

Markscheme

May 2017

Chemistry

Standard level

Paper 3

This markscheme is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

Section A

Question			Answers	Notes	Total
1.	a		$\left\langle \frac{\sum (\text{renewables} + \text{hydroelectricity} + \text{nuclear})}{\text{total}} \right\rangle$ $\left\langle \left(\frac{8800 - 7200}{12600} \right) \times 100 \Rightarrow 13 \text{ \%} \right\rangle \checkmark$	Accept range of "11–16 %".	1
1.	b		$\langle 18000 = 0.54x - 2000 \rangle$ $x = 37037 \text{ «million tonnes of CO}_2 \rangle \checkmark$ $\left\langle \frac{32.00}{44.01} \times 37037 = 26930 \right\rangle$ $27000/2.7 \times 10^4 \text{ «million tonnes of O}_2 \rangle \checkmark$	<p>Accept "37000 «million tonnes of CO₂»" for M1.</p> <p>Award [2] for correct final answer with two significant figures.</p> <p>Award [1] for non rounded answers in range 26903–26936 «million tonnes of O₂».</p>	2
1.	c	i	<p>increase in «atmospheric» pressure OR increase in [O₂ (g)]/concentration of O₂ (g) OR decrease in [O₂ (aq)]/concentration of O₂ (aq) OR decrease in temperature ✓</p>	<p>Accept "increase in volume of oceans «due to polar ice cap melting»" OR "consumption of O₂ in oceans/O₂ (aq) «by living organisms»".</p> <p>State symbols required for oxygen concentration.</p>	1

(continued...)

(Question 1c continued)

Question			Answers	Notes	Total
1.	c	ii	summer in one station while winter in other OR stations are at different latitudes ✓ oxygen dissolves better in colder water ✓	Accept “opposite seasons «in each hemisphere»”. Do not accept “different locations with different temperatures” OR “stations are in different hemispheres”.	2
1.	c	iii	$\left(\frac{209400}{209460} - 1\right) \times 10^6 = -286.5$ «per meg» ✓	The nitrogen cancels so is not needed in the calculation. Negative sign required for mark.	1
1.	c	iv	decrease in [O ₂]/concentration of O ₂ OR increasing combustion of fossil fuels «consumes more O ₂ so [O ₂]/concentration of O ₂ decreases» OR warmer oceans/seas/water «as oxygen dissolves better in colder water» OR deforestation ✓	Accept “decrease in level of O ₂ ”. Accept “increasing CO ₂ production «consumes more O ₂ so [O ₂]/concentration of O ₂ decreases»”. Do not accept “decrease in amount of O ₂ ” OR “increase in greenhouse gases”.	1

Question			Answers	Notes	Total
2.	a		mass/ m of lighter before AND after the experiment ✓ volume of gas/ V_{gas} «collected in the cylinder» ✓ «ambient» pressure/ P «of the room» ✓ temperature/ T ✓	Accept “change in mass of lighter”. Accept “weight” for “mass”. Do not accept just “mass of lighter/gas”. Accept “volume of water displaced”. Do not accept “amount” for “volume” or “mass”.	4
2.	b	i	Any two of: pressure of gas not equalized with atmospheric/room pressure ✓ too large a recorded volume «of gas produces a lower value for molar mass of butane» OR cylinder tilted ✓ difficult to dry lighter «after experiment» OR higher mass of lighter due to moisture OR smaller change in mass but same volume «produces lower value for molar mass of butane» ✓ using degrees Celcius/ $^{\circ}C$ instead of Kelvin/ K for temperature ✓	Accept “vapour pressure of water not accounted for” OR “incorrect vapour pressure of water used” OR “air bubbles trapped in cylinder”. Do not accept “gas/bubbles escaping «the cylinder»” or other results leading to a larger molar mass. Accept “lighter might contain mixture of propane and butane”. Do not accept only “human errors” OR “faulty equipment” (without a clear explanation given for each) or “mistakes in calculations”.	2 max

(continued...)

(Question 2b continued)

Question			Answers	Notes	Total
2.	b	ii	record vapour pressure of water «at that temperature» OR equalize pressure of gas in cylinder with atmospheric/room pressure OR tap cylinder before experiment «to dislodge trapped air» OR collect gas using a «gas» syringe/eudiometer/narrower/more precise graduated tube OR collect gas through tubing «so lighter does not get wet» OR dry lighter «before and after experiment» OR hold «measuring» cylinder vertical OR commence experiment with cylinder filled with water ✓	Accept “adjust cylinder «up or down» to ensure water level inside cylinder matches level outside”. Accept “repeat experiment/readings «to eliminate random errors»”. Accept “use pure butane gas”.	1

Section B

Option A — Materials

Question			Answers	Notes	Total										
3.	a		reinforcing «phase» ✓ «embedded in» matrix «phase» ✓		2										
3.	b		<table border="1"> <tr> <td></td> <td>Physical or chemical</td> <td>Bottom up or top down</td> <td rowspan="3">✓✓</td> </tr> <tr> <td>Lithography</td> <td>physical</td> <td>top down</td> </tr> <tr> <td>Metal coordination</td> <td>chemical</td> <td>bottom up</td> </tr> </table>		Physical or chemical	Bottom up or top down	✓✓	Lithography	physical	top down	Metal coordination	chemical	bottom up	Award [2] for all 4, [1] for 2 or 3 correct.	2
	Physical or chemical	Bottom up or top down	✓✓												
Lithography	physical	top down													
Metal coordination	chemical	bottom up													
3.	c	i	<p>Any three of:</p> <ul style="list-style-type: none"> contain a polar group «which locks into the polymer» ✓ a non-polar group «which weakens the forces between chains» ✓ embedded <u>between</u> chains of polymers ✓ «plasticizer molecules» fit between chains ✓ «plasticizer molecules» prevent chains from forming crystalline regions ✓ «plasticizer molecules» keeps strands/chains/molecules separated ✓ «plasticizer molecules» increase space/volume between chains ✓ weakens intermolecular/dipole-dipole/London/dispersion/instantaneous induced dipole-induced dipole/van der Waals/vdW forces ✓ 	Do not accept “«plasticizer molecules» “lower density” or “softer”.	3 max										
3.	c	ii	<p>more places «for plasticizers» to bond</p> <p>OR</p> <p>increased surface area ✓</p>		1										

Question		Answers	Notes	Total
4.		HDPE AND LDPE «have similar IR» ✓ both are polyethene/polyethylene OR only branching differs OR same bonds OR same bending/stretching/vibrations ✓	Accept “water bottle AND water bottle cap” for M1.	2

Question			Answers	Notes	Total
5.	a		carbon monoxide/CO adsorbs onto <u>palladium/Pd</u> ✓ bonds stretched/weakened/broken OR «new» bonds formed OR activation energy/ E_a «barrier» lowered «in both forward and reverse reactions» ✓ products/ CO_2 desorb «from catalyst surface» ✓		3
5.	b	i	Fe/iron OR Zn/zinc OR Co/cobalt OR Cd/cadmium OR Cr/chromium ✓	Accept "Mn/manganese".	1

(continued...)

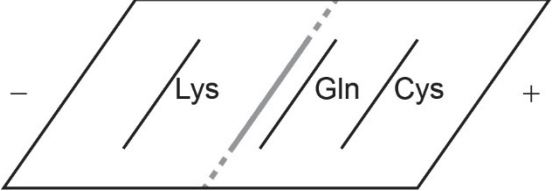
(Question 5b continued)

Question			Answers	Notes	Total
5.	b	ii	$\text{Ni}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{Fe}^{2+}(\text{aq})$ <p>OR</p> $\text{Ni}^{2+}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{Zn}^{2+}(\text{aq})$ <p>OR</p> $\text{Ni}^{2+}(\text{aq}) + \text{Co}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{Co}^{2+}(\text{aq})$ <p>OR</p> $\text{Ni}^{2+}(\text{aq}) + \text{Cd}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{Cd}^{2+}(\text{aq})$ <p>OR</p> $\text{Ni}^{2+}(\text{aq}) + \text{Cr}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{Cr}^{2+}(\text{aq}) \checkmark$	<p>Accept “$3\text{Ni}^{2+}(\text{aq}) + 2\text{Cr}(\text{s}) \rightarrow 3\text{Ni}(\text{s}) + 2\text{Cr}^{3+}(\text{aq})$”.</p> <p>Do not penalize similar equations involving formation of $\text{Fe}^{3+}(\text{aq})$, $\text{Mn}^{2+}(\text{aq})$ OR $\text{Co}^{3+}(\text{aq})$.</p> <p>Ignore Cl^- ions.</p> <p>Accept correctly balanced non-ionic equations eg, “$\text{NiCl}_2(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Ni}(\text{s}) + \text{ZnCl}_2(\text{aq})$” etc.</p> <p>Do not allow ECF from (b)(i).</p>	1
5.	c		$n(\text{e}^-) \llcorner = \frac{2.50 \text{ A} \times 3600 \text{ s}}{96500 \text{ C mol}^{-1}} \llcorner = 0.09326 \llcorner \text{ mol} \llcorner$ <p>OR</p> $n(\text{Ni}) \llcorner = \frac{0.09326 \text{ mol}}{2} \llcorner = 0.04663 \llcorner \text{ mol} \llcorner \checkmark$ $m(\text{Ni}) \llcorner = 0.04663 \text{ mol} \times 58.69 \text{ g mol}^{-1} \llcorner = 2.74 \llcorner \text{ g} \llcorner \checkmark$	<p>Award [2] for correct final answer.</p>	2

Question		Answers	Notes	Total
6.	a	<p><i>Polar molecule:</i> «orientation of molecule» influenced by electric field/«applied» voltage/«applied» potential «difference»/«applied» current OR can be switched on and off ✓</p> <p><i>Long alkyl chain:</i> prevent close packing of molecules OR molecules can align OR reduces the melting point of the liquid crystal/LC «phase making liquid at room temperature» ✓</p>	<p>Accept “makes molecule rod-shaped” for M2.</p>	2

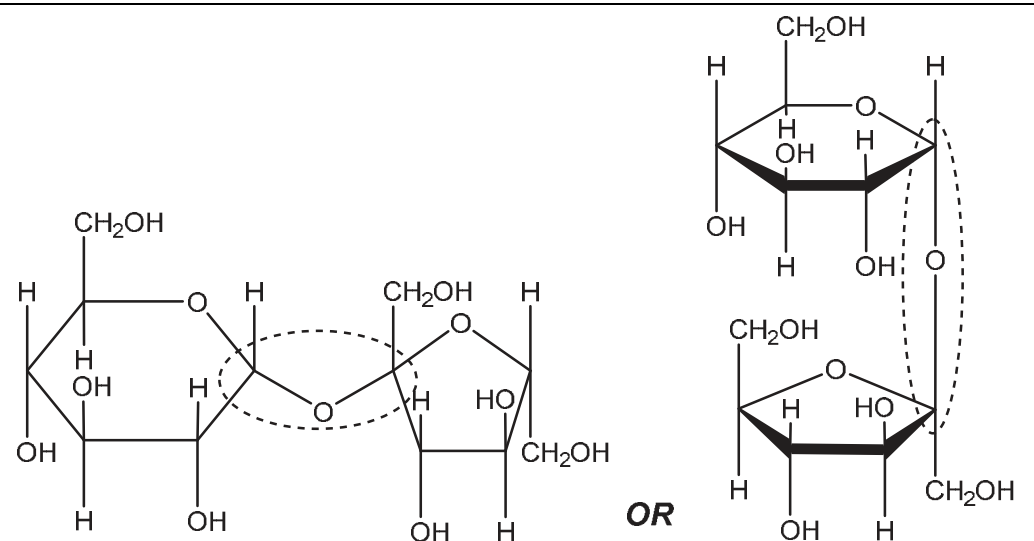
Question		Answers	Notes	Total
6.	b	inability to replicate calibrations below certain levels OR variation in methodology OR variation between machines calibrated with the same samples OR variation in plasma torches OR different detection limits for MS AND OES OR interference from solvents/other chemicals OR inability to produce pure standards OR chance that low signal AND blank are same ✓		1

Option B — Biochemistry

Question		Answers	Notes	Total
7.	a	$\begin{array}{ccccccc} & & \text{O} & \text{H} & & & \\ & & & & & & \\ \text{H}_2\text{N} & - & \text{CH} & - & \text{C} & - & \text{N} & - & \text{CH} & - & \text{COOH} \\ & & & & & & & & & & \\ & & \text{CH}_2\text{SH} & & & & (\text{CH}_2)_4\text{NH}_2 & & & & \end{array}$ <p>correct order ✓ amide link ✓</p>	<p>Accept CO-NH but not CO-HN for amide link.</p> <p>Penalize incorrect bond linkages or missing hydrogens once only in 7 (a) and 7 (c).</p>	2
7.	b	covalent ✓	Accept "S-S/disulfide".	1
7.	c	$\begin{array}{ccc} \text{H}_3\text{N}^+ & - & \text{CH} & - & \text{COOH} \\ & & & & \\ & & \text{CH}_2 & - & \text{SH} \quad \checkmark \end{array}$	Penalize incorrect bond linkages or missing hydrogens once only in 7 (a) and 7 (c).	1
7.	d	 <p>Cys and Gln move to positive electrode AND Lys to negative electrode ✓ Cys further to positive electrode than Gln ✓</p>	<p>Do not penalize if lines are omitted or if different markings are given (eg, spots etc.), as long as relative positions are correctly indicated.</p> <p>Accept Gln on original position indicated.</p> <p>Award [1 max] for reverse order of amino acids.</p>	2

Question		Answers	Notes	Total
8.	a	<p>stearic acid AND chain has no kinks/more regular structure OR stearic acid AND it has straight chain OR stearic acid AND no <u>C=C/carbon to carbon</u> double bonds OR stearic acid AND saturated OR stearic acid AND chains pack more closely together ✓</p> <p>stronger London/dispersion/instantaneous induced dipole-induced dipole forces «between molecules» ✓</p>	<p>Accept “stearic acid AND greater surface area/electron density”.</p> <p>M2 can only be scored if stearic acid is correctly identified.</p> <p>Accept “stronger intermolecular/van der Waals’/vdW forces”.</p>	2
8.	b	<p>«$n(I_2) = 0.123 \text{ dm}^3 \times 0.500 \text{ mol dm}^{-3} \Rightarrow 0.0615 \text{ «mol»}$ ✓</p> <p>«$m(I_2) = 0.0615 \text{ mol} \times 253.8 \text{ g mol}^{-1} \Rightarrow 15.6 \text{ «g»}$ ✓</p> <p>«iodine number = $\frac{15.6 \text{ g} \times 100}{10.0 \text{ g}}$ » = 156 ✓</p>	<p>Award [3] for correct final answer.</p> <p>Iodine number must be a whole number.</p> <p>Award [2 max] for 78.</p>	3

Question		Answers	Notes	Total
9.	a	$C_{17}H_{31}COONa$ ✓ $[(CH_3)_3NCH_2CH_2OH]OH$ ✓	Accept " $NaC_{17}H_{31}COO$ ". Accept " $(CH_3)_3N^+CH_2CH_2OH$ OR $[(CH_3)_3NCH_2CH_2OH]^+$ " if positive charge is shown. Accept suitable names (eg, sodium linoleate, choline hydroxide etc.) OR correct molecular formulas.	2
9.	b	hydrolysis ✓	Accept "nucleophilic substitution/displacement / S_N/S_N2 / saponification". Do not accept "acid hydrolysis".	1

Question		Answers	Notes	Total
10.	a	<p>Only in straight chain form: carbonyl OR aldehyde ✓</p> <p>Only in ring structure: hemiacetal ✓</p>	<p>Accept functional group abbreviations (eg, CHO etc.).</p> <p>Accept "ether".</p>	2
10.	b	 <p>OR</p> <p>correct link between the two monosaccharides ✓</p>	<p>Correct 1,4 beta link AND all bonds on the 2 carbons in the link required for mark.</p> <p>Ignore any errors in the rest of the structure.</p> <p>Penalize extra atoms on carbons in link.</p>	1

Question		Answers	Notes	Total
10.	c	plastic «more» biodegradable/degrades into nontoxic products OR plastic can be produced using green technology/renewable resource OR reduces fossil fuel use/petrochemicals OR easily plasticized OR used to form thermoplasts ✓		1
10.	d	minimize «negative» impact on environment OR minimize waste produced OR consider atom economy OR efficiency of synthetic process OR problems of side reactions/lower yields OR control temperature «inside large reactors» OR availability of starting/raw materials OR minimize energy costs OR value for money/cost effectiveness/cost of production ✓		1

Question		Answers	Notes	Total
11.		«mostly» non-polar OR hydrocarbon backbone OR only 1 hydroxyl «group so mostly non-polar» ✓	<i>Accept “alcohol/hydroxy” for “hydroxyl” but not “hydroxide”.</i>	1

Option C — Energy

Question			Answers	Notes	Total
12.	a	i	${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0\text{n} \checkmark$	Accept “n” for “ ${}^1_0\text{n}$ ”. Accept “ ${}^2\text{H} + {}^3\text{H} \rightarrow {}^4\text{He} + 1\text{n/n}$ ”.	1
12.	a	ii	higher binding energy/BE «per nucleon» for helium/products OR nucleons in products more tightly bound \checkmark mass defect/lost matter converted to energy \checkmark	Accept converse statement in M1. Accept “mass deficit” for “mass defect”.	2
12.	a	iii	spectrometry \checkmark	Accept “spectroscopy” for “spectrometry” OR more specific techniques such as “atomic absorption spectrometry/AAS”, “astrophotometry” etc. Do not award mark for incorrect specific spectrometric techniques. Do not accept “spectrum”.	1
12.	b		«extensive system of» conjugation/alternating single and double «carbon to carbon» bonds OR delocalized electrons «over much of the molecule» \checkmark		1

Question		Answers			Notes	Total
13.	a	Energy source	Advantage	Disadvantage	<p><i>Do not award marks for converse statements for advantage and disadvantage.</i></p> <p><i>Points related to greenhouse gases should be counted only once for the entire question.</i></p> <p><i>Biofuels:</i></p> <p><i>Accept “«close to» carbon neutral”, “produce less greenhouse gases/CO₂” as an advantage.</i></p> <p><i>Accept “engines have to be modified if biodiesel used” as a disadvantage.</i></p> <p><i>Fossil Fuels:</i></p> <p><i>Accept specific pollution examples (eg, oil spills, toxic substances released when burning crude oil, etc.) as a disadvantage.</i></p>	4
		Biofuels	low carbon footprint OR sustainable/renewable OR lower emissions of CO for «biodiesel/ethanol» OR economic security/availability in countries without crude oil ✓	lower energy content/specific energy OR high cost (only if a specific example if given eg, growing corn for ethanol etc.) OR use agricultural resources/fertilizers/pesticides/water OR biodiesel has high viscosity/clogs fuel injectors OR less suitable in low temperatures OR increased NO _x emissions for biodiesel OR greenhouse gases/CO ₂ «still/also» produced ✓		
		Fossil fuels	higher energy content/specific energy OR low cost OR readily accessible ✓	linked to climate change/global warming/increased release of greenhouse gases OR not sustainable/renewable OR greater pollution possibilities ✓		

Question			Answers	Notes	Total
13.	b	i	<p>«specific energy =» 142 ✓ kJ g⁻¹ ✓</p>	<p><i>Accept other correct values with the correct corresponding units.</i> <i>M2 can be scored independently.</i></p>	2
13.	b	ii	<p>large volumes of hydrogen required OR hydrogen has lower energy density ✓</p> <p>not easily transportable «form» as it is a gas OR heavy containers required to carry AND compress/regulate «hydrogen» OR high energy/cost required to compress hydrogen to transportable liquid form OR atmospheric pollution may be generated during production of hydrogen OR hydrogen fuel cells do not work at very low temperatures OR highly flammable when compressed/difficult to extinguish fires OR leaks not easy to detect OR high cost of production OR lack of filling stations/availability to consumer «in many countries» ✓</p>	<p><i>Accept “hydrogen combustion contributes to» knocking in engines” OR “modified engine required” for M2.</i></p> <p><i>Accept “explosive” but not “more dangerous” for M2.</i></p>	2

Question			Answers	Notes	Total	
14.	a		Type of radiation	Region	Accept "B" alone for incoming radiation from sun. All three correct answers necessary for mark.	1
			Incoming radiation from sun	A «and B»		
			Re-radiated from Earth's surface	B		
			Absorbed by CO ₂ in the atmosphere	B ✓		
14.	b	i	CO ₂ (aq) + H ₂ O (l) ⇌ H ₂ CO ₃ (aq) ✓	State symbols AND equilibrium arrow required for mark. Accept CO ₂ (aq) + H ₂ O (l) ⇌ H ⁺ (aq) + HCO ₃ ⁻ (aq). CO ₂ (aq) + H ₂ O (l) ⇌ 2H ⁺ (aq) + CO ₃ ²⁻ (aq).	1	

(continued...)

(Question 14b continued)

Question			Answers	Notes	Total
14.	b	ii	$\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$ OR $\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ OR $\text{H}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ OR $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ OR $\text{H}_2\text{CO}_3(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{H}_3\text{O}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$ OR $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons 2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$ ✓ equilibrium shifts to the right causing increase in $[\text{H}_3\text{O}^+]/[\text{H}^+]$ «thereby decreasing pH» ✓	<p><i>Equilibrium sign needed in (b) (ii) but penalize missing equilibrium sign once only in b (i) and (ii).</i></p> <p><i>Do not accept “$\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})$” unless equation was not given in b (i).</i></p>	2

Question			Answers	Notes	Total
14.	c	i	$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$ OR $3C(s) + H_2O(g) + O_2(g) \rightarrow 3CO(g) + H_2(g)$ OR $4C(s) + 2H_2O(g) + O_2(g) \rightarrow 4CO(g) + 2H_2(g)$ OR $5C(s) + H_2O(g) + 2O_2(g) \rightarrow 5CO(g) + H_2(g) \checkmark$	<i>Accept other correctly balanced equations which produce both CO AND H₂.</i>	1
14.	c	ii	$8CO(g) + 17H_2(g) \rightarrow C_8H_{18}(l) + 8H_2O(g) \checkmark$		1
14.	c	iii	coal more plentiful than crude oil OR syngas can be produced from biomass/renewable source OR syngas can undergo liquefaction to form octanes/no need to transport crude OR syngas can be produced by gasification underground, using carbon OR capture/storage «to not release CO ₂ to the atmosphere» OR coal gasification produces other usable products/slag \checkmark		1

Option D — Medicinal chemistry

Question			Answers	Notes	Total
15.	a	i	$n(\text{salicylic acid}) = \left\langle \frac{2.65 \text{ g}}{138.13 \text{ g mol}^{-1}} \Rightarrow 0.0192 \text{ «mol»} \right\rangle$ <p>AND</p> $n(\text{ethanoic anhydride}) = \left\langle \frac{2.51 \text{ g}}{102.10 \text{ g mol}^{-1}} \Rightarrow 0.0246 \text{ «mol»} \right\rangle \checkmark$		1
15.	a	ii	$\left\langle \text{mass} = 0.0192 \text{ mol} \times 180.17 \text{ g mol}^{-1} \Rightarrow 3.46 \text{ «g»} \right\rangle \checkmark$	Award ECF mark only if limiting reagent determined in (i) has been used.	1
15.	a	iii	<p>Any two of:</p> <p>melting point ✓</p> <p>mass spectrometry/MS ✓</p> <p>high-performance liquid chromatography/HPLC ✓</p> <p>NMR/nuclear magnetic resonance ✓</p> <p>X-ray crystallography ✓</p> <p>elemental analysis «for elemental percent composition» ✓</p>	<p>Accept “spectroscopy” instead of “spectrometry” where mentioned but not “spectrum”.</p> <p>Accept “infra-red spectroscopy/IR” OR “ultraviolet «-visible» spectroscopy/UV/UV-Vis”.</p> <p>Do not accept “gas chromatography/GC”.</p> <p>Accept “thin-layer chromatography/TLC” as an alternative to “HPLC”.</p>	2 max

Question			Answers	Notes	Total
15.	b	i	react with NaOH ✓	Accept "NaHCO ₃ " or "Na ₂ CO ₃ " instead of "NaOH". Accept chemical equation OR name for reagent used.	1
15.	b	ii	«marginally» higher AND increase rate of dispersion OR «marginally» higher AND increase absorption in mouth/stomach «mucosa» OR «approximately the» same AND ionic salt reacts with HCl/acid in stomach to produce aspirin again ✓	Do not accept "«marginally» higher AND greater solubility in blood".	1

Question		Answers	Notes	Total
16.	a	<p>Any two of:</p> <p>diamorphine has ester/ethanoate/acetate «groups» AND morphine has hydroxyl «groups» ✓</p> <p>diamorphine/ester/ethanoate/acetate groups less polar ✓</p> <p>diamorphine more soluble in lipids ✓</p>	<p>Accept “alcohol/hydroxy” for “hydroxyl” but not “hydroxide”.</p> <p>Accept “diamorphine non-polar”.</p> <p>Accept converse statements.</p>	2 max
16.	b	<p>ethanoic/acetic anhydride</p> <p>OR</p> <p>ethanoyl/acetyl chloride ✓</p>	<p>Accept other possible reagents, such as ethanoic/acetic acid or acetyl bromide.</p> <p>Accept chemical formulas.</p>	1
16.	c	<p>morphine has a smaller therapeutic window ✓</p>	<p>Accept converse statements.</p> <p>Accept “codeine has lower activity” OR “codeine has lower risk of overdose” OR “codeine is less potent”.</p> <p>Do not accept “lower abuse potential for codeine” OR “codeine less addictive” OR “codeine has a lower bioavailability”.</p>	1

Question		Answers	Notes	Total
17.	a	<p><i>Ranitidine:</i> Blocks/binds H₂-histamine receptors «in cells of stomach lining»</p> <p>OR</p> <p>prevents histamine molecules binding to H₂-histamine receptors «and triggering acid secretion» ✓</p> <p><i>Omeprazole:</i> inhibits enzyme/gastric proton pump which secretes H⁺ ions «into gastric juice» ✓</p>	<p>Accept “H₂ receptor antagonist” for M1.</p>	2
17.	b	<p>$[\text{Na}_2\text{CO}_3] = \left\langle \frac{0.500 \text{ g}}{105.99 \text{ g mol}^{-1} \times 0.075 \text{ dm}^3} \Rightarrow 0.0629 \text{ mol dm}^{-3} \right\rangle \checkmark$</p> <p>«$\text{pH} = \text{p}K_a + \log \frac{[\text{conj base}]}{[\text{conj acid}]}$»</p> <p>«$\text{pH} = 10.35 - 0.201 \Rightarrow 10.15 \checkmark$»</p>	<p>Alternative method involving K_a may be used to deduce pH in M2.</p> <p>Award [2] for correct final answer.</p>	2

Question			Answers	Notes	Total
18.	a	i	<p><i>One similarity:</i> both contain amido «group» ✓</p> <p><i>One difference:</i> oseltamivir contains ester «group» AND zanamivir does not OR oseltamivir contains amino «group» AND zanamivir does not «but contains a guanidino group» OR zanamivir contains carboxyl «group» AND oseltamivir does not OR zanamivir contains «several» hydroxyl «groups» AND oseltamivir does not OR oseltamivir contains ester «group» AND zanamivir contains carboxyl «group» OR oseltamivir contains ester «group» AND zanamivir contains «several» hydroxyl «groups» ✓</p>	<p>Accept “both contain ether «group»” OR “both contain alkene/alkenyl «group»” OR “both contain carbonyl «group»” OR “both contain amino/amine «group»”. Latter cannot be given in combination with second difference alternative with respect to amino group.</p> <p>Accept “amide/carboxamide/carbamoyl” for “amido”.</p> <p>Accept “amine” for “amino”.</p> <p>Accept “carboxylic acid” for “carboxyl”.</p> <p>Accept “hydroxy/alcohol” for “hydroxyl”, but not “hydroxide”.</p>	2

Question			Answers	Notes	Total
18.	a	ii	1050-1410 OR 1620-1680 OR 1700-1750 OR 2500–3000 OR 3200–3600 OR 2850-3090 OR 3300-3500 «cm ⁻¹ » ✓		1
18.	b		«negative» side-effects of medication on patient/volunteers OR effects on environment «from all materials used and produced» OR potential for abuse OR drugs may be developed that are contrary to some religious doctrines OR animal testing OR risk to benefit ratio OR appropriate consent of patient volunteers ✓		1

Question		Answers	Notes	Total
19.	a	<p>Any of:</p> <p>«most are» toxic «to living organisms»</p> <p>OR</p> <p>incomplete combustion/incineration can produce toxic products/dioxins/phosgene</p> <p>OR</p> <p>carcinogenic ✓</p> <p>«some can be» greenhouse gases ✓</p> <p>ozone-depleting ✓</p> <p>can contribute to formation of «photochemical» smog ✓</p> <p>accumulate in groundwater</p> <p>OR</p> <p>have limited biodegradability ✓</p> <p>cost/hazards of disposal ✓</p>	<p><i>Do not accept “harmful to the environment”.</i></p> <p><i>Do not accept just “pollutes water”.</i></p>	1 max
19.	b	<p>use organic solvent-free synthetic methods</p> <p>OR</p> <p>use water as a solvent</p> <p>OR</p> <p>based on atom economy</p> <p>OR</p> <p>recover/reuse solvents ✓</p>		1