Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2023

Chemistry

Higher level

Paper 3

29 pages

International Baccalaureate
Baccalauréat International
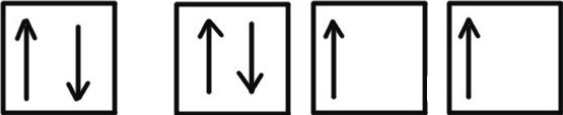**Bachillerato Internacional**

Subject details: Chemistry higher level Paper 3 Markscheme

Candidates are required to answer ALL questions in Section A [15 marks] and all questions from ONE option in Section B [30 marks].
Maximum total = [45 marks].
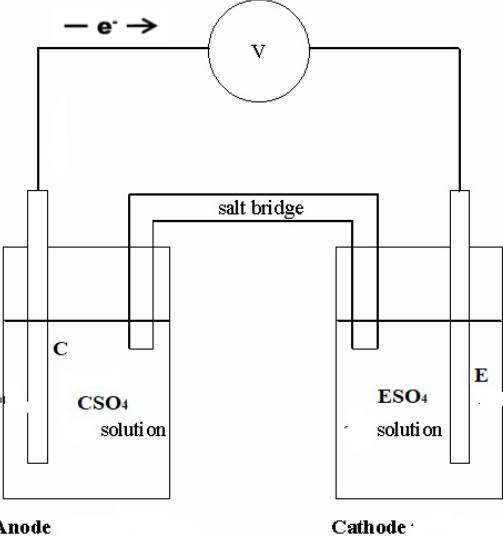
1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "max" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (/). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "*OR*". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ALTERNATIVE 1 *etc*. Either alternative can be accepted.

8. Words inside chevrons « » in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by *OWTTE* (or words to that effect) in the "Notes" column.

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then follow through marks should be awarded. When marking, indicate this by adding ECF (error carried forward) on the script.

14. Do not penalize candidates for errors in units or significant figures, unless it is specifically referred to in the "Notes" column.

15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the "Notes" column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the "Notes" column.

16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the "Notes" column.

17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the "Notes" column.

Section A

Question			Answers	Notes	Total
1.	**(a)**		ionization energy breaks bond/attractive force between nucleus and electron **AND** electron affinity forms bond/attractive force between nucleus and electron ✓	*Accept for ionization energy "energy needed/endothermic to remove an electron".* ***AND*** *for electron affinity "energy released/exothermic adding an electron".*	**1**
1.	**(b)**		electron «removed» from 2p in B **AND** 2s in Be ✓ shielding effect of 2s «reduces energy needed to remove 2p» **OR** 2p at higher energy level/further from nucleus **OR** full 2s more stable «than single electron in p» ✓	*Accept electron configurations of **both** B and Be for M1.*	**2**
1.	**(c)**			*Accept second arrow, representing opposite spin, in any 2p box.* *Accept half-arrows.*	**1**

Question			Answers	Notes	Total
1.	**(d)**		greater repulsion when electrons occupy same orbital ✓	*Accept electron added to stable half-filled p sublevel.*	**1**
1.	**(e)**		*Largest first ionization energy:* highest nuclear charge «for a similar radius/same energy level» ***OR*** smallest radius ***OR*** stable octet ✓ *Largest positive first electron affinity:* adding to new principal energy level ***OR*** «much» further from nucleus ***OR*** shielded by completed inner shell ✓	*Do **not** accept "complete octet" without reference to stability for M1.*	**2**

	Question		Answers	Notes	Total
1.	(f)		**ALTERNATIVE 1:** «Xe» lower/smaller/less positive **AND** larger radius **OR** «Xe» lower/smaller/less positive **AND** smaller energy gap to next «principal» energy level ✓ **ALTERNATIVE 2:** «Xe» greater **AND** very high nuclear charge **OR** «Xe » greater **AND** poor shielding by inner «d» orbitals ✓	*Accept converse arguments for either alternative only if it is clear that Ne being referred to.*	1

	Question		Answers	Notes	Total
2	(a)	(i)	+2/II ✓	*Do **not** accept A^{2+}, A^{+2}, 2 **OR** 2+.*	1
2.	(a)	(ii)	C A B D E ✓	*Do **not** accept reverse order unless the answer makes it clear which is the most reactive.*	1

Question	Answers	Notes	Total
2. (b)	 two half cells with electrodes, solutions, salt bridge and connecting wire ✓ C as anode **AND** E as cathode ✓ CSO$_4$ **AND** ESO$_4$ «solutions» labelled ✓ electron flow shown «on wire» from more reactive to less reactive metal ✓	*Voltmeter not needed.* *Accept salt bridge even if not labelled.* *Do **not** award M1 if a battery is included.* *Do **not** award M1 if liquid level not shown in container, or if electrodes and ends of salt bridge are not in solutions.* *Accept salt of C/C^{2+}«(aq)» **AND** salt of E/E^{2+}«(aq)» for M3.*	4
2. (c)	copper/Cu **OR** silver/Ag ✓	*Accept lead/Pb, tin/Sn or nickel/Ni.*	1
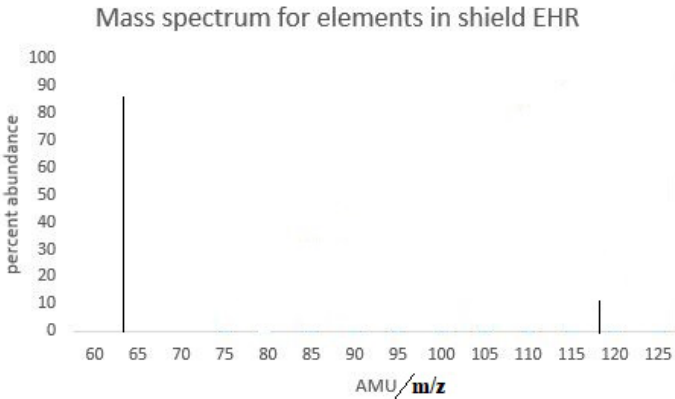
Section B

Option A — Materials

Question			Answers	Notes	Total
3.	(a)	(i)	$2CO(g) \rightarrow C(s) + CO_2(g)$ ✓	*Accept reversible arrows.*	1
3.	(a)	(ii)	«100 × 12.01 / 2 × (12.01+16.00) = » 21.44% ✓		1
3.	(a)	(iii)	«gaseous» reactants adsorb onto «metal» surface ***OR*** catalyst provides surface for reaction to occur ✓ weakens «reactant» bonds ***OR*** products desorb ✓	*Accept lowers activation energy for M2.*	2
3.	(a)	(iv)	bottom up ***AND*** molecular assembly «rather than decomposition» ✓		1

	Question		Answers	Notes	Total
3.	**(a)**	**(v)**	*Any one of:* more easily airborne/inhaled ✓ have similar dimensions as biological molecules/interfere with biochemical reactions ✓ easily absorbed into body ✓ may cross cell membranes ✓ large surface area could increase toxicity ✓ human defence system not effective with small size ✓	*Do **not** accept just large surface area **OR** toxic/increased toxicity.*	**1 max**
3.	**(b)**	**(i)**	fluids with «some» properties that are anisotropic/depend on molecular orientation «relative to a fixed axis» ✓	*Do **not** accept general references to a mesophase.*	**1**
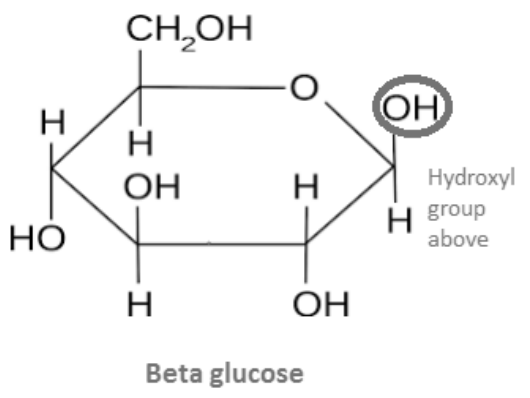
	Question		Answers	Notes	Total
3.	**(b)**	**(ii)**	polar «molecules» ✓ change orientation upon application of electric field **OR** «in some orientations» molecules rotate plane of polarization «of polarized light» ✓		**2**
3.	**(b)**	**(iii)**	7 ✓		**1**
3.	**(b)**	**(iv)**	3300 to 3500 ✓	*Accept amine/amide/N-H bond.*	**1**
3.	**(b)**	**(v)**	*Monomers:* addition: unsaturated/containing C=C/C≡C ✓ condensation: monomers have two reactive sites/functional groups ✓ *Products*: addition: one product/no by-products **AND** condensation: small molecule/HCl eliminated/two products ✓	*Double/triple bond must be stated as between carbon atoms.* *Accept H_2O eliminated in condensation reaction.*	**3**

	Question		Answers	Notes	Total
4.	(a)		metal ions/atoms have different sizes ✓ cations/atoms/layers do not slide over each other as easily ✓ «irregularities» obstruct free movement of electrons ✓	*Accept electrons move less easily/less delocalized for M3.*	**3**
4.	(b)		straight line increasing and going through origin/(0,0) ✓		**1**
4.	(c)	(i)	 89% at 63.5 ***AND*** 10% at 118 ✓	*Accept range 62.5-64.5 for Cu and 117-119 for Sn.* *Accept 85-95 % for Cu and 5-15 % for Sn.*	**1**
4.	(c)	(ii)	vapourize «the sample» ✓ ionize «the sample» ✓	*Accept relevant equations.*	**2**

Question			Answers	Notes	Total
5.	**(a)**	**(i)**	Coordination number: 12 ✓ Number of atoms per unit cell: 4 ✓		**2**
5.	**(a)**	**(ii)**	V= «$(3.61 \times 10^{-8}$ cm$)^3$ =» 4.70×10^{-23} «cm^3» ✓ Mass of unit cell = «63.55 g mol^{-1} x 4 ÷ 6.02×10^{23}» 4.22×10^{-22} « g » ✓ 4.22×10^{-22} g ÷4.70×10^{-23} «cm^3» 8.98 g cm^{-3} ✓	*Award [3] for correct final answer.*	**3**
5.	**(b)**		K_{sp} =[Cu^{2+}][OH$^-$]^2 **OR** 2.2×10^{-20} =[Cu^{2+}] x $(10^{-5})^2$ ✓ [Cu^{2+}] «= K$_{sp}$/[OH$^-$]^2 =2.2×10^{-20}/$(10^{-5})^2$» = 2.2×10^{-10}«mol dm^{-3}» ✓	*Award [2] for correct final answer.*	**2**
5.	**(c)**		Cu^{2+} + •O$_2^-$ → Cu$^+$ + O$_2$ ✓ Cu$^+$ + H$_2$O$_2$ → Cu^{2+} + OH$^-$ + •OH ✓		**2**
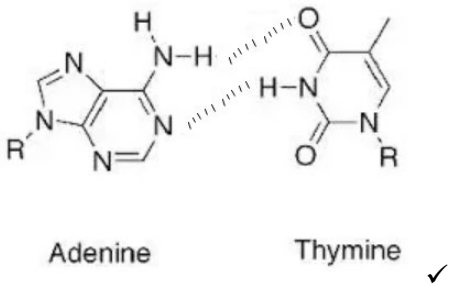
Option B — Biochemistry

Question			Answers	Notes	Total
6.	**(a)**		cannot be synthesized «by the human body» ✓		1
6.	**(b)**		temperature **AND** pH ✓		1

Question			Answers	Notes	Total
7.	**(a)**	**(i)**	$C_x(H_2O)_y$ ✓		1
7.	**(a)**	**(ii)**	«n=10.5g/180.18g mol^{-1}=» 0.0583 «mol» ✓ «0.0583 mol x 2810 kJ mol^{-1} =» 164 «kJ» ✓	*Award [2] for correct final answer.* *Award [1 max] for −164 «kJ».*	2

Question			Answers	Notes	Total
7.	(b)		Beta glucose ✓	*Entire structure must be correct to score the mark.* *Ignore incorrect connectivity.*	1
7.	(c)		«provides dietary» fibre/roughage ✓	*Accept prevents constipation, etc.*	1
7.	(d)	(i)	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ ✓ $C_{57}H_{110}O_6 + 81.5O_2 \rightarrow 57CO_2 + 55H_2O$ **OR** $2C_{57}H_{110}O_6 + 163O_2 \rightarrow 114CO_2 + 110H_2O$ ✓		2
7.	(d)	(ii)	more **AND** contains less oxygen/contains more carbon/more reduced ✓		1

Question			Answers	Notes	Total
7.	**(e)**		*Chemical composition*: glycerol **AND** «two» fatty acids **AND** «one» phosphate ✓ *Function*: cell/plasma membrane ✓	*Accept suitable diagram for M1.* *Do **not** accept "hydrophilic head and hydrophobic tail" for M1.* *Accept insulation or lipid transport for M2.* *Do **not** accept cell wall for cell membrane.*	**2**

Question			Answers	Notes	Total
8.	**(a)**	**(i)**	*Identity of spot C:* leucine ✓		**1**
8.	**(a)**	**(ii)**	serine **AND** more polar «than phenylalanine» **OR** serine **AND** OH group «on side chain» ✓ hydrogen bonding/greater affinity with stationary phase **OR** less soluble/poor affinity in solvent/mobile phase ✓	*M2 may be scored without M1.*	**2**
8.	**(b)**		bind to substrate at active site ✓ «provide» alternative pathway with lower «activation» energy ✓	*Must have idea of binding to substrate **AND** a specific active site for M1.*	**2**

Question			Answers	Notes	Total
8.	**(c)**		additives to detergents/washing powders/liquids ***OR*** breakdown oil spills/industrial waste ✓	*Accept other industrial use.* *Do **not** accept non-industrial uses, such as pregnancy testing.*	**1**
8.	**(d)**		*Effect on K_m*: remains the same/no change ***AND*** *Effect on V_{max}*: decreases/reduced ✓ *Explanation for K_m:* no decrease in affinity of enzyme for substrate ✓ *Explanation for V_{max}:* binds at allosteric site ***OR*** binds away from active site ***OR*** changes shape of active site ***OR*** renders active site ineffective ✓		**3**

Question			Answers	Notes	Total
8.	(e)		$$\log_{10}\frac{I_0}{I} = \varepsilon l c$$ « $\qquad$ and $\log_{10} I_0/I = A$ » $\varepsilon l c = 0.50$ ✓ «$c = 0.50 / (0.75\ dm^3\ cm^{-1}\ mol^{-1} \times 1\ cm)$» 0.67 « $mol\ dm^{-3}$ » ✓	*Award [2] for correct final answer.*	2

Question			Answers	Notes	Total
9.	(a)		phosphate **AND** deoxyribose **AND** nitrogenous base ✓	*Accept named base.* *Do **not** accept 'sugar' or 'pentose sugar' in place of deoxyribose.*	1
9.	(b)			*Only 2 H bonds must be shown.* *Accept H bond from either H in NH_2 of Adenine, but not from both.* *Accept solid lines instead of dashes.*	1
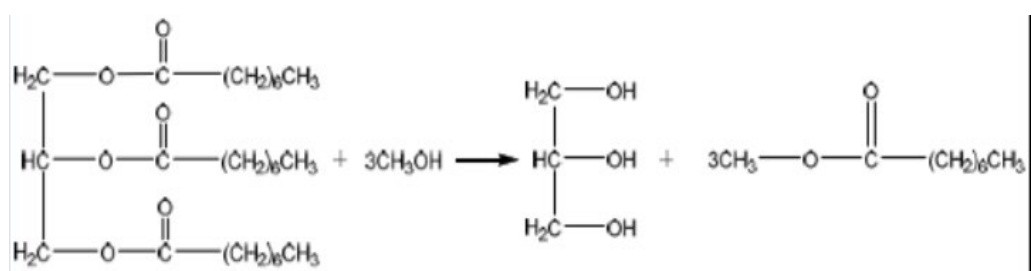
Question			Answers	Notes	Total
10.	**(a)**		X **AND** «high pH moves» equilibrium left **OR** X **AND** loss of proton/H⁺ «at high pH/due to excess OH⁻(aq)» **OR** X **AND** positive ion unlikely «at high pH» ✓		**1**
10.	**(b)**		temperature **OR** light ✓	*Accept other reasonable answer, eg. metal ions, enzymes, oxidising agent, etc.*	**1**
10.	**(c)**		*Similarity:* heme group **OR** Fe cation/Fe²⁺ ✓ *Difference:* myoglobin has one polypeptide chain **AND** hemoglobin has four polypeptide chains **OR** myoglobin has one heme «group» **AND** hemoglobin has four heme «groups» **OR** myoglobin has no quaternary structure **AND** hemoglobin has quaternary structure ✓	*Accept both are globular proteins or both are metalloproteins.* *Do **not** accept both are polymers of amino acids.*	**2**
11.			chemicals found in an organism that are not normally present ✓		**1**

Option C — Energy

	Question		Answers	Notes	Total
12.	**(a)**	**(i)**	33% of energy input/released «in fission» is converted to electricity ✓	*Do **not** accept generalizations, such as "Only produces 33% useful energy."*	**1**
12.	**(a)**	**(ii)**	X $^{3}_{2}He$ **AND** Y $^{3}_{1}H$ ✓		**1**
12.	**(a)**	**(iii)**	2nd/Y/$^{3}_{1}H$ **AND** formation $^{3}_{1}H$ has greater increase in binding energy «per nucleon than formation $^{3}_{2}He$ ✓	*Accept 2nd/Y/$^{3}_{1}H$ **AND** "It is higher on the binding energy curve".*	**1**

Question			Answers	Notes	Total
12.	**(a)**	**(iv)**	m(deuteron) = 2.013553 «amu» × 1.660540 × 10^{-27} «kg amu^{-1}=» **OR** 3.343585 × 10^{-27} «kg» ✓ «Δm = (mass of reactants – mass of products)» Δm = «(1.672622 × 10^{-27} kg + 1.674927 × 10^{-27} kg) – 3.343585 × 10^{-27} kg =» 3.964 × 10^{-30} «kg» ✓ E = «mc^2 = 3.964 × 10^{-30} kg × (3.00 × 10^8 m s^{-1})^2 =» 3.568 × 10^{-13} «J» ✓	*Award [3] for correct final answer.*	**3**
12.	**(a)**	**(v)**	deuterium contains more atoms per unit mass «than uranium as it has a lower molar mass» ✓ fusion releases more energy per atom than fission ✓ «solid» uranium «much» more dense «than deuterium» **OR** uranium contains more atoms per unit volume «than deuterium, as it is a solid»✓ increase in density has a greater effect than fusion releasing more energy than fission ✓		**4**

	Question		Answers	Notes	Total
12.	**(a)**	**(vi)**	uranium converted to uranium hexafluoride/UF_6 «gas» ✓ centrifuge ***OR*** lower mass isotope/^{235}U effuses/diffuses more rapidly ***OR*** higher mass isotope/^{238}U moves/closer to outside of centrifuge ***OR*** lower mass isotope/^{235}U stays in/removed from middle of centrifuge ✓		**2**
12.	**(b)**	**(i)**	$C_7H_{16} \rightarrow C_6H_5CH_3 + 4H_2$ ✓	*Accept C_7H_8 for $C_6H_5CH_3$.*	**1**
12.	**(b)**	**(ii)**	any alkane ***AND*** alkene where total sum of C=7 and H=16; e.g. C_5H_{12} ***AND*** C_2H_4 ✓		**1**

| **13.** | **(a)** | | $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ✓ | | **1** |

Question			Answers	Notes	Total
13.	(b)		 ester product ✓ glycerol **AND** correct balancing ✓		2
13.	(c)		conjugated bonds/alternating C=C bonds/delocalized electrons/bonding ✓	*Accept 'alternating single and double bonds'.* *Do **not** accept 'many double bonds'.*	1
13.	(d)	(i)	allow H⁺ ions to pass through/diffuse/move «from anode to cathode» ✓	*Do **not** accept diffusion of electrons or small molecules.*	1
13.	(d)	(ii)	Anode: $CH_3COO^-(aq) + 2H_2O(l) \rightarrow 2CO_2(g) + 7H^+(aq) + 8e^-$ ✓ Cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ ✓ Overall Equation: $CH_3COO^-(aq) + H^+(aq) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ ✓		3
13.	(d)	(iii)	fuel supply is wastewater/organic material ✓	*Accept bacterium reproduces.*	1

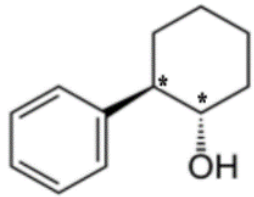| Question			Answers	Notes	Total
14.	(a)		glacier/ice sheets/ retreat/melting **OR** rising sea levels ✓	*Accept other reasonable answers, e.g. ocean acidification, severe weather patterns.* *Do **not** accept just 'climate change'.*	1
14.	(b)		«increase in bond» stretching/vibrating/bending **OR** bond angles/lengths change ✓	*Accept dipole moment changes.* *Accept light energy is converted into mechanical/potential/internal energy of the molecule.*	1
14.	(c)		«M_r CH_4: M_r CO_2/ 16.05 ÷ 44.01 =» 0.365 ✓ «21 × 0.365 = » 7.66 «times» ✓	*Award **[2]** for correct final answer.* *Accept 7.64 «times» (integer M_rs).* *Award **[1 max]** for 57.6 «times» if inverted ratio is used.*	2
15.	(a)		negative above junction **AND** positive below junction ✓ e^- flow from n-type through wire to light globe **OR** from light globe to p-type through wire.✓		2
15.	(b)		silicon/Si **OR** germanium/Ge ✓		1

Option D — Medicinal chemistry

Question			Answers	Notes	Total
16.	**(a)**		*Any **two** of:* oral ✓ inhalation ✓ topical/applied to the skin ✓ parenteral/injection ✓ suppositories ✓ eye/ear drops ✓	*One mark for any **two** correct methods.* *Count multiple methods of injection (intramuscular, subcutaneous, intravenous) as just one method.*	**1**
16.	**(b)**		interferes with pain at source «of injury» ✓ prevents release of prostaglandins/substances causing swelling/pain ✓		**2**

16.	**(c)**		**ALTERNATIVE 1:**
			    A: $CH_3COOCOCH_3$ ✓
			    B: CH_3COOH ✓
			
			ALTERNATIVE 2:
			    A: CH_3COOH ✓
			    B: H_2O ✓
			
			ALTERNATIVE 3:
			    A: CH_3COCl ✓
			    B: HCl ✓
				Accept expanded structural formulas.	**2**

Question			Answers	Notes	Total
16.	**(d)**		*Advantage*: strong/severe/surgical pain relief **OR** stops coughing reflex **OR** fast action ✓ *Disadvantage*: addiction **OR** constipation **OR** tolerance «leading to overdose» ✓	*Accept strong painkillers/analgesics for M1.* *Accept constipation for M1 if not given as a disadvantage.* *Accept small therapeutic window for M2.* *Accept other named specific side effect for M2.*	**2**

Question			Answers	Notes	Total
17.	**(a)**		$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ **AND** $Al(OH)_3(s) + 3HCl(aq) \rightarrow AlCl_3(aq) + 3H_2O(l)$ ✓	*Accept appropriate ionic equations.* *Do **not** accept H_2CO_3 as a product of first reaction.* *Ignore equilibrium arrows.*	**1**

	Question		Answers	Notes	Total
17.	**(b)**		«n(MgCO$_3$) = 2.00g/84.32g mol^{-1}=» 0.0237« mol» **AND** «n(Al(OH)$_3$) = 2.00g/78.01g mol^{-1} =» 0.0256 «mol» ✓ «0.0237n(MgCO$_3$) × 2 =» 0.0474 «n(HCl) neutralised» **AND** «0.0256 n(Al(OH)$_3$) × 3 =» 0.0768 «n(HCl) neutralised» ✓	*Award [1 max] for any two correct calculations.*	**2**
18.	**(a)**		*Any two of:* «bind to receptors to» prevent virus entering cell ✓ alter genetic material of cell/cytoplasm «to prevent replication» ✓ block enzyme activity in cell «to prevent replication» ✓ prevent virus leaving cell «by inhibiting viral enzyme/neuraminidase» ✓		**2 max**
18.	**(b)**		side chain modified ✓ overcome antibiotic resistance/ penicillinase ineffective ✓	*Accept R group instead of side chain. Accept increase the stability of penicillin in GIT/gastrointestinal tract for M2.*	**2**

Question			Answers	Notes	Total
19.	**(a)**		✓✓ one for each carbon correctly identified	*Apply 'list principle' if any answer has more than two carbon atoms marked.*	**2**
19.	**(b)**		needles «of European» yew «tree» ✓		**1**
19.	**(c)**		*Any two of:* energy efficiency ✓ prevention of waste/recycling ✓ atom economy/more efficient processes ✓ safer/reduced use of solvents ✓ design for degradation ✓ more sustainable sourcing of reactants/feedstock ✓	*Accept specific examples.*	**2 max**

Question			Answers	Notes	Total
20.	(a)		TAT: spread to multiple sites **AND** alpha particles **OR** «cancers of the» blood/leukaemia **AND** alpha particles ✓ BNCT: head/neck/brain «cancers» **AND** neutrons ✓	*Award [1] for 2 correct cancers or 2 correct particles.*	**2**
20.	(b)		*Any two of:* gamma radiation **AND** easily traced ✓ weak/low-energy/low-frequency «gamma» radiation «low risk to patient» ✓ short half-life «low risk to patient» ✓ binds to range of biologically-active substances ✓ «gamma-radiation of approximately» same frequency as X-rays «so can be detected using existing X-ray equipment» ✓ easily obtained ✓	*Accept non-ionising radiation.*	**2 max**
20.	(c)		«$N_t = N_0(0.5)^{t/t1/2}$ =» 1.0×10^{-7} mol dm^{-3} × $(0.5)^{22.00/6.01}$ ✓ «N_t =» 7.9×10^{-9} «mol dm^{-3}» ✓	*Award [2] for correct final answer.*	**2**

Question			Answers	Notes	Total
21.	(a)	(i)	chromatography ✓	*Accept any named form of chromatography.* *Accept extraction.*	1
21.	(a)	(ii)	*m/z 288:* molecular ion/M^+/$C_{19}H_{28}O_2$ $^+$ ✓ *m/z 273:* $C_{18}H_{25}O_2$ $^+$ ***OR*** loss of methyl/CH_3 group" or "$(M - CH_3)^+$ ✓	*Charge needed, penalize missing charge once only.*	2
21.	(b)		**ALTERNATIVE 1:** $C_2H_5OH(g) \rightarrow C_2H_4O(aq) + 2H^+ + 2e^-$ ✓ $3C_2H_5OH(g) + Cr_2O_7{}^{2-}(aq) + 8H^+(aq) \rightarrow 3C_2H_4O(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$ ✓ **ALTERNATIVE 2:** $C_2H_5OH(g) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+ + 4e^-$ ✓ $3C_2H_5OH(g) + 2Cr_2O_7{}^{2-}(aq) + 16H^+(aq) \rightarrow 3CH_3COOH(aq) + 4Cr^{3+}(aq) + 11H_2O(l)$ ✓	*Accept C_2H_6O for C_2H_5OH.*	2