

Question	Expected Answers	Marks
1 a	A = benzene; B = propene;	2
1 b	Advantage = sale of co-product adds to profit/less waste to dispose of; Disadvantage = separation of co-products is costly/different demands for each product;	2
1 c i	Electrophilic; substitution;	2
1 c ii	AlCl <sub>3</sub> polarises the propene molecule; the $\delta^+$ carbon; reacts with the benzene ring; (clearly labelled diagram acceptable)	3
1 d i	Tube connected with no leaks; Production of vapour; Vapour contacts catalyst; Liquid product is condensed/H <sub>2</sub> (g) collected or vented safely;	4
1 d ii	Acidified; potassium dichromate; reflux; (allow formulae if correct)	3
1 d iii	Orange; to green-blue;	2
1 e	Infra-red: C=O; at $\sim 1700\text{ cm}^{-1}$ ; n.m.r.: only one signal; implies only one type of <sup>1</sup> H; OR peak at 2.2; suggests -CO-CH <sub>3</sub> ; Mass spec: molecular ion peak at 58; matches M <sub>r</sub> of propanone (allow loss of -CH <sub>3</sub> ; to give fragment at 43;)	6
1 f i	Same type of bonds present so same absorptions; Strong absorption at $1700\text{ cm}^{-1}$ for C=O; Both have C-H and C=O bonds; (2 marks for 2 points made)	2
1 f ii	Mass spec/ <sup>1</sup> H nmr/ <sup>13</sup> C nmr/glc;	1

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2 a	+5; +3; -3; max 2 if signs after numbers	3
2 b i	Powerful proton ( $H^+$ ) donors (AW);	1
2 b ii	$pH = -\log[H^+(aq)]$ / measure of $[H^+(aq)]$ ;	1
2 b iii	$[H^+] = 0.015 \text{ mol dm}^{-3}$ (stated or implied); $pH = 1.82$ ;	2
2 c i	$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$ right hand side correct; balanced; state symbols;	3
2 c ii	$[OH^-] = 2 \times 0.00250 = 0.005 \text{ mol dm}^{-3}$ ; $K_w = 1 \times 10^{-14} = [H^+][0.005]$ ; $[H^+] = 2 \times 10^{-12} \text{ mol dm}^{-3}$ ; $pH = 11.7$ ;	4
2 d i	Layered structure; Silicate/aluminate sheets; <u>Surface of layers negatively charged;</u> <u>Charges on <math>NH_4^+</math> and <math>NO_3^-</math> identified;</u> $NH_4^+$ attracted to surface but $NO_3^-$ passes through; (+ 1 mark for QWC)	5 + 1
2 d ii	$Na^+(aq)$ shown; $NH_4^+$ shown attached to the clay surface; $\rightarrow Na^+$ attached to the clay surface and $NH_4^+(aq)$ shown;	3
2 d iii	Ion exchange/elution	1

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3 a i	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$	1												
3 a ii	Al; gains oxygen/loses electrons/oxidation state becomes more positive;	2												
3 a iii	Allow $Cl_2$ produced in electrolysis method - toxic Heat energy needed to make $SrCl_2$ molten is expensive /cost of electricity is high; (NOT just 'expensive')	1												
3 b	For each example there should be a description of the structure (arrangement of atoms relative to each other) and the bonding (how the atoms are held together). Max 3 marks for each substance to include 1 mark each for structure, bonding, relevant detail. (1 mark for QWC)  <table style="width: 100%; border-collapse: collapse;"> <tr> <td></td> <td style="text-align: center;">Al</td> <td style="text-align: center;">SrS</td> <td style="text-align: center;">CO<sub>2</sub></td> </tr> <tr> <td>Structure</td> <td style="text-align: center;">metallic (giant)</td> <td style="text-align: center;">ionic (giant)</td> <td style="text-align: center;">simple molecular/ simple covalent</td> </tr> <tr> <td>Bonding</td> <td style="text-align: center;">attraction of nuclei for deloc. e<sup>-</sup>s</td> <td style="text-align: center;">attraction between ions (+/-)</td> <td style="text-align: center;">weak intermol. forces between molecules, strong cov. bonds betw. atoms within mols</td> </tr> </table>		Al	SrS	CO <sub>2</sub>	Structure	metallic (giant)	ionic (giant)	simple molecular/ simple covalent	Bonding	attraction of nuclei for deloc. e <sup>-</sup> s	attraction between ions (+/-)	weak intermol. forces between molecules, strong cov. bonds betw. atoms within mols	9 + 1
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3 c i	$Sr^+(g) \rightarrow Sr^{2+}(g) + e^-$ equation; state symbol;	2												
3 c ii	1 <sup>st</sup> & 2 <sup>nd</sup> ionisation enth. - low (removal of $3s^2$ & $5s^2$ e <sup>-</sup> s); Sharp increase between 2 <sup>nd</sup> and 3 <sup>rd</sup> because it is more difficult to remove e <sup>-</sup> s from inner core (2p and 4p);	2												
3 c iii	Sum of the 1 <sup>st</sup> and 2 <sup>nd</sup> ionisation enthalpies is less for Sr than for Mg; Indicates that Sr forms 2+ ions more readily than Mg;	2												
3 c iv	Positive Sr ion labelled; surrounded by more than two water molecules; correct structure of water shown with O(- shown at least once;	3												
3 d i	$\Delta H_2$ ; $\Delta H_5$ ; $\Delta H_6$ (or $\Delta H_6/2$ ); $\Delta H_1$ ;	4												
3 d ii	$\Delta H_{LE} = \Delta H_1 - \Delta H_2 - \Delta H_3 - \Delta H_4 - \Delta H_5 - \Delta H_6$	1												
3 d iii	$= -829 - [+164 + 550 + 1064 + (2 \times 122) + (2 \times -349)]$ $= -2153 \text{ kJ mol}^{-1}$	2												

Question	Expected Answers	Marks
4 a i	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>2 marks</p> </div> <div style="text-align: center;"> <p>1 mark</p> </div> </div>	2
4 a ii	Group of atoms conferring pharmacological activity on a molecule; (AW)	1
4 b i	Optical isomer/non-superimposable mirror image	1
4 b ii	Mirror image drawn correctly; Chiral centre clearly indicated;	2
4 b iii	3 out of the following 4 points:- one isomer/enantiomer fits precisely; into shape of receptor/active site; functional groups correctly positioned; for reaction;	3
4 b iv	Are compounds which show promise as new drugs/medicines but which need modification;	1
4 b v	Molecular modelling	1

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5 a	Two from: Monitoring is expensive; Distillation expensive because heat energy required; Reactant/feedstock/ $\text{Cl}_2$ is expensive/dangerous; Disposal of waste gases (acid/toxic);	2
5 b i	Simple molecular structure; Strong covalent bonds between Ti-Cl; Weak intermolecular attractions (instantaneous – induced dipole) between molecules; Little energy required to overcome; Reason why non-conducting; (1 mark for QWC)	5 + 1
5 b ii	$\text{TiCl}_4(\text{l}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{TiO}_2(\text{s}) + 4\text{HCl}(\text{aq})$ Products; balanced; state symbols; (allow correct equation showing $\text{Ti}(\text{OH})_4$ )	3
5 c	Excited electrons; Drop back to lower energy levels; Emitting energy in the form of electromagnetic radiation/light/photon; $\Delta E = h\nu$ stated/implied; the frequencies/wavelengths emitted are characteristic for each element;	5
5 d i	Ester link correct (at least one); Rest of molecule correct; Water shown; Balanced;	4
5 d ii	Condensation/esterification;	1
5 d iii	Presence of oxygen; Generation of radicals; Cross-linking of unsaturated groups;	3
5 d iv	Different components have different retention times; Peak height/area gives measure of amount of each component; Ratio of palmitate:stearate esters in unknown oil measured; Compared to ratio in known oils;	4