

Markscheme

Specimen paper

Chemistry

Higher level

Paper 2

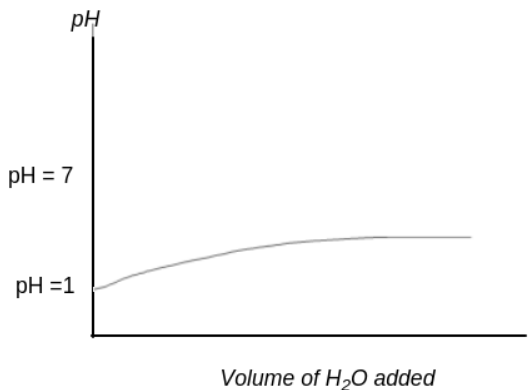
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Question			Answers	Notes	Total
1.	(a)		$n_{\text{C}} = \frac{39.99 \text{ g}}{12.01 \text{ g mol}^{-1}} = 3.33 \text{ «mol»}$ $n_{\text{H}} = \frac{6.73 \text{ g}}{1.01 \text{ g mol}^{-1}} = 6.66 \text{ «mol»}$ $n_{\text{O}} = \frac{53.28 \text{ g}}{16.00 \text{ g mol}^{-1}} = 3.33 \text{ «mol»} \checkmark$ $\text{CH}_2\text{O} \checkmark$		2
1.	(b)		$n_{\text{HX}} (= n_{\text{NaOH}}) = 0.750 \text{ «mol dm}^{-3}\text{»} \times 0.02230 \text{ «dm}^3\text{»} / 0.0167 \text{ «mol»} \checkmark$ $M_{\text{HX}} = \left(\frac{1.51 \text{ g}}{0.0167 \text{ mol}} \right) = 90.4 \text{ g mol}^{-1} \checkmark$	Accept 90.3 «g mol ⁻¹ ».	2
1.	(c)		$\text{C}_3\text{H}_6\text{O}_3 \checkmark$	Accept consistent feasible structural formula.	1
1.	(d)		carboxyl/COOH $\checkmark$	Do not accept “carbonyl/C=O”.	1
1.	(e)	(i)	Y: O-H/hydroxyl «with hydrogen bonding» AND Z: C=O/carbonyl «in carboxylic acid» $\checkmark$		1
1.	(e)	(ii)	$\begin{array}{c} \text{H} \\ \\ \text{H}_3\text{C} - \text{C} - \text{COOH} \\ \\ \text{OH} \end{array}$ OR $\text{HO}-\text{CH}_2-\text{CH}_2-\text{COOH} \checkmark$		1

Question			Answers	Notes	Total
2.	(a)	(i)	repelled by «hitting/close contact with» gold nucleus ✓		1
2.	(a)	(ii)	atom is mainly empty space/vacuum OR nucleus is very small «compared to the size of the atom» ✓		1
2.	(b)	(i)	discrete/series of lines of different frequency/wavelength ✓		1
2.	(b)	(ii)	energy of photon relates to a frequency «in the spectrum» ✓ energy of photon depends on difference in energy levels ✓		2
2.	(b)	(iii)	5250 «kJ mol ⁻¹ » ✓		1
2.	(b)	(iv)	H half/lower nuclear charge/number of protons ✓ H larger/double radius ✓		2
2.	(b)	(v)	electron-electron interactions «need to be taken in account» ✓		1
2.	(c)		<i>Any one of:</i> new evidence new technology developments in related models models incomplete/failed to account for all observations ✓		1

Question			Answers	Notes	Total
3.	(a)		Li(CoO₂)₂ + Li⁺ + e⁻ → 2LiCoO₂ ✓ Species moving: Lithium ions/Li⁺ ✓ Li → Li⁺ + e⁻ ✓		3
3.	(b)	(i)	$\Delta H_{\text{discharge}}$: negative AND E_{cell} : positive AND $\Delta G_{\text{discharge}}$: negative ✓		1
3.	(b)	(ii)	$\Delta G_{\text{recharge}} > \Delta G_{\text{discharge}}$ ✓		1
3.	(c)	(i)	separate curves/lines for Li and K sketched AND both increasing ✓ steeper gradient for Li OR curve/line for Li higher ✓		2
3.	(c)	(ii)	equal masses «of different substances» do not contain equal amounts/moles ✓		1
3.	(c)	(iii)	«Avg electronegativity = 1.8 Δ electronegativity = 1.6» % covalent character = 45-55 ✓ ionic ✓		2
3.	(c)	(iv)	$\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus = -62 - 298 \times -0.011 =$ $-59 \text{ «kJ mol}^{-1}\text{»}$ ✓		1

Question			Answers	Notes	Total
3.	(c)	(v)	$[:C\equiv C:]^{2-}$ 2- charge ✓ $:C\equiv C:$ ✓		2
3.	(c)	(vi)	sp ✓		1

Question			Answers	Notes	Total
4.	(a)	(i)	 start at pH = 1 ✓ curve with decreasing gradient ✓ must finish below pH = 7 ✓		3
4.	(a)	(ii)	$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$ OR $K_a = \frac{[H^+]^2}{[CH_3COOH]}$ OR $pK_a = 2pH - 1$ OR $pH = \frac{pK_a + 1}{2} = \checkmark$ 2.88 ✓		2

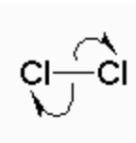
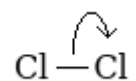
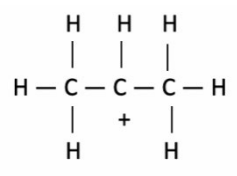
Question			Answers	Notes	Total
4.	(b)	(i)	Oxidation state: +3 ✓ Charge of complex ion: 2+ ✓		2
4.	(b)	(ii)	two chlorides covalently bonded/coordination bond to cobalt ion ✓ one chloride ionically bonded to complex ion ✓		2
4.	(b)	(iii)	3d sub-level split in presence of ligands ✓ light is absorbed when electrons promoted between split-levels ✓ colour seen is complementary to the light absorbed ✓		3
4.	(b)	(iv)	complex $[\text{Co}(\text{NH}_3)_6] \text{Cl}_3$ ✓ absorbs blue-purple light/wavelength 424 nm/shortest wavelength/highest energy ✓		2

Question			Answers	Notes	Total
5.	(a)		$\text{C}_{17}\text{H}_{36}(\text{l}) + 26\text{O}_2(\text{g}) \rightarrow 17\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\text{l}) \checkmark$		1
5.	(b)	(i)	$n_{\text{C}_{17}\text{H}_{36}} = \ll \frac{2.00 \text{ g}}{[(17 \times 12.01 \text{ g mol}^{-1}) + (36 \times 1.01 \text{ g mol}^{-1})]} = \frac{2.00 \text{ g}}{240.53 \text{ g mol}^{-1}} = \gg$ $0.008315/0.00831 \text{ «mol»} \checkmark$ $\ll \text{energy} = 11350 \text{ kJ mol}^{-1} \times 0.008315 \text{ mol} = \gg 94.4 \text{ «kJ»} \checkmark$		2
5.	(b)	(ii)	$94\,400 = 500.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ K}^{-1} \times \Delta T \checkmark$ $\Delta T = 45.2 \text{ «K»} \checkmark$		2
5.	(b)	(iii)	<i>Any two:</i> water does not evaporate $\checkmark$ heat is not lost to the surroundings OR all heat is transferred to the water $\checkmark$ density of water is $1 \text{ g cm}^{-3} \checkmark$ water is pure $\checkmark$ complete combustion $\checkmark$		2 max

Question			Answers	Notes	Total
5.	(c)		CO ₂ consumed while plant is growing «and later released when biofuel is combusted» OR photosynthesis uses up CO ₂ «later released when biofuel is combusted» ✓		1
5.	(d)	(i)	bonds broken: 4(C – C) / 4 × 346 ✓ bonds formed: 2(C=C) / 2 × 614 ✓ $\Delta H^\ominus = \text{«}4 \times 346 \text{ kJ} - 2 \times 614 \text{ kJ} / 1384 \text{ kJ} - 1228 \text{ kJ} = \text{»}$ $\Delta H^\ominus = \text{«}+ \text{»}156 \text{ «kJ»}$ ✓	Award [3] for correct final answer.	3
5.	(d)	(ii)	« $\Delta H = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$ » $\Delta H = (-311.5 + 2(52.0)) - (-393.9)$ ✓ $\Delta H = \text{«}+ \text{»}186.4 \text{ «kJ mol}^{-1}\text{»}$ ✓		2
5.	(d)	(iii)	(d)(ii) more accurate than (d)(i) as bond energies are average values OR (d)(ii) more accurate than (d)(i) as not specific to bonds in the reaction ✓		1
5.	(d)	(iv)	positive AND increase in number of moles/molecules «of gas» ✓		1
5.	(d)	(v)	$\Delta H > 0$ «and $\Delta S > 0$ » AND reaction spontaneous if $\Delta G \text{ «} = \Delta H - T\Delta S \text{»} < 0$ ✓ at high«er» T reaction «more» spontaneous/ ΔG «more» negative ✓		2

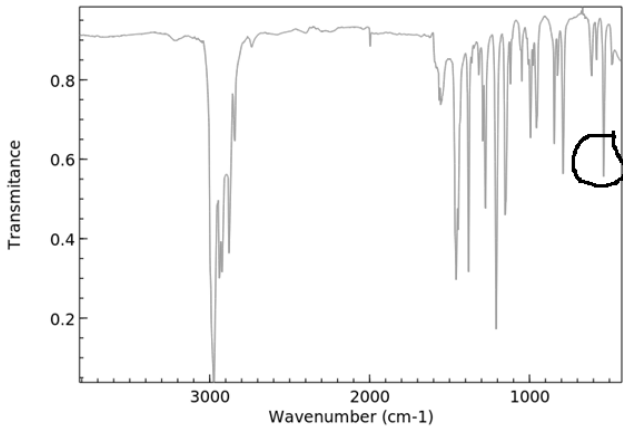
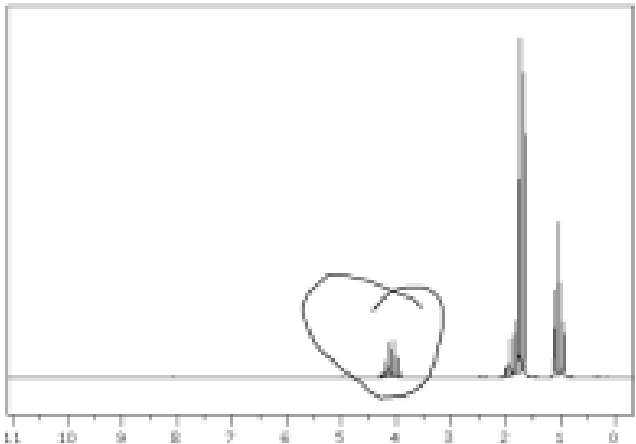
Question			Answers	Notes	Total
5.	(e)		$\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g}) \checkmark$		1
5.	(f)	(i)	condensation/esterification AND H_2O / water $\checkmark$		1
5.	(f)	(ii)	$\frac{\ll 20(12.01) + 38(1.01) + 2(16.00) = 310.58}{100 \times 310.58} =$ $\frac{(310.58 + 18.02)}{(310.58 + 18.02)} \gg$ 94.5 % $\checkmark$		1
5.	(f)	(iii)	<i>Any two of:</i> sustainable development $\checkmark$ more economical/efficient $\checkmark$ better use of natural resources $\checkmark$ reduces waste $\checkmark$		2 max
5.	(f)	(iv)	$K = \frac{[\text{C}_{17}\text{H}_{33}\text{COOCH}_2\text{CH}_3][\text{H}_2\text{O}]}{[\text{C}_{17}\text{H}_{33}\text{COOH}][\text{CH}_3\text{CH}_2\text{OH}]}$	Accept expressions with $[\text{X}(\text{l})]$ instead of $[\text{H}_2\text{O}]$.	1

Question			Answers	Notes	Total
5.	(g)	(i)	K small AND $[\text{reactants}]_{\text{eqm}} = [\text{reactants}]_0 / 0.10$ ✓ $n_{\text{oleate}} = \ll (0.10 \times 0.10 \times 9.3 \times 10^{-5})^{1/2} = \gg 9.6 \times 10^{-4} \text{ «mol»}$ ✓		2
5.	(g)	(ii)	remove water OR add more oleic acid OR add more ethanol ✓		1

Question			Answers	Notes	Total
6.	(a)	(i)	 $\text{Cl}-\text{Cl} \rightarrow 2 \text{Cl}\cdot$ 2 Cl• ✓ single-barbed/fish-hooks ✓	Accept chlorine atoms.	2
6.	(a)	(ii)	 $\text{Cl}-\text{Cl} \rightarrow \text{Cl}^+ + \text{Cl}^-$ full/double-barbed arrow AND charges on both ions are required for mark. ✓		1
6.	(a)	(iii)	Cl ⁺ AND can accept a pair of electrons to form a new bond ✓		1
6.	(a)	(iv)	 ✓		1
6.	(a)	(v)	positive inductive effects from two -CH ₃ /methyl groups ✓		1

Question			Answers	Notes	Total
6.	(b)	(i)	hydrogen bonding stronger than dipole-dipole ✓		1
6.	(b)	(ii)	«increase because» stronger London/dispersion forces ✓ more electrons OR surface contact ✓		2
6.	(b)	(iii)	lower AND more compact shape reduces contact area/London/ dispersion forces ✓		1
6.	(b)	(iv)	more electrons increase London/dispersion forces ✓		1

Question			Answers	Notes	Total
6.	(c)	(i)	$\begin{array}{c} \text{H}_3\text{C} - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{Br} \end{array}$ $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\ \\ \text{Br} \end{array}$ ✓		2
6.	(c)	(ii)	$\begin{array}{c} \text{CH}_2\text{CH}_3 \\ \\ \text{C} \\ / \quad \backslash \\ \text{CH}_3 \quad \text{H} \\ \\ \text{Br} \end{array}$ mirror $\begin{array}{c} \text{CH}_3\text{CH}_2 \\ \\ \text{C} \\ / \quad \backslash \\ \text{H} \quad \text{CH}_3 \\ \\ \text{Br} \end{array}$ ✓		1

Question			Answers	Notes	Total
6.	(c)	(iii)	 ✓  ✓		2

Question			Answers	Notes	Total
6.	(c)	(iv)	<i>IR</i> : no AND same bonds ✓ <i>¹H NMR</i> : yes AND tertiary «isomer» one signal ✓	Accept "yes AND difference in "fingerprint" region/ $1500\text{--}500\text{ cm}^{-1}$ /fewer peaks in tertiary isomer «due to more symmetrical molecule».	2
