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### Question 1 (a) (i)

<table>
<thead>
<tr>
<th>m/e</th>
<th>identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>$^{35}\text{Cl}$</td>
</tr>
<tr>
<td>37</td>
<td>$^{37}\text{Cl}$</td>
</tr>
<tr>
<td>70</td>
<td>$^{35}\text{Cl}^{35}\text{Cl}$ or $^{35}\text{Cl}^{37}\text{Cl}$</td>
</tr>
<tr>
<td>72</td>
<td>$^{37}\text{Cl}^{35}\text{Cl}$</td>
</tr>
<tr>
<td>74</td>
<td>$^{37}\text{Cl}^{37}\text{Cl}$ or $^{37}\text{Cl}^{37}\text{Cl}$</td>
</tr>
</tbody>
</table>

35, 37, 70, 72, 74 correct formulae
at least one structure as a positive ion

1 1

### Question 1 (ii)

9:6:1

1 [4]

### Question 1 (b) (i)

Correct charges
Correct electrons

1 1

### Question 1 (b) (ii)

Lattice energy = $\Delta H_{\text{l}}(\text{SrCl}_2) - (\Delta H_{\text{at}}(\text{Sr}) + \Delta H_{\text{at}}(\text{Cl}) + \Delta H_{\text{at}}(\text{Cl}) + 2\Delta H_{\text{at}}(\text{Cl}))$

$= +(-830) - (+164 + 548 + 1060 + 242 + (2 \times -349))$

$= -2146$ (kJ mol$^{-1}$)

1 1

### Question 1 (c) (i)

$\text{SrCO}_3 + 2\text{HNO}_3 \rightarrow \text{Sr(NO}_3)_2 + \text{CO}_2 + \text{H}_2\text{O}$

1
| (ii) | \( \text{Sr(NO}_3\text{)}_2 \rightarrow \text{SrO} + 2\text{NO}_2 + 0.5 \text{O}_2 \) | 1 | [2] |
| (d) | (down the group) nitrates become more stable / require a higher temperature to decompose as size/radius of ion increases OR charge density of ion decreases so polarisation/distortion of anion/nitrate ion/NO\(_3^-\)/NO bond decreases | 1 | 1 | [3] |
| 2 (a) | \( \text{BrO}_3^- + 5\text{Br}^- + 6\text{H}^+ \rightarrow 3\text{Br}_2 + 3\text{H}_2\text{O} \) five correct species correct balancing | 1 | 1 | [2] |
| (b) (i) | [BrO\(_3^-\)] 1\(^{st}\) order and the concentration is x2, rate doubles OR evidence using expt 1 & 4 eg ratios [H\(^+\)] 2\(^{nd}\) order and the concentration is x2, rate x4 OR evidence using expt 1 & 2 [Br\(^-\)] 1\(^{st}\) order and the concentration is x4, rate x4 OR evidence using expt 1 & 3 eg ratios | 1 | 1 | 1 |
| (ii) | (Rate =) \( k \ [\text{BrO}_3^-][\text{Br}^-][\text{H}^+]^2 \) | 1 |
| (iii) | \( k = 1.32 \text{ mol}^{-3} \text{ dm}^9 \text{ s}^{-1} \) | 1 | 1 | [6] |
| 3 (a) (i) | chromium and copper | 1 |
| (ii) | (all orbitals have the) same energy | 1 |
| (iii) | correct id of one higher energy d orbital the other higher energy d orbital | 1 | 1 | [4] |
| (b) (i) | pale blue precipitate A Cu(OH)$_2$ OR [Cu(OH)$_2$(H$_2$O)$_4$]$^{2+}$ OR [Cu(NH$_3$)$_4$(H$_2$O)$_2$]$^{2+}$ OR [CuCl$_4$]$^{2-}$ solution B solution C | 1 | 1 | 1 |
| (ii) | solution B royal/deep/dark blue OR violet-blue solution C yellow/green | 1 | 1 |
| (iii) | redox OR oxidation of Cu OR reduction of Cu$^{2+}$ AND reducing agent/reductant | 1 | 6 |
| (c) | 3d-shell is full/3d$^{10}$/no vacant d-orbital/d-orbitals full electrons cannot move between orbitals OR transitions cannot occur | 1 | 2 |
| (d) | green/yellow orange/red AND blue/violet light is absorbed | 1 | 2 |
| 4 (a) | (HCl) stronger acid/more dissociated/ionised in solution (HCl has) more ions/higher concentration of ions | 1 | 2 |
| (b) (i) | A solution that resists changes in the pH/keeps pH fairly constant when small quantities/amounts/vols of acid/H$^+$ or base/OH$^-$ are added | 1 | 1 |
| (ii) | add (ethanoic acid) to NaOH OR an equation excess (ethanoic acid) OR mix with sodium ethanoate | 1 | 4 |
| (c) | CH$_3$CH(NH$_2$)COOH + H$^+$ $\rightarrow$ CH$_3$CH(NH$_3^+$)COOH CH$_3$CH(NH$_2$)COOH + OH$^-$ $\rightarrow$ CH$_3$CH(NH$_2$)COO$^-$ + H$_2$O | 1 | 2 |
(d) (i) 

\[
\text{HOOC} \quad \text{COOHH} \\
\quad \text{OH} \\
\quad \text{HOOC} \\
\quad \text{COOHOH} \\
\quad \text{H} \\
\quad \text{OH} \\
\quad \text{HOOC} \\
\quad \text{COOHOH} \\
\quad \text{H}
\]

\[\text{pKa 2.99} \quad \text{pKa 4.40}\]

\[
\text{HO} \quad \text{OH} \\
\quad \text{OR} \\
\quad \text{O} \\
\quad \text{OH} \\
\quad \text{O} \\
\quad \text{OH} \\
\quad \text{O}
\]

\[\text{pKa 2.99} \quad \text{pKa 4.40}\]

\[
\text{HOOC} \quad \text{COOHH} \\
\quad \text{OH} \\
\quad \text{HOOC} \\
\quad \text{COOHOH} \\
\quad \text{H} \\
\quad \text{OH} \\
\quad \text{HOOC} \\
\quad \text{COOHOH} \\
\quad \text{H}
\]

1

(ii)

\[
\text{(S, R)} \\
\quad \text{(R, S)} \\
\quad \text{(R, R)}
\]

any two of the above

2 [4]

5 (a)

any five of these seven points.

- \(\sigma\)-bonds are between C-C OR C-H
- carbons are sp\(^2\)
- rings of charge above and below the ring must be in diagram
- presence of \(\sigma\)-bonds
- electrons/bonds are delocalised
- planar molecule/bond angles 120\(^\circ\)
- all C-C are the same length/have intermediate bond length between C-C & C=C

5 [5]
(b) Reagent X e.g. Br₂, HNO₃, Na, NaOH, benzenediazonium salt/ion; RCOCI; Fe³⁺; H₂+Ni substituted product for L-DOPA & vanillin (examples given are for X = Br₂ and NaOH)

Reagent Y e.g. HCl; Na₂CO₃, Mg, SOCt₂; PCt₅, ROH + c.H₂SO₄; HCl+NaNO₂ / HNO₂; CH₃Cl Correct substituted product for L-DOPA

Reagent Z e.g. acidified Cr₂O₇²⁻; 2,4-DNPH, hydrazine; Fehling's, Tollens'; HCN; HCN + NaCN; NaBH₄ ; correct substituted product for vanillin

6 (a) (i) C₁₅H₂₁NO₂

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(ii) \[
\begin{align*}
\text{O} & \quad \text{OCH}_3 \\
\text{NHCH}_2\text{CH}_3 & \\
\end{align*}
\]

1

(iii) any two of ketone, amine or ether

2 [4]
(b)

(i) **LiAlH₄**

![Structure 1](image1.png)

Reduction / nucleophilic addition

(ii) **HCl (aq)**

![Structure 2](image2.png)

Acid-base / neutralisation

(iii) **CH₃COCl**

![Structure 3](image3.png)

Acylation / condensation

**allow** addition + elimination

**allow** nucleophilic substitution

1 mark for each correct structure
1 mark for each correct reaction type
<table>
<thead>
<tr>
<th>7 (a)</th>
<th>(ratio of) the concentrations / distribution / amount / mass of solute in two (immiscible) solvents at equilibrium OR equilibrium constant OR includes expression with $K$</th>
<th>1</th>
<th>[2]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$K_{pc} = [J \text{ in ether}] / [J \text{ in } H_2O]$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= \frac{2.14}{20}/(5-\frac{2.14}{75})$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 2.81 \text{ OR } 2.82$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1^{st}$ extraction: $2.81 = \frac{x}{10}/(5.0-x)/75$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2.81(5-x) = 7.5x$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$x = 1.36 \text{ g}$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2^{nd}$ extraction: $2.81 = \frac{y}{10}/(3.64-y)/75$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2.81(3.64-y) = 7.5y$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$y = 0.99 \text{ g}$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) water / solvent / named solvent</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) non-volatile liquid, for example mineral oil or at least a C$_{15}$ hydrocarbon oil</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) 1. $R_f$ (retardation factor) or distance travelled by solute and distance by solvent</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. retention time</td>
<td>1</td>
<td>[4]</td>
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</tbody>
</table>
(e)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Mark</th>
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</thead>
<tbody>
<tr>
<td>CO₂H</td>
<td>2</td>
</tr>
<tr>
<td>CH₂OH</td>
<td>1</td>
</tr>
<tr>
<td>CO₂H</td>
<td>3</td>
</tr>
</tbody>
</table>

8  (a)  
C = 33%  
A = T = 17%  

(b) (i) only one isomer may be active/be of therapeutic benefit  

(ii) the other (stereo) isomer may cause harm/side effects
(c) (i) structures of the following aldehydes:

- [Structure 1]
- [Structure 2]
- [Structure 3]
- [Structure 4]

Two correct structures = 1 mark
Two further correct structures = 1 mark

(ii) 3-methylbutanal

(iii)pentanal 5 absorptions
       2-methylbutanal 5 absorptions
       dimethylpropanal 2 absorptions

9 (a) nylon, terylene – condensation; PVC – addition – all three correct

(b) correct fully displayed formula of -CO-NH- unit
    correct polymer structure

(c) **sequence/order of amino acids** (in the polypeptide chain)

(d) hydrogen bond
    C=O and N-H in two different amino acids in the backbone diagram
(e) (i) disrupts hydrogen/ionic bonds as –COOH/NH₃⁺ is deprotonated
OR –NH₃⁺ + OH⁻ → NH₂ + H₂O linked to hydrogen/ionic bond disrupted
OR–COOH + OH⁻ → –COO⁻ + H₂O linked to hydrogen/ionic bond disrupted

(ii) Hg²⁺ interferes with/breaks the disulfide bond/bridge not sulfite, sulfate, sulfur, sulfide
OR -S-S- shown with Hg²⁺ in an equation
OR disrupting ionic interactions linked to carboxyl/COO⁻ groups

(iii) (Heat to 70 °C) breaks the van der Waals' forces/hydrogen bonding