.**
  - **Drew hydrogen bonding between the free –NH$_2$ and –COOH groups from the tyrosine to the serine residue.**
  - **indicated hydrogen bonding for the H atoms of the glycine residue.**
- **Many did not have complete hydrogen bonding diagram.**

**(iii)** The presence of alcohol reacts with the polar groups/ alcohol and **disrupts the hydrogen bonds in the secondary, tertiary** and quaternary **structures** of the **protein/enzyme/ chymotrypsin**. **[1m]**

Thus, the **conformation (or shape) of the active site** of the enzyme is **altered/change/destroyed** and inhibits its digestive activity. **[1m]**

- **Reject : Alcohol interacts/reacts with the serine residue, hence this inhibits the tyrosine from binding to the serine residue…**

  **(inhibitor only works if the *structure of the inhibitor is almost the same as the substrate*, alcohol does not have a structure like tyrosine-so such inhibiting of substrate does not work)**
- **alcohol disrupts the hydrogen bonds in the secondary, tertiary and quaternary structures *present in the active site of chymotrypsin*.**

- **Small handful of candidates still make the usual error of stating that the active site is altered, without mentioning that it is the *conformation/shape* of the active site that is altered.**

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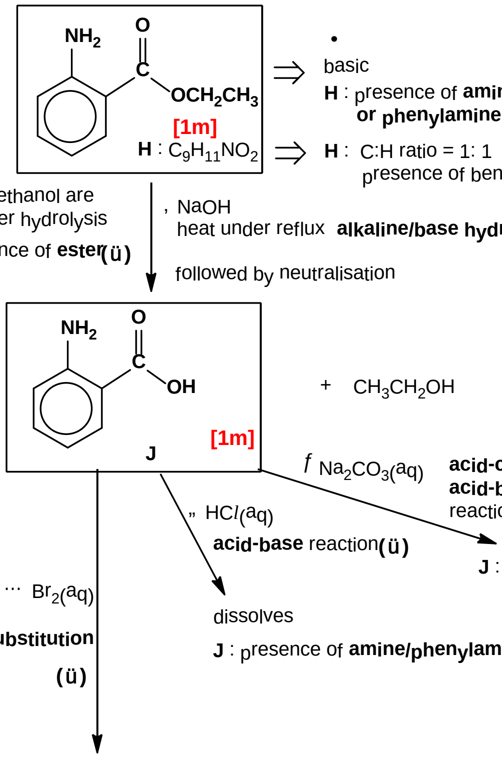
**3. (d)**



[1m]

**H** : $C_9H_{11}NO_2$

⇒ •
basic
**H** : presence of **amine or phenylamine**

⇒ **H** : C:H ratio = 1: 1
presence of benzene ring

Since **J** and ethanol are produced after hydrolysis
⇒ **H** : presence of **ester** **(ü)**

, NaOH
heat under reflux **alkaline/base hydrolysis** **(ü)**
followed by neutralisation

+ $CH_3CH_2OH$

[1m]

*f* $Na_2CO_3(aq)$ **acid-carbonate/ acid-base** **(ü)** reaction

reacts

**J** : presence of **carboxylic acid** **(ü)**

„ HC*l*(aq)
**acid-base** reaction**(ü)**

dissolves

**J** : presence of **amine/phenylamine**

… $Br_2(aq)$
**electrophilic substitution**
**(ü)**

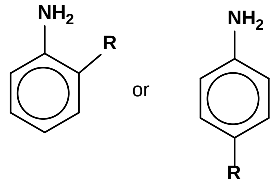
white ppt

**J** : presence of **phenylamine**

since 0.1 mol of J reacts with 0.2 mol of $Br_2(aq)$

⇒ **J** : presence of **one substituent group** on **2 or 4 or 6th position** wrt -$NH_2$ group of phenylamine.**(ü)***

***OR*** **J** contains



side-chain structure

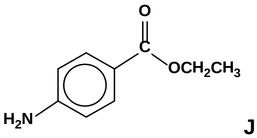
*can be inferred from the drawn structure- wrt –NH₂ only if phenylamine is shown.*

**(ü)***

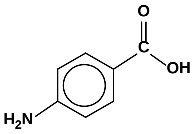
[1m] : mentions **phenylamine** in H or J
**2 - 3 (ü) : [1m]**
**4 - 5 (ü) : [2m]**
**6 - 7 (ü) : [3m]**

**OR Alternative answers:**

**H:**



**J :**



- **A few of the candidates concludes for rxn with HCl(aq) that *J is a polar molecule***
- **Some of the candidates concludes for rxn with Br₂(aq) that *J has a benzene ring* or *J has a benzene ring with more than 2 positions unoccupied* (but forgets about 3,5 position wrst –NH₂ group is also unoccupied)**

## General Comments for Q4

**Many students attempted this question. Generally well-done and answers are well-presented. Most students can achieve at least a pass for this question. Main problem is finding the $t_{1/2}$ for expt 3 (4aiii) and energy profile diagram (4bii).**

**4 (a) (i)** Compare **Expt. 1 and 2:**

When **$[OH^-]$ is increases to 1.5/**Error! Objects cannot be created from editing field codes. **times** of its original value **(or by 1.5 /**Error! Objects cannot be created from editing field codes. **times), rate increases to 1.5 times** of its original value **(or by 1.5 /**Error! Objects cannot be created from editing field codes. **times)**.

Hence, the **order of reaction with respect to (or w.r.t.) $OH^-$ is one**.

***OR:***

**Accept:** $[OH^-]$ ↑ 1.5 X, rate ↑ 1.5 X

Hence, the **order of reaction with respect to (or w.r.t.) $OH^-$ is one**.

***OR* rate α $[OH^-]$**

**[1m]**

Compare **Expt. 1 and 3:**

Let the order of reaction w.r.t $CH_3CHO$ be a.

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**Þ a = 1**

Hence, **the order of reaction with respect to (or w.r.t.) $CH_3CHO$ is one**.

***OR* rate α $[CH_3CHO]$**

***OR Alternatively:***

Compare **Expt 1 and 3:**

When **$[CH_3CHO]$ increases to 3 times** of its original value(or **by 3 times** or **↑ 3 X**) and the **$[OH^-]$ increases to 2 times** of its original value(or **by 2 times** or **↑ 2 X**), **rate increases to 6 times** of its original value(or **by 6 times** or **↑ 6 X**).

Hence, the **order of reaction with respect to (or w.r.t.) $CH_3CHO$ is one** .

**[1m]**

**Specific Comments:**

**Generally well-done. Students who attempted this part mostly achieve full marks. A few made careless mistakes in the calculations. The indices method was the most commonly seen when students compare expt 1(or 2) and 3.**

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**(ii)** **Rate = k $[CH_3CHO]\,[OH^-]$**

**Reject:** R(or r)ate eqn is k $[CH_3CHO]\,[OH^-]$

***OR*** R(or r)ate eqn = k $[CH_3CHO]\,[OH^-]$

k = Rate / $[CH_3CHO]\,[\,OH^{--}\,]$

From Expt 1: k = 0.0110 / [(0.10)(0.10)] = **1.10** **$mol^{-1}\,dm^3\,s^{-1}$**

**OR** From Expt 2: k = 0.0165 /{(0.10)(0.15)} = **1.10** **$mol^{-1}\,dm^3\,s^{-1}$**

**OR** From Expt 3: k = 0.0660/{(0.30)(0.20)} = **1.10** **$mol^{-1}\,dm^3\,s^{-1}$**

**[1m] e.c.f from a(i)**

**[1m] correct ans (accept 2-3 s.f.), e.c.f from rate eqn**

***Accept "1.1"(exact value)***

**[1m] for units, e.c.f from rate eqn**

**ECF:** If student obtains rate = k $[CH_3CHO]^2\,[OH^-]$,

k = Rate / $[CH_3CHO]^2\,[\,OH^{--}\,]$

From Expt 1: k = 0.0110 / $[(0.10)^2(0.10)]$

= **11.0** **$mol^{-2}\,dm^6\,s^{-1}$**

***Accept "11"(exact value)***

**Specific Comments:**

**A few still gave rate equation = k $[CH_3CHO]\,[OH^-]$. *Some miss out answering this part* and move on to the calculations straight away. A small number made mistakes in the units.**

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**4** **(a)** **(iii)** Half-life of $CH_3CHO$ in expt 3 = ½(9) = **4.5 s** (or **sec./seconds**) **[1m] No e.c.f**

*{Explanation:* **Explanation not req'd.**

*From Rate = k [$CH_3CHO$][$OH^-$]*

*Þ Rate = k'' [$CH_3CHO$] where k'' = k[$OH^-$]*

*and $t_{1/2}$ of $CH_3CHO$ = ln 2/k'' = 9 s in expt 1*

*Comparing expt 1 & 3:*

- *[$CH_3CHO$] is tripled but this has no effect on the half-life of $CH_3CHO$ since the $t_{1/2}$ of $CH_3CHO$ is independent of [$CH_3CHO$]. The rxn is first order with respect to $CH_3CHO$.*
- *When [$OH^-$] is doubled, k'' is doubled.*

  *Thus $t_{1/2}$ of $CH_3CHO$ is halved.*

*l Half-life of $CH_3CHO$ in expt 3 = ½(9) = 4.5 s}*

**Specific Comments:**

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**Not well-done. Many cannot give the correct answers. Only a small number got this right. Students seem to have problem with this type of question asking for $t_{1/2}$.**

**Many incorrectly deduce 27s (as well as 9s) as the answer, seeing that the the [$CH_3CHO$] is tripled.**

**Another common value seen was 1.5s. This was due to students pointing out that [$CH_3CHO$] is tripled and [$OH^-$] is doubled.**

**(b)** **(i)** **Step 1** **[1m]**

The rate determining step involves only **one** molecule of **$CH_3CHO$** reacting **with/and/+ one $OH^-$** ion. **[1m]**

**ECF:** If student obtains rate = k [$CH_3CHO$]$^2$ [$OH^-$] in **4a(ii)**, accept Step **2** supported with appropriate reasoning ***or*** derive from equations.

**Specific Comments:**

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**A small number achieve full marks for the explanation. They miss out 'one' molecule and 'one' ion. None manage to get this part correct if they got the wrong rate equation from the previous part. Some still regard $OH^-$ ion as a molecule.**

**The only ECF allowed mentioned above was earned by a small no. of students. This was usually due to them concluding incorrectly**

rate = k [$CH_3CHO$]$^2$ [$OH^-$] in **4a(ii)**.

**4 (b) (ii)**

~~(ü) 3 humps~~

(ü) 3 humps

(ü) Axes labeled

~~(ü) Axes labeled~~

(ü) Reactants and products labelled

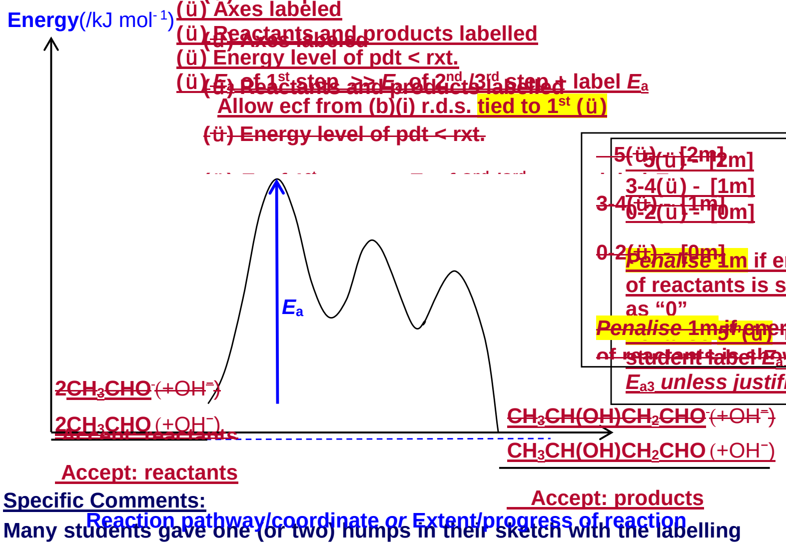
(ü) Energy level of pdt < rxt.

(ü) $E_a$ of 1st step >> $E_a$ of 2nd /3rd step + label $E_a$

~~(ü) Reactants and products labelled~~

Allow ecf from (b)(i) r.d.s. tied to 1st (ü)

~~(ü) Energy level of pdt < rxt.~~



~~5(ü) - [2m]~~

5(ü) - [2m]

3-4(ü) - [1m]

~~3-4(ü) - [1m]~~

0-2(ü) - [0m]

~~0-2(ü) - [0m]~~

*Penalise* 1m if energy of reactants is shown as "0"

~~*Penalise* 1m if energy of reactants is shown~~

*Penalise* 5th (ü) if student label $E_{a1}$, $E_{a2}$, $E_{a3}$ *unless justified*

**Specific Comments:**

**Many students gave one (or two) humps in their sketch with the labelling of $E_a$, reactants and products~~.~~, wrong label of x-axis as time or no of molecules (confusing with Boltzmann distribution).**

**The concept of (overall) $E_a$ of a reaction may need to be reinforced since many students use $E_{a1}$, $E_{a2}$, $E_{a3}$ in their labelling, without recognising that $E_{a1}$ is the (overall) $E_a$ of the forward reaction.**

**A number of students drew the following energy profile. Students were penalised 1m. It should be reiterated that intermediates, being less stable than reactants and products, usually exist for short period of time (or usually instantaneously) and as such, by drawing the following profile, it seems to indicate that intermediates exist for a significant period of time in the reaction.**

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**4 (b) (ii)**

~~(X) 3 humps~~

~~(ü) Axes labeled~~

~~(ü) Reactants and products labelled~~

~~(ü) Energy level of pdt < rxt.~~

(X) 3 humps

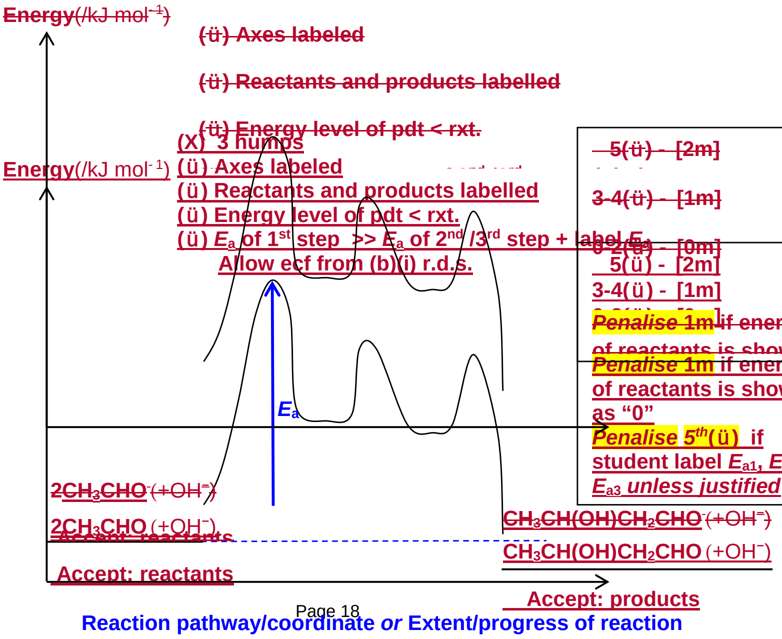
(ü) Axes labeled

(ü) Reactants and products labelled

(ü) Energy level of pdt < rxt.

(ü) $E_a$ of 1st step >> $E_a$ of 2nd /3rd step + label $E_a$

Allow ecf from (b)(i) r.d.s.



~~5(ü) - [2m]~~

~~3-4(ü) - [1m]~~

~~0-2(ü) - [0m]~~

5(ü) - [2m]

3-4(ü) - [1m]

~~*Penalise* 1m if energy of reactants is shown~~

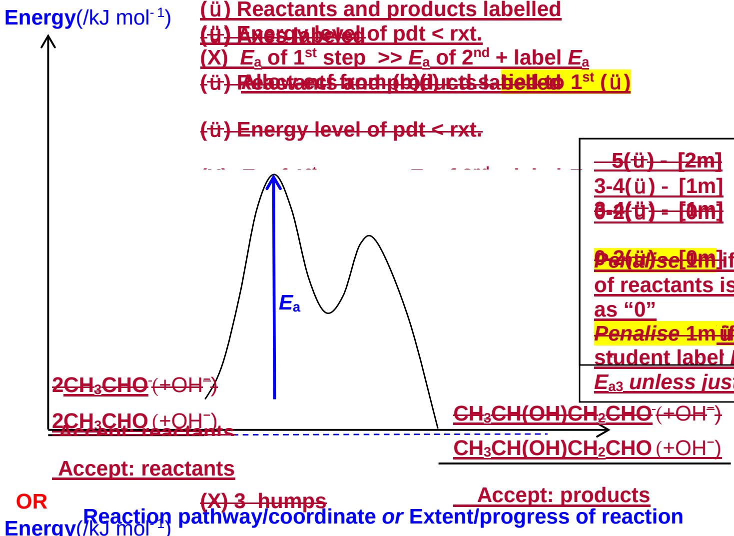
*Penalise* 1m if energy of reactants is shown as "0"

*Penalise* 5th (ü) if student label $E_{a1}$, $E_{a2}$, $E_{a3}$ *unless justified*

**4** **(b)** **(ii)** **OR**

(X) 3 humps
~~(X) 3 humps~~
~~(ü) Axes labeled~~
(ü) Reactants and products labelled
~~(ü) Axes labeled~~
(ü) Energy level of pdt < rxt.
(X) $E_a$ of 1st step >> $E_a$ of 2nd + label $E_a$
~~(ü) Reactants and products labelled~~
Allow ecf from (b)(i) r.d.s. tied to 1st (ü)

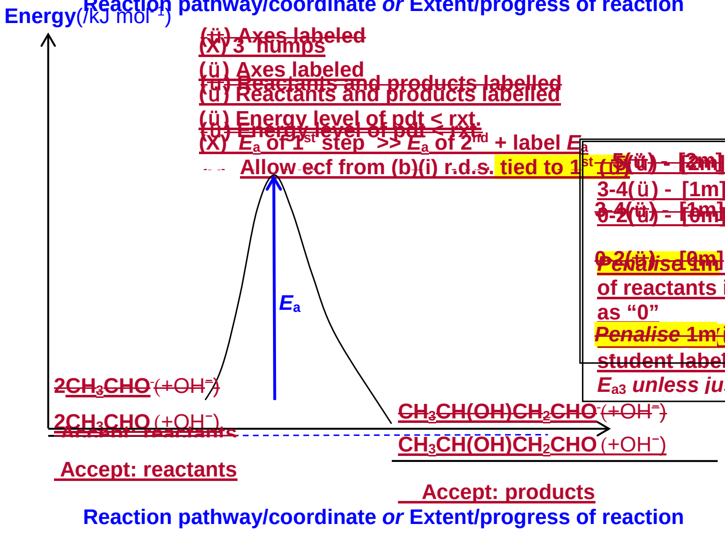
~~(ü) Energy level of pdt < rxt.~~



~~5(ü) - [2m]~~
3-4(ü) - [1m]
~~3-4(ü) - [1m]~~
~~0-2(ü) - [0m]~~
~~0-2(ü) - [0m]~~
~~*Penalise* 1m~~ (ü) if energy of reactants is shown as "0"
~~*Penalise* 1m if energy student label $E_{a1}$, $E_{a2}$, $E_{a3}$ unless justified~~

**(ii)** **OR**

~~(X) 3 humps~~
~~(ü) Axes labeled~~
(X) 3 humps
(ü) Axes labeled
~~(ü) Reactants and products labelled~~
(ü) Reactants and products labelled
(ü) Energy level of pdt < rxt.
~~(ü) Energy level of pdt < rxt.~~
(X) $E_a$ of 1st step >> $E_a$ of 2nd + label $E_a$
Allow ecf from (b)(i) r.d.s. tied to 1st (ü)



~~5(ü) - [2m]~~
3-4(ü) - [1m]
~~3-4(ü) - [1m]~~
~~0-2(ü) - [0m]~~
~~0-2(ü) - [0m]~~
~~*Penalise* 1m~~ (ü) if energy of reactants is shown as "0"
~~*Penalise* 1m if energy student label $E_{a1}$, $E_{a2}$, $E_{a3}$ unless justified~~

**(iii)** **Acid-base/ Neutralisation** reaction **[1m]**

**Specific Comments:**

**A large number gave 'nucleophilic substitution'. A small number gave 'free-radical substitution'.**

**4** **(b)** **(iv)** **Error! Objects cannot be created from editing field codes.** **(P) for $^{d+}$C and $^{d-}$O** **(P)**

Accept if **$^{-}$:$CH_2COH$** is drawn in place of $^{-}$:$CH_2CHO$. *Circle!*

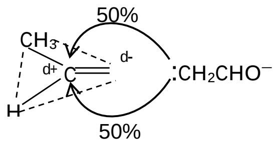
In Step 2, there is an **equal probability/possibility/chance** of the **$^{-}$:$CH_2CHO$/$^{-}CH_2CHO$/nucleophile attacking either side** (or **top or bottom**) **of** the trigonal **planar >C=O group**, producing an equimolar mixture of the two optical isomers. **(P)**

**3(P) – [1m]**
**0 – 2 (P) – [0m]**

***From Organic Summary Handbk (Section 2 pg. 19):***

**[1m]**

Arrangement around carbonyl C atom is trigonal planar. Hence there is equal probability of $^{-}$:$CH_2CHO$ nucleophile attacking either side of the plane, producing a racemic mixture (50:50 proportion of each optical isomer).



$^{-}$**:** $CH_2CHO$ can attack *from the top*

**OR**

$^{-}$**:** $CH_2CHO$ can attack *from the bottom*

**Specific Comments:**

**Some students gave carbocation as intermediate and wrote a 2-step mechanism instead. For the explanation, many students give planar carbonyl compound/molecule. A number drew the wrong nucleophile or the carbonyl compound (replace –CHO with -COOH).**

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**4** **(c)** **Error! Objects cannot be created from editing field codes.**

**Error! Objects cannot be created from editing field codes.** **Error! Objects cannot be created from editing field codes.**

**[1m] for each correct structure for <u>ANY 2</u>** of the 3 structures below

**<u>Specific Comments:</u>**

**A very small number got full marks. Most earned at least 1 mark. Many gave repetition of answers (mirror image of their 1st structure), or give wrong bond linkage. This question involved students using the 3-step mechanism given to deduce the possible products from this reaction.**

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**4 (d) (i)** **Cu$^{+}$** **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$** **Reject: [Ar] $3d^{10}$ *unless* [Ar] is defined**

**Cu$^{2+}$** **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$** **Reject: [Ar] $3d^9$ *unless* [Ar] is defined**

**[1m]**

**Specific Comments:**

**Generally well-done. Most students achieve full marks. There were still some who removed electrons from the 3d first before the 4s orbitals.**

**(ii)** Cu(II) / Cu$^{2+}$ ion has partially-filled d orbitals in its $3d^9$ configuration. Cu(II) / Cu$^{2+}$ complexes are coloured because electron transition between d orbitals is possible.

In a **Cu(II) / Cu$^{2+}$** complex, the presence of **ligands causes the** 3**d orbitals to split into 2 sets** of different energies. **(P)***

The **difference in energies** (DE) **between these two sets of d orbitals is** so **small** **(P)*** such that **radiation from the visible region/ visible light/ visible spectrum** of the electromagnetic spectrum **is absorbed** **(P)$^{\#}$** **when an electron moves/transits/excites/promotes/shifts/travels from a d orbital of lower energy to a partially filled/incompletely filled/ unfilled** (or **vacant) d orbital of higher energy**. **[1m]** Hence, copper(II) complexes are coloured.

**5(P) – [3m]**
**3 – 4 (P) – [2m]**
**2 (P) – [1m]**
**0 – 1 (P) – [0m]**

**(P)*– [1m]**
**(P)$^{\#}$– [1m]**

The **colour seen/reflected/transmitted** will be the **complement/ complementary of the colours absorbed**. **(P)$^{\#}$**

**Cu(I) / Cu$^{+}$** ion has **fully/completely/totally filled** 3**d orbitals** **OR** **no empty or partially filled** 3**d orbitals**.

Thus electron transitions between d-orbitals are not possible. Hence, copper(I) complexes are colourless.

**[1m]**

**Specific Comments:**

**Students generally score full marks for this part, if they have studied. Those who did not do well obviously did not study the topic well, especially on the aspect of ligands causing the splitting of d-orbitals.**

**There were a no. of rather short ans merely describing that Cu(I) / Cu$^{+}$ ion has fully/completely filled 3d orbitals OR no empty or partially filled 3d orbitals**

***and* Cu(II) / Cu$^{2+}$ ion has partially-filled d orbitals in its $3d^9$ configuration.**

**Students need to recognize the question clearly asks them to "explain…" and take note of the mark allocation in this part of the qns.**

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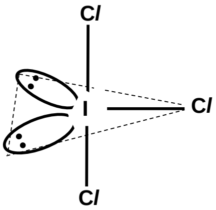
**General Comments for Q5**

**This is one of the most popular questions. Most students who attempted this question gained close to ten marks.**

**In this question, we found that most students could correctly identify the concept being tested in each part. However, they are unable to express their ideas using the correct scientific terms. See comments for individual parts for details.**

**Some students also make careless/ spelling mistakes in this question which caused them to lose a number of marks. Questions in which students demonstrated their carelessness include (a)(v); (b)(i).**

**5. (a) (i)**



*[dotted plane must be drawn]* **[1m]**

Shape: **T-Shaped/T shape** *[do not accept "t"]* **[1m]**

**Common mistakes:**

1. **Many students drew the lone pairs of electrons on the axial position instead of the equatorial positions. Could they have forgotten their year one's work on shapes of molecules?**
2. **In addition, a number of students actually written out the number of bond-pairs and lone-pairs correctly (3 bp, 2 lp), yet they cannot produce the correct molecular shape.**
3. **For those who got the shape right, they drew imprecise dotted lines.**
4. **Others left out drawing the dotted lines. A few left out the lobes for the lone pairs.**
5. **A large number of students drew dot-and-cross diagram for the $ICl_3$ molecule instead of shape of the molecule. Could it be they did not understand the requirement of the question or they do not know the shape at all?**

**5** **(a)** **(ii)** F is from Period 2 while I is from Period 5.

**I can expand its octet** structure/**accommodate more than 8 electrons** in its outer shell because it has **energetically accessible vacant d orbitals** but F cannot expand its octet structure. Thus $FCl_3$ does not exist. **[1m]**

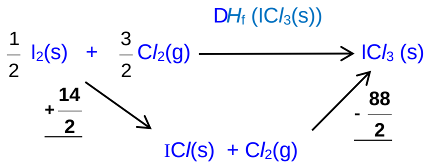
*[Note: circle wrong period no.]*

OR **F does not have energetically accessible vacant d orbital**s and hence it **does not allow expansion of octet/ accommodation of more than 8 electrons**. Thus $FCl_3$ does not exist.

**Common mistakes:**

1. **Instead of stating that F does not have energetically accessible vacant 3d orbitals to expand its octet structure, students stated $FCl_3$.**
2. **Students omit the word 'octet' or 'configuration' or 'structure' in their explanation.**
3. **This is the part with the most types of spelling mistakes. 'Octet' was frequently spelled as 'octect', expand was spelt wrongly too.**
4. **Students describe the vacant 3d orbitals as energetically 'feasible' instead of 'accessible'.**
5. **In addition, many students wrote "energetically accessible d orbitals" and forgot to add the word "vacant".**
6. **Two common misconceptions from students to account for why $FCl_3$ does not exist are (a) that 'F is a very small atom, so it cannot accommodate three Cl atoms around it as the resulting $FCl_3$ will be unstable' or (b) F is very electronegative, hence, F does not share its electrons, unlike iodine.**

**(iii)**

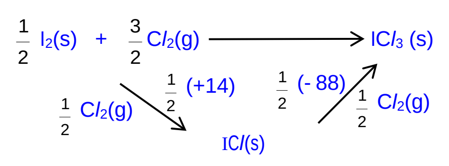


**[1m]** correct energy cycle (all equations are balanced with correct state symbols and correctly labeled

By Hess' Law: $\Delta H_f$ ($ICl_3$) = $+\frac{14}{2} + (-\frac{88}{2})$ = **–37 or –37.0** kJ mol$^{-1}$ **[1m]**

**Common mistakes:**

**1. The energy cycle is very often not balanced. One common type of wrong energy cycle is shown below (where $Cl_2$ (of various coefficients) is inserted at the arrows):**



**In the above cycle, we can see another common mistake, that is students did not label $\Delta H_f(ICl_3)$ although there is no penalty here.**

**2. One or more state symbols were also left out.**

**3. A good number of students did not realize that they need to half the value of the enthalpy changes, resulting in many leaving the answer as -74.0 kJ mol$^{-1}$.**

**4. A typical area for careless mistakes where the subtraction is incorrectly done for $\Delta H_f(ICl_3)$.**

**5** **(a)** **(iv)** $\Delta S^{\cdot}$ is negative due to a **decrease in disorder** as reaction proceeds with **decrease/drop in the number of gaseous particles/molecules** from 1.5 mol to 0 mol. **[1m]**

**Common mistakes:**

1. **Many students missed out on stating 'there was a decrease in disorder' when there is a negative entropy change.**
2. **A common misconception was that some students reasoned that 'the decrease in disorder is due the change of states from gaseous reactants to solid products' or due to 'mixing'.**
3. **We did not mark for the numerical value of changes in the amount of gas particles. However, we note that many students got the mark for part (iv) although they have used the wrong equation to deduce the answer. For instance, they often wrote that the 'decrease in disorder…….from 2 mol to 0 mol.' It is highly likely that they are referring to this equation for their answer: 2ICl(s) + $2Cl_2$(g) ® $2ICl_3$(s) instead of the formation of solid trichloride.**
4. **A small number of students wrote "gaseous ions" or "gaseous atoms" instead of "gaseous molecules".**

**(v)** D$H$ < 0, D$S$ < 0, **–TD$S_f$ >0**

D$G_{f'}$ = D$H_{f'}$– TD$S_{f'}$

At **low temperature**, **|–TDS |<|D$H$ |** (or **magnitude –TDS < D$H$ )** and thus **D$G_f$ < 0** (or **D$G_f$ is negative).** Since D$G_f$ < 0**,** reaction is spontaneous at low temperature. **[1m]**

**Common mistakes:**

1. **Many did not state the first point, i.e. - TDS > 0 or simply just state 'the sign of TDS is positive', the second of which is not helpful in their explanation.**
2. **Many misused the modulus sign, e.g., they stated that |DH| is negative.**
3. **A good number did not include the '- ' sign when they are comparing DH with - TDS**

**(vi)** D$G_{f'}$ ($ICl_3$) = D$H_{f'}$ ($ICl_3$) – TD$S_{f'}$($ICl_3$)

= **–37 –(298)(–225 ´ $10^{-3}$)** **[1m]** correct subst *in kJ mol$^{-1}$ or J mol$^{-1}$* *ecf(iii)*

= +**30.1** kJ mol$^{-1}$ **[1m]** *2 – 4 sf, in kJ mol$^{-1}$ or J mol$^{-1}$*

Since D$G_f$ > 0, formation of $ICl_3$ is **not spontaneous** at 298K. **[1m]** ***e.c.f from*** D$G_{f'}$

**Reject:**

1. Conclusion on whether the reaction is spontaneous or not if a value for D$G_f$ is not computed by students.

2. 'energetically feasible' in place of 'spontaneous'

**Note:**

2 marks are lost if the students substitute values that are not of the same units:

e.g. D$G_{f'}$ ($ICl_3$) = **–37 –(298)(–225 ´ $10^{-3}$)**

There is ecf from (a)(iii) if the units are consistent for all the values substituted.

**Common mistakes:**

1. **Some did not convert 225 to kJ mol$^{-1}$ K$^{-1}$, some carelessly substituted '255' instead of '225'.**
2. **Some thought that a positive DG meant spontaneous reaction!**

3. **Some used the term, 'energetically feasible' instead of 'spontaneous'**
4. **Some did not know the requirement of the question despite being a similar question to their tutorial on Entropy. These students did not calculate any value for $\Delta G$ to predict spontaneity of the reaction. Instead, they gave a qualitative explanation.**

**5. (b) (i)** **$K_{sp} = [Ag^+][I^-]$** **[1m]**

Let $y$ mol dm$^{-3}$ be the solubility of AgI at 25°C.

$AgI(s) = Ag^+(aq) + I^-(aq)$

$\qquad\qquad y \qquad\quad y$

$K_{sp} = [Ag^+][I^-]$

$8.52 \times 10^{-17} = y^2$

$\Rightarrow\ y = 9.23 \times 10^{-9}$

**$[Ag^+]$ = 9.23 x $10^{-9}$** mol dm$^{-3}$ **[1m] ecf from expression + 3sf**

**Reject:**

1. **$K_{sp}$ [AgI]**

**Common mistakes:**

1. **Students wrote expression for AgCl instead of AgI.**
2. **Even if expression is correct, students substituted wrong Ksp value for calculation.**
3. **Some also substituted wrong power in the Ksp value for calculation, e.g. $10^{-7}$ was used instead of the correct $10^{-17}$.**

**(ii)**

White ppt: **Ag*Cl*** **[1m] for the identities of ppt, which can be inferred from eqn/answer**

Yellow ppt: **AgI**

When $AgNO_3(aq)$ is added to Na*Cl*(aq), the white ppt formed is Ag*Cl*.

$Ag^+(aq) + 2NH_3(aq) \rightarrow Ag(NH_3)_2^+(aq)$ accept '='

OR $AgCl(s) + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq) + Cl^-(aq)$

**$AgCl(s) = Ag^+(aq) + Cl^-(aq)$ ------(*)**

When $NH_3(aq)$ is added, $Ag^+$ **forms** a soluble colorless **complex $Ag(NH_3)_2^+$**, resulting in a **decrease of $[Ag^+(aq)]$** causing the **equilibrium** position **of (*) to shift to the right**. Thus Ag*Cl* dissolves when excess $NH_3(aq)$ is added. **[1m]**

When NaI(aq) is added to $[Ag(NH_3)_2]^+$, the yellow ppt formed is AgI(s).

AgI is formed since

- **$K_{sp}$ of AgI** is much **smaller than $K_{sp}$ of Ag*Cl*** **[1m]**
- the ionic product of $[Ag^+][I^-]$ will be greater than $K_{sp}$ of AgI.

**Common mistakes:**

1. **Students did not state the identities of white and yellow ppt explicity. They probably did not understand from the question that they need to give the identities of the two ppt in their answers.**
2. **The second mark is also difficult to award to students as very few of them knew how to explain why the white ppt dissolves.**
3. **They also got the formula of the complex wrong, common**

**wrong formulae include AgOH, $AgNH_3$ (without the charge), $AgNH_4$, $AgNO_3$**

4. **For the third mark, instead of quoting the difference in Ksp values for the two silver halides as a reason for the different behaviours with ammonia, students said that the reason was because iodide ions was a stronger reducing agent than chloride ions/iodide is a stronger ligand than chloride.**
5. **Good students generally can answer the dissolving of AgCl in excess $NH_3$ but lost that mark due to missing state symbols in the equilibrium equation.**

**(c)** **(i)** **Misty/White fumes(or gas)** of $HCl$ will be observed.

**Orange-red/Orange/Orange-brown/Red-brown/brown fumes(or gas)** of $Br_2$ with pungent misty HBr(g) will be observed. **[1m]**

**$NaX + H_2SO_4 \rightarrow NaHSO_4 + HX$** where X = **Cl, Br** ***[accept ionic eqn]*** **[1m]**

**$2HBr + H_2SO_4 \rightarrow 2H_2O + SO_2 + Br_2$** **[1m]**

**$HBr/Br^-$ is a stronger reducing agent (or has greater reducing power)** than $HCl/Cl^-$. **[1m]**

Hence HBr can reduce conc. $H_2SO_4$ (O.S. of S = +6) to $SO_2$ (O.S. of S = +4) and itself oxidised to $Br_2$. But $HCl$ cannot reduce conc. $H_2SO_4$.

**Common mistakes:**

1. **More students gave the correct observations here.**
2. **A few of them stated 'brown solution/liquid' instead of 'brown fumes'.**
3. **Some left out the word, 'gas' , in their description and hence, lost the mark as it is not clear if the student meant solution or gas.**
4. **A number of them said that bromide ion is a stronger oxidising agent, instead of it being a stronger reducing agent.**
5. **Many did not even give an explanation for the difference in observations.**
6. **Some students wrote "$Na_2SO_4$" in place of "$NaHSO_4$" when trying to balance the first equation. A few incorrectly wrote "$H_2S$" in place of "$SO_2$" for the 2nd eqn for Br.**

**(ii)** **Very little HI left** for the reaction with alcohol since most of the HI formed will be oxidised to $I_2$. **[1m]**

OR

**Most of the HI** formed **will be oxidised to $I_2$** as HI is an even stronger reducing agent than HBr, while concentrated sulfuric acid is reduced to give mainly $H_2S$ and $SO_2$. Thus the remaining HI will not be enough (or too little HI left) to react with alcohol to give alkyl iodide.

**Common mistakes:**

1. **Many did not conclude that very little HI is left for the reaction even though they gave a reasonable explanation as to why the specified reaction is not used to prepare alkyl iodides. One logical reason that students propsed is that HI is unstable and hence, decomposes to $H_2$ and $I_2$ readily, and hence is hardly available to react with alcohol to give alkyl iodide.**
2. **Some students commented on the reducing power of HI instead and did not explain clearly how this could lead to the specified reaction not being used to prepare alkyl iodide.**