Diploma Programme
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Markscheme

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Chemistry

Standard level

Paper 3

23 pages

Section A

Question			Answers	Notes	Total
1.	a	i	*HOCl:* +1 ***AND*** ClO_2*:* +4 ✓	*Accept "I" and "IV" but **not** "1+/1" and "4+/4" notations.*	**1**
1.	a	ii	«most» CT values are higher for «bacterium» B ***OR*** «generally» higher dosage needed for «bacterium» B ✓	*Accept converse arguments.* *Accept "concentration" for "dosage".*	**1**
1.	a	iii	«$CT = 1.50 \times 10^{-5} \times 10^{3}\,mg\,dm^{-3} \times 9.82\,min =$» 1.47×10^{-1} «$mg\,min\,dm^{-3}$» ✓		**1**
1.	a	iv	lower than CT value/minimum dosage/1.8×10^{-1} «mg min dm^{-3}» ***AND*** no/insufficient ✓	*Accept "concentration" for "dosage".*	**1**
1.	b	i	higher CT value at lower temperature ***OR*** higher dosage «of chlorine» needed at low temperature ✓	*Accept "effectiveness decreases at lower temperature".* *Accept "concentration" for "dosage".* *Accept converse arguments.*	**1**
1.	b	ii	labeled axes (y: CT and x: pH) ***AND*** curve with increasing gradient ✓	*Do **not** accept axes the wrong way round.* *Accept a linear sketch.*	**1**
1.	b	iii	values at pH 9.0 approximately 3 times values at pH 6.0 ***OR*** increase in CT values in same ratio ✓	*The exact ratio is 2.9 times.* *Do **not** accept just "increase in value".*	**1**
1.	b	iv	[HOCl] decreases ***AND*** [OCl^-] increases ✓		**1**

(continued)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**c**		plastic disposal/pollution ***OR*** plastic bottles use up petroleum/non-renewable raw material ***OR*** chemicals in plastic bottle can contaminate water ***OR*** **«**prolonged**»** storage in plastic can cause contamination of water ***OR*** plastic water bottles sometimes reused without proper hygiene considerations ✓	*Accept other valid answers.* *Accept economic considerations such as "greater production costs", "greater transport costs" or "bottled water more expensive than tap water".*	**1**

2.	**a**		repeat steps 3 and 4 ***OR*** repeat step 5 ***OR*** conduct a third heating ***OR*** **«**re**»**heat ***AND*** **«**re**»**weigh ✓ water still present ***OR*** need two consistent readings ***OR*** heat to constant mass ✓	*Accept "ensure even/strong heating" for M1.* *Do **not** accept "cleaning/washing the crucible".*	**2**

(continued)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**b**		soot/carbon deposited ***OR*** incomplete combustion ***OR*** air hole of Bunsen burner closed/not fully open ✓ **«**value of **x»** lower ✓	*Accept "using a yellow **«**Bunsen burner**»** flame" for M1.* *Only award M2 if M1 correct.*	**2**
2.	**c**		all mass loss is due to water loss ✓ all the water **«**of crystallization**»** is lost ✓ crucible does not absorb/lose water ✓ crystal/$BaCl_2$ does not decompose/hydrolyse/oxidize/react with oxygen/air **«**when heated**»** ✓	*Accept "no loss of crystals/$BaCl_2$ occurs", "no impurities in the **«**weighed hydrated**»** salt", "reaction goes to completion", "heat was consistent/strong", "crystal/$BaCl_2$ does not absorb water during cooling", "balance has been calibrated" or "crucible was clean at the start".* *Do **not** accept "heat loss to surroundings" or "no carbon deposited on crucible".* *Reference to defects in apparatus not accepted.* *Do **not** penalize if $BaCl_2.xH_2O$ is used for $BaCl_2$.*	**2 max**

Section B

Option A — Materials

Question			Answers	Notes	Total
3.	a		*MgO:* ionic ***AND*** *SiC:* covalent ✓	*Accept "covalent network/network covalent" for "covalent" but not just "network".*	1
3.	b		metallic «bonding» ✓		1

4.	a		«$0.300\,A \times 9.00 \times 10^3\,s$ =» 2.70×10^3 «C» ✓		1
4.	b		«mol $e^- = \frac{2700\,C}{96500\,C\,mol^{-1}}$ =» 2.80×10^{-2} «mol» ✓		1
4.	c		«$\frac{1.07\,g}{0.0280\,mol}$ =» 38.2 «g» ✓		1
4.	d		«$\frac{114.82\,g}{38.2\,g\,mol^{-1}}$ e^- =» 3.01/3.00 «mol e^-» ✓		1
4.	e		In^{3+}/3+ ***AND*** $In_2(SO_4)_3$ ✓	*Do **not** accept "+3/3".*	1

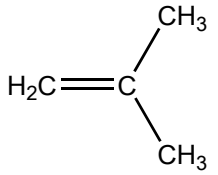
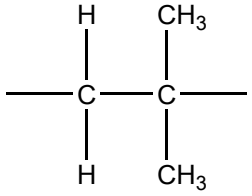
5.	a		pores/cavities/channels/holes/cage-like structures ✓ «only» reactants with appropriate/specific size/geometry fit inside/go through/are activated/can react ✓	*Accept "molecules/ions" for reactants.*	2

(continued)

(Question 5 continued)

Question			Answers	Notes	Total
5.	**b**	**i**	iron**«**0**»«**penta**»**carbonyl/$Fe(CO)_5$ catalyst decomposes ***OR*** $Fe(CO)_5(g) \rightarrow Fe(s) + 5CO(g)$ ***OR*** metal nanocatalyst/clusters/particles formed **«***in situ***»** ✓ $2CO(g) \rightarrow CO_2(g) + C(s)$ ✓	*Accept "cobalt-molybdenum/Co-Mo/CoMo" as a catalyst.* *Accept "conversion of CO molecules into CNTs/ SWNTs" for M2.*	**2**
5.	**b**	**ii**	higher efficiency per unit mass/volume of the catalyst **«**due to higher surface to mass/volume ratio**»** ***OR*** greater selectivity **«**due to metal nanoclusters/surface topology/pore size**»** ***OR*** higher stability of the catalyst **«**due to lower tendency to aggregation**»** ***OR*** reduced cost of the catalyst/product/chemicals **«**as precious metals can be replaced with nanocatalysts made of inexpensive materials**»** ✓	*Accept "high conversion efficiency".* *Accept specific examples such as use of nanocatalysts in fuel cells/catalytic converters **«**leading to reduced use of Pt/Rh/Pd**».*** *Accept "nanocatalysts often operate under milder conditions **«**so less energy consumption involved/so promotes principles of green chemistry**»".*** *Accept "lower energy consumption" **OR** "reduced carbon footprint" **OR** "reduced global warming".* *Accept "nanocatalysts often have long lifetimes **«**so more economical**».*** *Accept "some nanocatalysts have enzyme mimicking activities".*	**1**

(continued)

Question			Answers	Notes	Total
6.	a	i	 ***OR*** $H_2C{=}C(CH_3)_2$ ✓		1
6.	a	ii	 ***OR*** $–CH_2C(CH_3)_2–$ ✓	*Continuation bonds needed for mark.* *No penalty if square brackets present or "n" appears after the bracket/formula.*	1
6.	b		«same mass of product as reactant, thus» 100 «%» ✓	*Accept "less than 100 %" only if a reason is given (eg, the catalyst is not converted into the product, or other reasonable answer).*	1

(continued)

(Question 6 continued)

Question			Answers	Notes	Total
6.	**c**	**i**	due to stability of plastics/strong covalent bonds ***OR*** low volatility preventing good mixing with oxygen **«**gas**»** ***OR*** lack of/insufficient oxygen ***OR*** plastics are often parts of devices with non-combustible components **«**which mechanically prevent the combustion of plastic components**»** ***OR*** PVC already partly oxidised **«**because some C–H bonds are replaced with C–Cl bonds**»**, so it cannot produce enough heat for complete combustion ***OR*** many industrial/household materials contain additives that reduce their flammability/act as flame retardants ✓		**1**

6.	**c**	**ii**	weakly bound to the PVC/no covalent bonds to PVC/only London/ dispersion/instantaneous induced dipole-induced dipole forces between DEHP and PVC ***AND*** leach/evaporate **«**from PVC**»** to atmosphere/food chain ***OR*** has low polarity/contains non-polar hydrocarbon chains ***AND*** fat-soluble/ deposits in the fatty tissues ***OR*** has unusual structural fragments/is a xenobiotic/difficult to metabolise ***AND*** stays in the body for a long time ✓		**1**

(continued)

Question			Answers	Notes	Total
7.	a		<table><tr><th>Lyotropic LCs</th><th></th><th>Thermotropic LCs</th></tr><tr><td>solutions</td><td>AND</td><td>pure substances</td></tr><tr><td>LC over certain <u>concentration</u> range</td><td>AND</td><td>LC over a <u>temperature</u> range «between the solid and liquid phases»</td></tr></table> ✓ ✓	*Do **not** award any credit if one type only is described as the question asks how they differ.*	**2**
7.	b		decreases ***AND*** as energy **«**added**»** overcomes interparticle forces ***OR*** decreases ***AND*** as energy **«**added**»** causes faster movement **«**of particles**»** ✓		**1**

(continued)

Option B — Biochemistry

Question			Answers	Notes	Total
8.	**a**		*Name of the chemical link:* ester/ethoxycarbonyl ***AND*** *Name of the other product:* water ✓	*Do **not** accept formulas.* *Do **not** accept "esterification".*	**1**
8.	**b**	**i**	coconut oil ***AND*** lowest **«**percentage of**»** unsaturated fatty acids ***OR*** coconut oil ***AND*** smallest number of C=C bonds ***OR*** coconut oil ***AND*** highest **«**percentage of**»** saturated fatty acids ✓	*Accept "fats" for "fatty acids".*	**1**
8.	**b**	**ii**	soybean oil ***AND*** highest **«**percentage of**»** polyunsaturated fatty acids ***OR*** soybean oil ***AND*** greatest number of C=C bonds ***OR*** soybean oil ***AND*** lowest **«**percentage of**»** saturated fatty acids ✓	*Accept "fats" for "fatty acids".*	**1**
8.	**b**	**iii**	*Beef fat:* **«**P/S $= \frac{3}{59} =$**»** 0.05 ***AND*** *Soybean oil:* **«**P/S $= \frac{50 + 8}{14} =$**»** 4.1 ✓		**1**
8.	**b**	**iv**	**«**higher proportion of**»** polyunsaturated fatty acids decrease risk of atherosclerosis/heart disease/cardiovascular disease/CVD ***OR*** **«**higher proportion of**»** polyunsaturated fatty acids which are less likely to be deposited on the walls of arteries **«**than saturated fatty acids**»** ✓	*Accept converse arguments.* *Accept correct arguments in terms of HDL and LDL but not in terms of "good" and "bad" cholesterol.* *Accept "fats" for "fatty acids".*	**1**

(continued)

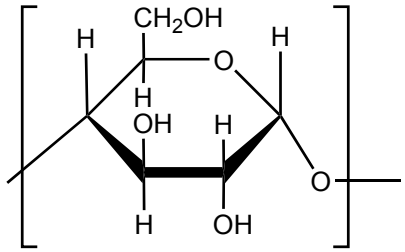
(Question 8 continued)

Question			Answers	Notes	Total
8.	**b**	**v**	*Any two of:* cotton seed oil has **«**a higher proportion of**»** longer chain/greater molar mass fatty acids ✓ molecules of cotton seed oil have greater surface area/have higher electron density ✓ stronger London/dispersion/instantaneous induced dipole-induced dipole forces between chains in cotton seed oil ✓	*Accept converse arguments.* *Accept "fats" for "fatty acids".* *Accept "molecules of cotton seed oil are packed more closely/have more regular structure" for M2.*	**2 max**

9.	**a**		CO_2 ***AND*** H_2O ***AND*** sun ✓	*Accept names.* *Accept "sunlight/light/photons" instead of "sun".*	**1**
9.	**b**	**i**	both have formula $C_x(H_2O)_y$ ***OR*** both contain several OH/hydroxyl **«**groups**»** ***AND*** a C=O/carbonyl **«**group**»** ✓	*Accept "both have the formula $C_nH_{2n}O_n$ / empirical formula CH_2O" but do **not** accept "both have same molecular formula/have formula $C_3H_6O_3$".* *Accept "aldehyde or ketone" for "carbonyl".*	**1**

(continued)

(Question 9 continued)

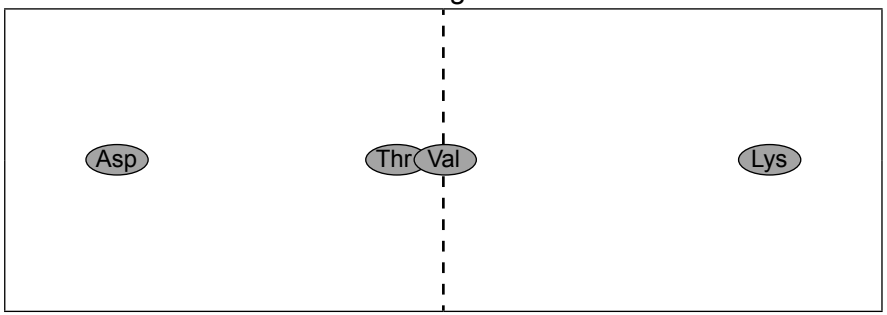
Question			Answers	Notes	Total
9.	**b**	**ii**	***X*** RCHO/CHO ***OR*** C=O/carbonyl **«**group with C**»** bonded to H ***OR*** formyl **«**group**»** ***OR*** C=O/carbonyl **«**group**»** at end of chain/at C–1 **«**atom**»** ***AND*** ***Y*** R_2CO/RCOR' ***OR*** carbonyl/C=O **«**group with C**»** bonded to two C/R **«**groups**»** ***OR*** C=O/carbonyl **«**group**»** in middle of chain/at C–2 **«**atom**»** ✓	*Accept "alkyl" for "R".* *Accept "**X**: aldose/aldehyde **AND** **Y**: ketose/ ketone".* *Accept "CO" for "C=O".*	**1**
9.	**c**	**i**	 continuation bonds ***AND*** open O on either but not both ends ✓	*Brackets are not necessary for the mark.* *Do **not** accept β-isomer.* *Mark may be awarded if a polymer is shown but with the repeating unit clearly identified.* *3-D representation is **not** required.*	**1**

(continued)

(Question 9 continued)

Question			Answers	Notes	Total
9.	**c**	**ii**	*Advantage:* *Any one of:* biodegradable / break down naturally/by bacteria ✓ compostable ✓ does not contribute to land-fill ✓ renewable/sustainable resource ✓ starch grains swell ***AND*** help break up plastic ✓ lower greenhouse gas emissions ✓ uses less fossil fuels than traditional plastics ✓ less energy needed for production ✓ *Disadvantage:* *Any one of:* land use **«**affects biodiversity/loss of habitat**»** ✓ growing corn for plastics instead of food ✓ **«**starch**»** breakdown can increase acidity of soil/compost ✓ **«**starch**»** breakdown can produce methane **«**especially when buried**»** ✓ sensitive to moisture/bacteria/acidic foods ✓ **«**bioplastics sometimes**»** degrade quickly/before end of use ✓ cannot be reused ✓ poor mechanical strength ✓ eutrophication ✓ increased use of fertilizers/pesticides/phosphorus/nitrogen **«**has negative environmental effects**»** ✓	*Ignore any reference to cost.* *Do **not** accept just "decompose easily".* *Accept "prone to site explosions/fires" or "low heat resistance" for disadvantage.* *Only award **[1 max]** if the same example is used for the advantage and disadvantage.*	**2 max**

(continued)

Question			Answers	Notes	Total
10.	**a**		2-amino-4-methylpentanoic acid ✓	*Accept 4-methyl-2-aminopentanoic acid.*	**1**
10.	**b**	**i**	Origin (+) Anode  (−) Cathode Lys on cathode side ***AND*** Asp on anode side ✓ Val at origin ***AND*** Thr on anode side but closer to origin than Asp ✓	*Val and Thr need not overlap.* *Accept any (reasonable) size and demarcation of position so long as position relative to origin is correct.* *Accept crosses for spots.* *Award **[1 max]** for any two correct.* *Award **[1 max]** if net direction of spots is reversed.* *Award **[1 max]** if the four points are in the correct order but not in a straight line.*	**2**
10.	**b**	**ii**	different sizes/molar masses/chain lengths «so move with different speeds» ✓		**1**
10.	**c**		«20^3 =» 8000 ✓		**1**
10.	**d**	**i**	hydrogen bonds ✓		**1**
10.	**d**	**ii**	carboxamide/amide/amido ***OR*** C=O ***AND*** N–H ✓	*Accept peptide.*	**1**

(continued)

Option C — Energy

Question			Answers	Notes	Total
11.	**a**	**i**	«$\frac{1.58 \times 10^7\,\text{J}}{80.0\,\text{kg}} = \frac{15.8\,\text{MJ}}{80.0\,\text{kg}} =$» 1.98×10^{-1} «MJ kg^{-1}» ✓		**1**
11.	**a**	**ii**	gasoline releases more energy from a given mass of fuel ***OR*** gasoline has higher specific energy ✓	*Do **not** accept volume in place of mass as question refers to specific energy, not energy density.*	**1**
11.	**b**	**i**	«$\frac{15.8\,\text{MJ}}{34.3\,\text{MJ dm}^{-3}}$» $= 4.61 \times 10^{-1}$ «dm^3» ✓		**1**
11.	**b**	**ii**	«$4.61 \times 10^{-1}\ \text{dm}^3 \times 32.0\ \text{km dm}^{-3} \times 4$» $= 59.0/59.1$ «km» ✓		**1**

12.	**a**		«tends to» decrease with longer/larger/heavier alkanes ✓ «tends to» increase with bulkier/more branched alkanes ✓	*Accept "octane number decreases with the separation between branches" **OR** "increases with the more central position of branches".* *Accept converse arguments.*	**2**
12.	**b**		$C_7H_{16} \rightarrow C_6H_5CH_3 + 4H_2$ ✓	*Accept "C_7H_8" for "$C_6H_5CH_3$".*	**1**

(continued)

Question			Answers	Notes	Total
13.	a		*Any two of:* $CO_2(g) \overset{H_2O(l)}{\rightleftharpoons} CO_2(aq)$ ✓ $CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ ***OR*** HCO_3^- ***AND*** H^+ are formed **«**by dissolved CO_2**»** ✓ **«**increasing $[CO_2]$**»** shifts equilibrium to right/increases acidity/ decreases pH ✓	*$H_2O(l)$ not required over equilibrium sign for M1.* *State symbols required in the equation in M1.* *Accept "H_2CO_3" at either side of the equilibrium in M2.* *Equilibrium sign required for M1 but **not** for M2.*	**2 max**
13.	b	i	bond length/C=O changes ***OR*** **«**asymmetric**»** stretching **«**of bonds**»** ***OR*** bond angle/OCO changes ✓ photon re-emitted in random direction ***OR*** polarity/dipole **«**moment**»** changes ***OR*** dipole **«**moment**»** created **«**when molecule absorbs IR**»** ✓	*Accept "molecule bends" for M1.* *Accept appropriate diagrams.*	**2**
13.	b	ii	CO_2 gas **«**ten times**»** more effective as greenhouse gas/GHG than H_2O ***OR*** CO_2 gas levels keep increasing **«**unlike H_2O**»** ***OR*** CO_2 has higher Global Warming Potential/GWP than H_2O ***OR*** CO_2 stays in the atmosphere for longer than H_2O ✓	*Accept converse arguments.*	**1**

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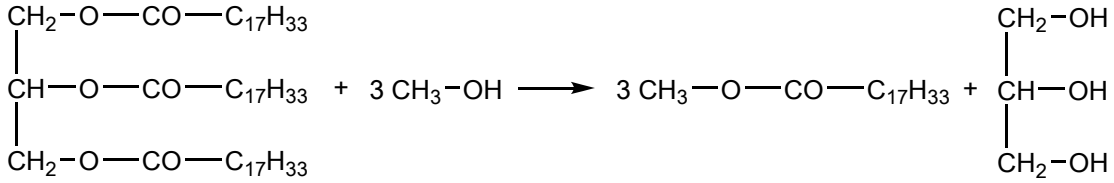
Question			Answers	Notes	Total
14.	**a**		 methyl ester formula ***AND*** glycerol formula ✓ correct balancing ✓	*Award M2 only if M1 is correct.*	**2**
14.	**b**		**«**methyl esters have**»** low**«**er**»** viscosity/surface tensions ***OR*** «methyl esters have» high**«**er**»** volatility ***OR*** **«**combustion of vegetable oils**»** produces carbon deposits in engine/reduces engine life ✓	*Accept converse arguments.*	**1**
15.	**a**	**i**	product has higher binding energy **«**per nucleon**»**/more stable ***OR*** nucleons in product more tightly bound **«**with one another**»** ✓ lighter elements **«**than Fe**»** can fuse/combine with loss of mass/mass defect **«**and release vast amount of energy**»** ✓	*Accept "mass is converted to energy" for M2.*	**2**
15.	**a**	**ii**	*Any one of:* deuterium/fuel is abundant/cheap ✓ **«**helium**»** products not radioactive ✓ fusion much less dangerous than fission ✓ large amounts/shipments of radioactive fuel not required ✓ far less radioactive waste **«**created by fast moving neutrons**»** has to be stored ✓	*Accept "reduces greenhouse gas emissions/global warming"* ***OR*** *"no radioactive waste"* ***OR*** *"more reliable power"* ***OR*** *"fewer safety issues".* *Do* ***not*** *accept "gives out a large amount of energy" as it is in the stem of the question.*	**1**
15.	**b**	**i**	**«**$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{0.693}{25.3 \text{ days}}$ **=»** 2.74×10^{-2} $\underline{\text{day}}^{-1}$ ✓	*Need correct unit for mark.*	**1**

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(Question 15 continued)

Question			Answers	Notes	Total
15.	**b**	**ii**	«4 half-lives; $1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8} \rightarrow \frac{1}{16}$ =» $\frac{1}{16}$ / 6.25×10^{-2} ***OR*** «$\frac{N}{N_0} = e^{-\lambda t} = e^{-0.0274 \times 101.2}$=» 6.25×10^{-2} ✓	*Accept 6.25%.*	**1**

(continued)

Option D — Medicinal chemistry

Question			Answers	Notes	Total
16.	**a**	**i**	bond angles smaller/distorted ***OR*** instability resulting from abnormal bond angles ***OR*** bond angles **«**approximately**»** 90° instead of 109.5°/120° ✓	*Accept "109/110°" for "109.5°".*	**1**
16.	**a**	**ii**	asterisks (*) on all 3 lactam ring carbon atoms ✓	*Must mark all 3 carbon atoms.* *Ignore asterisks on the RHS carbon atoms of the five-membered ring.*	**1**
16.	**b**	**i**	beta-lactam/four-membered ring **«**in clavulanic acid**»** reacts with enzyme/ beta lactamase ✓	*Accept "acts as enzyme inhibitor/suicide substrate/preferentially binds to enzyme".*	**1**
16.	**b**	**ii**	antibiotics not effective against viruses ***OR*** viruses have no cell wall/cell structure/target structures to attack ✓ increasing exposure of bacteria **«**to antibiotic**»** increases resistance ✓	*Accept "antibiotics kill beneficial bacteria" for M2.*	**2**

17.	**a**		**«**oral bioavailability is**»** low ***OR*** drug is broken down/pH too low/unable to be absorbed from gut ***OR*** only a small proportion of the drug **«**taken by mouth**»** reaches the target organ ✓		**1**
17.	**b**		ethoxycarbonyl/carbonyl attached to oxygen ✓	*Accept "ester".*	**1**

(continued)

(Question 17 continued)

Question			Answers	Notes	Total
17.	**c**		*Any one of:* fermentation ***OR*** microbial production ✓ genetically engineered bacteria/E.coli ✓ sweetgum **«**seeds/leaves/bark**»** ***OR*** pine/fir/spruce tree **«**needles**»** ***OR*** *Ginkgo biloba* ✓	*Accept other specific examples of more plentiful plant sources.*	**1 max**

18.	**a**		***ALTERNATIVE 1:*** **«**theoretical yield $= \frac{1.552\,\text{g}}{138.13\,\text{g mol}^{-1}} \times 180.17\,\text{g mol}^{-1}$**=»** 2.024 **«**g**»** ✓ **«**experimental yield $= \frac{1.124\,\text{g}}{2.024\,\text{g}} \times 100$ **=»** 55.53 **«**%**»** ✓ ***ALTERNATIVE 2:*** **«** $\frac{1.552\,\text{g}}{138.13\,\text{g mol}^{-1}}$ **»** = 0.01124 **«**mol salicylic acid/aspirin theoretical**»** ***AND*** **«** $\frac{1.124\,\text{g}}{180.17\,\text{g mol}^{-1}}$ **»** = 0.006239 **«**mol aspirin experimental**»** ✓ **«**experimental yield $= \frac{0.006239\,\text{mol}}{0.01124\,\text{mol}}$ x 100 **=»** 55.51 **«**%**»** ✓	*Accept answers in the range 55.4 % to 55.7 %.* *Award **[2]** for correct final answer.*	**2**

(continued)

(Question 18 continued)

Question			Answers	Notes	Total
18.	**b**		low temperature gives greater difference between solubility of aspirin and impurities ***OR*** **«**product**»** crystallizes out from cold solution/**«**ice-cold water/lower temperature**»** speeds up crystallization process ***OR*** aspirin/product has low solubility **«**in water**»** at low temperatures ✓		**1**
18.	**c**		recrystallized melting point is higher ***OR*** recrystallized melting point is closer to pure substance/literature value ✓ smaller range of values ✓		**2**
18.	**d**		intercepts pain stimulus at source/acts at site of pain ***OR*** interferes with production of pain sensitizing substances/prostaglandins **«**at site of pain**»** ✓		**1**

19.	**a**		**«**ranitidine**»** blocks/inhibits histamine binding to **«**H2**»** receptor ***OR*** ranitidine binds to same **«**H2**»** receptors **«**as histamine**»** ***OR*** competes with histamine for binding ✓		**1**
19.	**b**		proton pump ***OR*** H^+/K^+ ATPase enzyme ✓	*Accept "**«**secretary surface of**»** parietal cells".* *Do **not** accept "stomach/stomach wall".*	**1**
19.	**c**		$Al(OH)_3(s) + 3H^+(aq) \rightarrow Al^{3+}(aq) + 3H_2O(l)$ ***OR*** $Al(OH)_3(s) + 3HCl(aq) \rightarrow AlCl_3(aq) + 3H_2O(l)$ ✓		**1**

(continued)

Question			Answers	Notes	Total
20.	**a**		*Similarity:* both contain **«**at least one**»** benzene/aromatic ring ***OR*** both contain amino **«**group**»** ✓ *Difference:* diamorphine has one benzene/aromatic ring ***AND*** methadone has two phenyl **«**groups**»** ***OR*** diamorphine has one vinylene/ethenylene/1,2-ethenediyl **«**group**»** ***AND*** methadone has no vinylene/ethenylene/1,2-ethenediyl **«**group**»** ***OR*** diamorphine has one ether **«**group**»** ***AND*** methadone has no ether **«**group**»** ***OR*** diamorphine has **«**two**»** ethanoate/acetate **«**groups**»** ***AND*** methadone has no ethanoate/acetate **«**groups**»** ✓	*Accept "both contain carbonyl **«**groups**»**".* *Accept "amine" for "amino **«**group**»".* *Accept "phenyl" for "benzene ring" in M1 and M2 although there are no phenyl groups in diamorphine, as the benzene ring in this compound is a part of a polycyclic structure.* *Do **not** accept "arene" or "benzene" alone in M1 and M2.* *Accept "alkenyl/alkene" for "vinylene/ethenylene/1,2-ethenediyl" and "ester" for "ethanoate/acetate".* *Accept "methadone has a ketone/carbonyl **AND** diamorphine does not/has an ester/ethanoate/acetate".* *Accept "diamorphine is a heterocycle/heterocyclic compound **AND** methadone is not a heterocycle/heterocyclic compound".*	**2**
20.	**b**		feeling depressed/anxious/irritable ***OR*** craving for opioids/heroin ***OR*** experience fever/cold sweats/nausea/vomiting/insomnia/muscle pain/cramps/diarrhea/increased rate of respiration/increased heartbeat/lacrimation ✓	*Accept listed symptoms (eg, depression, anxiety, fever etc.).* *Some of the most common symptoms are listed here – there may be other valid ones.* *Accept "headaches".*	**1**