## Multiple Choice Answers

Q32: D



## Multiple Choice Answers

Q40: D



<table>
<tr><td>3(a)(i)</td><td>M1 Heat (solid FA 5)<br>AND<br>observe condensation, droplets, steam, water vapour<br><br>M2 Make an aqueous solution of FA 5 / dissolve in water to use for tests<br><br>M3 (To portion of the solution) add aqueous $NH_3$<br>AND<br>white ppt AND insoluble in excess $NH_3$<br><br>M4 (To portion of the solution) add aqueous barium chloride or barium nitrate<br>AND<br>white precipitate<br><br>M5 to distinguish sulfate / sulfite<br>(white precipitate from M4) insoluble in hydrochloric OR nitric acid<br>OR<br>$KMnO_4$ is not decolourised / remains purple (added after M4 or directly to FA 5 (aq))</td></tr>
<tr><td>3(a)(ii)</td><td><table><tr><td>$Zn^{2+}$</td><td>X</td></tr><tr><td>$SO_4^{2-}$</td><td>✓</td></tr><tr><td>$H_2O$</td><td>✓</td></tr></table></td></tr>
<tr><td>3(b)(i)</td><td>• (FA 6) starting colour purple<br>• solid jumps / moves around<br>• black residue<br>• test with glowing splint<br>• splint relights / glows more brightly</td></tr>
<tr><td>3(b)(ii)</td><td>(dark) Green</td></tr>
</table>

3(c)(i)

'No change' 2 correct = *, 3 correct = **

2* = 1 mark

Max mark = 4

| *test* | *observations* | | |
|---|---|---|---|
| | **FA 7** | **FA 8** | **FA 9** |
| **Test 1**<br>Add<br>hydrogen peroxide | Bubbles/ effervescence *<br><br>Purple / **FA 7** (solution) to colourless (solution) *<br><br>(Gas / oxygen) relights glowing splint * | No change | Bubbles / effervescence *<br><br>(Gas/ oxygen) relights glowing splint * |
| **Test 2**<br>Add<br>sodium hydroxide, then | | Off-white ppt* | No change |
| leave to stand | | brown ppt on standing* | |
| **Test 3**<br>Add aqueous iron(II) sulfate | Turns colourless / yellow **OR** colourless / yellow solution formed* | No change | |

3(c)(ii)

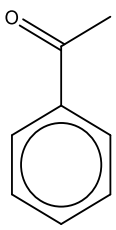
manganese / Mn

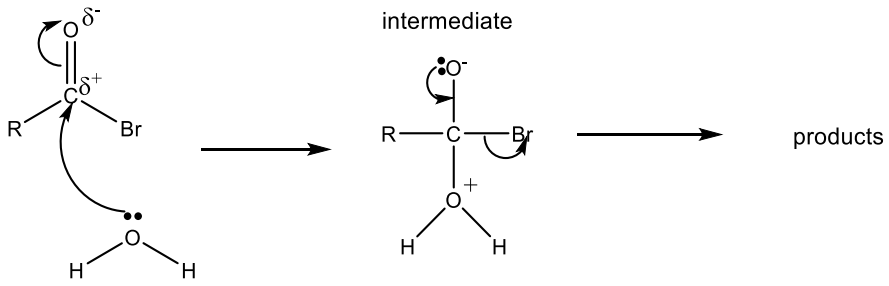
3(c)(iii)

| | **FA 6 / FA 7** | **FA 8** |
|---|---|---|
| oxidation state | (+)7 | (+)2 |

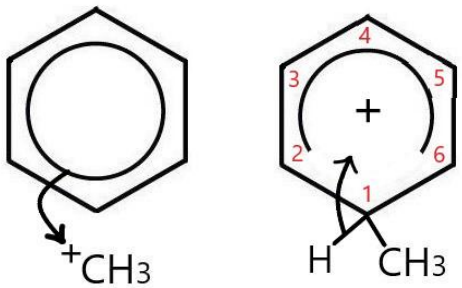
| | |
|---|---|
| 1(a)(i) | $Sr(HCO_3)_2 \rightarrow SrCO_3 + CO_2 + H_2O$ |
| 1(a)(ii) | **M1**: radius of cation / $M^{2+}$ increases **OR** charge density of cation / $M^{2+}$ decreases<br><br>**M2**: less polarisation / less distortion of the anion / carbonate ion |
| 1(b) | **M1**: least soluble $CaF_2 < SrF_2 < BaF_2$ most soluble<br><br>**M2**: $\Delta H_{latt}$ and $\Delta H_{hyd}$ both become less exothermic / less negative<br><br>**M3**: $\Delta H_{hyd}$ changes less / becomes less exothermic by a smaller extent<br>**OR** $\Delta H_{latt}$ changes more / becomes less exothermic by a larger extent<br><br>**M4**: $\Delta H_{sol}$ becomes more exothermic / more negative |
| 1(c)(i) | enthalpy change when one mole of gaseous ions dissolve in water to form a solution |
| 1(c)(ii) | **M1**: ionic radii **AND** ionic charge<br><br>**M2**: (ionic) radii increase / charge density decreases **AND** $\Delta H_{hyd}$ decreases/less exothermic **AND** less attraction between water molecules and (gaseous) ions<br>**OR**<br>as ionic charge increases / charge density increases **AND** $\Delta H_{hyd}$ increases/more exothermic **AND** more attraction between water molecules and (gaseous) ions |
| 1(d) | **M1**: use of –2957 / –1926 / –505 **AND** 2 × (–505)<br><br>**M2**: correct signs and evaluation<br><br>$\Delta H_{sol}$ of $MgF_2(s) = -1926 + (2 \times -505) - (-2957) = (+)21$ kJ mol$^{-1}$ |
| 1(e)(i) | **M1:** $K_{sp} = [Hg_2^{2+}] [F^-]^2$<br><br>**M2:** units = mol$^3$ dm$^{-9}$ |
| 1(e)(ii) | $K_{sp} = 2^2 \times (9.20 \times 10^{-3})^3 =$ **$3.11 \times 10^{-6}$** min 2sf |
| 2(a) | the (3)d and (4)s sub-shells / orbitals / electrons are close / similar in energy |
| 2(b) | species or ion formed by a central metal atom/ion **AND** surrounded by/bonded to (one or more) ligands |
| 2(c)(i) | NaOH / $OH^-$(aq) **AND** precipitation / ligand exchange / deprotonation / acid–base |
| 2(c)(ii) | **M1**: $Fe(H_2O)_4(OH)_2$ is oxidised (from + 2 to + 3 on standing)<br><br>**M2**: $E^\ominus$ of $Fe(H_2O)_3(OH)_3$ is more negative than $E^\ominus$ of $O_2$<br>**OR** $E^\ominus_{cell} = 0.40 - (-0.56) = (+)0.96$ V<br><br>**M3**: $4Fe(H_2O)_4(OH)_2 + O_2 \rightarrow 4Fe(H_2O)_3(OH)_3 + 2H_2O$ |
| 2(d) | $\Delta G^\ominus = -2 \times 1.67 \times 96\,500 = -322\,310$ J mol$^{-1}$<br><br>**M1:** $\Delta G^\ominus = -nE^\ominus_{cell}F$ **AND** n = 2<br>**OR** $-2 \times 1.67 \times 96\,500$<br><br>**M2:** $\Delta G^\ominus = -322.3$ kJ mol$^{-1}$ |

| | |
|---|---|
| 3(a) | heterogeneous **AND** $MnO_2$ is in a different state / phase to the reactants / $H_2O_2$ |
| 3(b)(i) | **M1:** (expt 2 and 3) $[I^-] \times 2$ initial rate $\times 2$ so 1st order wrt $[I^-]$<br><br>**M2:** (expt 1 and 2) $[I^-] \times 2$, $[H_2O_2] \times 0.5$ initial rate $\times 1$ so 1st order wrt $[H_2O_2]$<br>**OR** (expt 1 and 4) $[I^-] \times 4$ initial rate $\times 4$ **AND** $[H^+] \times 4$ so zero order wrt $[H^+]$<br>**OR** (expt 1 and 3) $[I^-] \times 4$, $[H_2O_2] \times 0.5$ initial rate $\times 2$ so 1st order wrt $[H_2O_2]$<br><br>**M3:** (expt 1 and 4) $[I^-]$ x 4 , $[H^+] \times 4$ initial rate $\times 4$ so zero order wrt $[H^+]$<br>**OR** (expt 3 and 4) $[H_2O_2] \times 2$ initial rate $\times 2$**AND** $[H^+]$ x 4 so zero order wrt $[H^+]$<br>**OR** (expt 3 and 4) $[H_2O_2] \times 2$, $[H^+] \times 4$ initial rate $\times 2$ so 1st order wrt $[H_2O_2]$<br><br>**M4:** rate = $k$ $[H_2O_2]$ $[I^-]$ **OR** rate = $k$ $[H_2O_2]$ $[I^-]$ $[H^+]^0$ |
| 3(b)(ii) | **M1:** $k = 2.42 \times 10^{-3} \div (0.045 \times 0.030) = 1.79$ min 2sf<br><br>**M2:** units = $dm^3\ mol^{-1}\ s^{-1}$ |
| 3(c)(i) | **M1:** calculation of one $t_{1/2} = 60\ s \pm 5\ s$<br><br>**M2:** two $t_{1/2}$ calculated that are constant |
| 3(c)(ii) | $k = \ln 2 \div 60 = 0.0116$ **OR** $k = 0.693 \div 60 = 0.0116$ min 2sf |
| 3(d) | increases $k$ and increases the rate of reaction |

| | |
|---|---|
| 8(a)(i) | $NO_2$ group directs to 3 (and 5) / meta position **AND** due to being an electron-withdrawing / electronegative group |
| 8(a)(ii) | $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$<br>**OR** $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$ |
| 8(b)(i) |  |
| 8(b)(ii) | **M1:** (reaction 1) ethanoyl chloride / $CH_3COCl$ **AND** $AlCl_3$<br><br>**M2:** (reaction 2) 2-bromopropane / $(CH_3)_2CHBr$ **AND** $FeBr_3$ |
| 8(c) | **M1:**<br>with $C_6H_5Br$ no change / no precipitate **AND**<br>with $C_6H_5CH_2Br$ cream precipitate<br><br>in $C_6H_5Br$<br>**M2:** lone pair / p-orbital on Br delocalised / overlaps with ring / $\pi$ system<br><br>**M3:** C–Br bond stronger / has partially double bond character |

| | |
|---|---|
| 8(d)(i) | (nucleophilic) addition–elimination |
| 8(d)(ii) |  <br>**M1 M2:**<br>• lone pair on O<br>• curly arrow from (lone pair) O (in $H_2O$) to C (of C=O)<br>• correct dipole on C=O<br>• curly arrow from the C=O bond to O atom<br>any two [1], all four [2]<br><br>**M3:** correct intermediate<br><br>**M4:** curly arrow from (lone pair on) $O^{(-)}$ to C–O bond **AND** curly arrow from C–Br to Br |



| | |
|---|---|
| 9(a) | • all C atoms are $sp^2$ hybridised<br>• bonds between C atoms are σ and π<br>• C–C σ bonds are formed by overlap of $sp^2$ hybrid orbitals<br>• C–C π bonds are formed by overlap of p orbitals<br>• bonds between C and H atoms are σ<br>• C–H bonds are formed by overlap of $sp^2$ hybrid orbitals and s orbitals<br><br>Any two [1], any four [2], all six [3] |
| 9(b) | $CH_3Cl$ and $AlCl_3$ |
| 9(c) |  <br>**M1:** curly arrow from within hexagon towards $^+C$<br>**M2:** intermediate, usual rules for horseshoe and + charge<br>**M3:** curly arrow from C–H bond into ring **AND** $H^+$ product |
| 9(d) | **M1:** $HNO_3$ **AND** $H_2SO_4$<br>**M2:** concentrated **AND** 25 °C ⩽ T ⩽ 60 °C |
| 9(e) | alkaline $KMnO_4$ |
| 9(f) | 4-nitrobenzoic acid |
| 9(g) | (hot) concentrated HCl and Sn |
| 9(h) | **M1:** perform step 3 before step 2 **OR** perform step 2 before step 1<br><br>**M2:** COOH is 3-directing **OR** $NO_2$ is 3-directing |