

Markscheme

May 2023

Chemistry

Standard level

Paper 3

26 pages

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Subject details: Chemistry standard 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 [**20 marks**].

Maximum total = [**35 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 underlined 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)	gases «and others are solids» ✓	<i>Do not accept “lower density” alone.</i>	1
1.	(b)	smaller values are diatomic «gases» OR larger values are monatomic «gases» ✓	<i>Accept “smaller values are species that exist as molecules”. Do not accept answers referring only to noble gases or electron configurations.</i>	1
1.	(c)	«different» allotropes ✓	<i>Accept “different structural forms” OR “oxygen forms different molecules”. Accept correct formulas or names of allotropes. Accept monatomic oxygen/O only if mentioned with respect to other allotropic form or explanation provided. Do not accept “different isotopes” alone.</i>	1
1.	(d)	<i>Any two of:</i> increasing «effective» nuclear charge/Z/atomic number/number of protons ✓ increasing number of delocalized/bonding/valence electrons ✓ increasing attractions between positive «metal» ions/cations and delocalized electrons OR stronger metallic bonding OR decreasing radii ✓		2 max

Question			Answers	Notes	Total
1.	(e)		any estimated value in the range of 20-40 «cm ³ mol ⁻¹ ». ✓	Accept any range of values also between 20 to 40 «cm ³ mol ⁻¹ ».	1
1.	(f)		<p>no AND probability of finding an electron is low OR no AND all measurements have uncertainties «even though there will always be uncertainty as to what the exact value is»</p> <p>OR</p> <p>yes AND X-ray diffraction can indicate separation of nuclei «in the element» OR yes AND can take a sample of the element, measure its volume and calculate number of particles OR yes AND bond length can be measured by microwave spectroscopy/electron diffraction/neutron diffraction ✓</p>	<p>Accept “no AND position of electron cannot be determined” for M1. Accept “no AND atoms made up of «mainly» empty space that cannot be measured” for M1. Accept “no AND atoms have different volumes in different states «of matter»” for M1. Accept “no AND the distance between two nuclei is measured and the radius/volume/size of atom is estimated” for M1. Accept references to the Heisenberg uncertainty principle for M1.</p>	1
2.	(a)	(i)	<p>green to purple OR green to brown OR green to purple-green ✓</p>	<p>Accept “colourless to purple”. Accept “green to grey/blueish”. Do not accept “clear” for “colourless”. Do not accept “purple to “brown”. Do not accept blue as final colour.</p>	1
2.	(a)	(ii)	none / no effect ✓		1

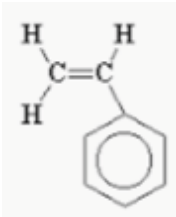
Question			Answers	Notes	Total
2.	(b)		systematic ✓	<i>Class must be stated, not specific examples.</i>	1
2.	(c)	(i)	$\left(\frac{0.1}{3.1} \times 100 = \right) 3 \text{ (\%)} \checkmark$		1
2.	(c)	(ii)	using more dilute potassium manganate(VII) OR using more dilute titrant OR larger aliquot/volume of filtrate ✓	<i>Accept “using a pipette with more precision” OR “using a volumetric flask” OR “using a better balance/scale” OR “determining a more accurate mass”.</i> <i>Do not accept “weight” for “mass”.</i>	1

Question			Answers	Notes	Total
2.	(c)	(iii)	<p>ALTERNATIVE 1 mass Fe in the 79.6 g kale $\langle\langle = 8.66 \times 10^{-4} \times \frac{500}{10.0} \rangle\rangle$ = 0.0433 «g» ✓ percent by mass $\langle\langle = \frac{0.0433}{79.6} \times 100 \rangle\rangle$ = 0.0544«%» ✓</p> <p>ALTERNATIVE 2 mass of kale in titration flask $\langle\langle = 79.6 \times \frac{10.0}{500} \rangle\rangle$ = 1.592 «g» ✓ percent by mass $\langle\langle = \frac{8.66 \times 10^{-4}}{1.592} \times 100 \rangle\rangle$ = 0.0544«%» ✓</p>	<p>Award [2] for correct final answer.</p> <p>For ALTERNATIVE 2: Award M1 for either 1.59 «g» OR 1.592 «g» and Award M2 for 0.0545«%» OR 0.0544«%».</p> <p>M2 must be to 3 sig. fig.</p> <p>Award [1 max] for 0.00109«%».</p>	2
2.	(d)		<p>other substances in the leaves «as well as iron» react with the manganate(VII) «ion» OR kale modified to have more iron/Fe OR iron/Fe in water/pipes/container used for boiling OR manganate(VII) oxidized/reacted with other ions/substances/metals OR manganate(VII) concentration changes over time ✓</p>	<p>Accept “different species of kale can result in more iron/Fe «content»” OR “sample of kale not representative” OR “sample of kale grown in different soils” OR “kale sample being dry/dehydrated”.</p>	1

Section B

Option A — Materials

Question			Answers	Notes	Total
3.	(a)		Any one of: Zn, Cr, Fe, Cd, Co, Ni, Sn, Pb, Sb, As, Bi, Cu, Ag, Pd, Hg, Pt ✓	Accept "Au". Accept name or symbol of metal.	1
3.	(b)	(i)	$\text{Al}^{3+} + 3 \text{e}^- \rightarrow \text{Al(l)} \checkmark$	Do not penalize if equilibrium arrow used.	1
3.	(b)	(ii)	$\left\langle \left\langle \frac{2 \times 26.98}{2 \times 26.98 + 3 \times 16.00} \times 100 = \right\rangle \right\rangle 52.92\% \checkmark$	Accept "0.5229".	1
3.	(b)	(iii)	high energy consumption «that has environmental implications» OR large amounts of waste «produced by mining and purification of the ore» OR mining has negative impact on landscape OR greenhouse gas/pollution from transport/machinery ✓	Accept "fluorine/fluorine compounds produced" or their formulas. OR "carbon dioxide/carbon monoxide released".	1
3.	(b)	(iv)	average electronegativity 2.5 AND electronegativity difference 1.8 ✓ border between ionic and «polar» covalent ✓	Accept "partially covalent/high covalent character" for M2. Award [2] for calculation of %ionic character = «1.8/3.2 =» 56%.	2

Question			Answers	Notes	Total
3.	(c)	(i)	electrons AND «positive» ions «in gaseous state» ✓	Accept “gaseous atoms, «many of» which have lost their electrons”. Do not accept “gaseous ions” alone.	1
3.	(c)	(ii)	Identification: «emit» light/photons of characteristic frequencies ✓ Concentration: intensity/brightness of light «proportional to concentration» ✓	For M1 accept “energies/wavelengths” for “frequencies”. For M2 accept “signal strength/peak height”. Do not accept a general statement such as “concentrations can be detected by absorbance of the radiation «in OES»” for M2.	2
3.	(d)		«held together by strong» covalent bonds «and defect free/regular 2D/3D» ✓		1
4.	(a)	(i)	 ✓	Accept “-C ₆ H ₅ ” for phenyl group.	1
4.	(a)	(ii)	B AND chains «of polymer» can align/pack more closely ✓	Do not accept “stronger intermolecular forces between chains”.	1

Question			Answers	Notes	Total
4.	(b)		forms an intermediate/activated complex ✓ «intermediate/activated complex» dissociates to form product « AND catalyst» ✓	Accept correct annotated energy profile for either mark.	2
4.	(c)		«lyotropic liquid crystals» exist over a given concentration range AND other liquid crystals exist over a certain temperature range ✓		1
4.	(d)	(i)	volatile hydrocarbon/pentane «incorporated in beads of the polymer» ✓ vaporizes/boils when heated «causing polymer to expand» ✓	Accept names or formulas for M1. Accept “carbon dioxide” for M1.	2
4.	(d)	(ii)	«good» thermal/electrical insulator OR soft/provides shock resistance OR low density OR easily moulded/versatile OR water resistant OR durable ✓	Accept “easy on-site usage” OR “environmentally sustainable” OR “non-toxic” OR «chemically» inert”. Accept “lightweight” for “low density”.	1
4.	(e)		strong covalent bonds ✓	Accept “close packing of chains” OR “hydrophobicity”.	1
4.	(f)		«RIC» 7 ✓		1

Option B — Biochemistry

Question		Answers	Notes	Total
5.		$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ ✓		1

6.	(a)	<table border="1"> <thead> <tr> <th>Structure Level</th> <th>Interactions between amino acids</th> </tr> </thead> <tbody> <tr> <td>primary</td> <td>covalent bonding OR peptide bond OR amide bond ✓</td> </tr> <tr> <td>secondary</td> <td>hydrogen bonding ✓</td> </tr> <tr> <td>tertiary</td> <td>interactions between R groups/side chains OR ionic/electrostatic «attraction» OR hydrogen bonding OR hydrophobic interactions OR disulfide bridges OR London/dispersion/van der Waals/«instantaneous» induced dipole-induced dipole ✓</td> </tr> </tbody> </table>		Structure Level	Interactions between amino acids	primary	covalent bonding OR peptide bond OR amide bond ✓	secondary	hydrogen bonding ✓	tertiary	interactions between R groups/side chains OR ionic/electrostatic «attraction» OR hydrogen bonding OR hydrophobic interactions OR disulfide bridges OR London/dispersion/van der Waals/«instantaneous» induced dipole-induced dipole ✓	<p><i>Do not accept "amino acid sequence" for M1.</i></p> <p><i>Do not accept "alpha helix" OR "beta sheets" for M2.</i></p> <p><i>Accept "covalent bonding" for M3.</i></p>	3
		Structure Level	Interactions between amino acids										
		primary	covalent bonding OR peptide bond OR amide bond ✓										
		secondary	hydrogen bonding ✓										
tertiary	interactions between R groups/side chains OR ionic/electrostatic «attraction» OR hydrogen bonding OR hydrophobic interactions OR disulfide bridges OR London/dispersion/van der Waals/«instantaneous» induced dipole-induced dipole ✓												

Question		Answers	Notes	Total
6.	(b)	<p><i>Any two of:</i></p> <p>sample spotted on paper/stationary phase AND solvent moves up the paper OR continuous cycles of adsorption and desorption/dissolution OR analyte moves when in solvent AND does not move when on paper ✓</p> <p>different/depends on attractions to mobile phase AND stationary phase/paper OR «amino acids» separated based on solubilities in/affinity to the two phases OR separated based on polarities/polar attractions/molar masses of «amino acids» ✓</p> <p>developed with ninhydrin/reagent/locating agent OR become identified with UV «light» ✓</p> <p>«amino acids» identified by R_f/retention factor «values» OR R_f/retention factors «values» compared with known samples ✓</p>		2 max

Question		Answers	Notes	Total
7.	(a)	<p><i>Compare rancidity:</i> «both produce» disagreeable smell/taste/texture/appearance ✓</p> <p><i>Contrast reaction site:</i> hydrolytic reaction occurs at ester link/COOC link AND oxidative reaction occurs at carbon-carbon double bond/C=C ✓</p>	<p><i>Do not accept “double bond” alone for oxidative reaction site.</i></p>	2
7.	(b)	<p>5 C=C ✓</p> <p>«100 g/330.56 g mol⁻¹ x 5 x 253.8 g mol⁻¹ => 383.89 «g I₂» ✓</p>	<p><i>Award [2] for correct final answer.</i></p>	2
7.	(c)	<p>lipids are more reduced AND release/store more energy than carbohydrates «per gram» ✓</p> <p>lipids are less «water» soluble AND energy is released slower/less available than in carbohydrates ✓</p>	<p><i>Accept converse arguments.</i></p> <p><i>Award [1 max] for “carbohydrates used for short-term energy supply AND lipids used for long-term energy supply”</i> OR <i>“lipids more reduced AND less «water» soluble”.</i></p>	2
7.	(d)	<p>«stearic acid» straight chain/chain has no kinks/more regular structure OR «stearic acid» saturated/no «carbon-carbon» double bonds ✓.</p> <p>«stearic acid» chains pack more closely together OR stronger London/dispersion/instantaneous induced dipole-induced dipole forces «between molecules» ✓.</p>	<p><i>Accept greater surface area/electron density for M1.</i></p> <p><i>Accept stronger intermolecular/van der Waals’/vdW forces for M2.</i></p>	2

Question		Answers	Notes	Total
8.	(a)	<p><i>Bond:</i> glycosidic ✓</p> <p><i>By-product:</i> water/H₂O ✓</p>	<p>Accept "ether/C-O-C" OR "covalent/polar covalent" for M1.</p>	2
8.	(b)	<p>«15.00 g / 342.34 g mol⁻¹ =» 0.04382 «mol» ✓</p> <p>«0.04382 mol x 5640 kJ mol⁻¹ = » 247.1 «kJ» ✓</p>	<p>Award [2] for correct final answer.</p> <p>Accept "-247.1 «kJ»" for M2.</p>	2
9.		«mostly» not synthesized by body «and needed for proper growth/metabolism» ✓	Do not accept "needed for proper growth/metabolism" alone.	1
10.		<p>host molecule/super molecule forms complex/bond with guest/xenobiotic «facilitating their removal»</p> <p>OR</p> <p>shape/size of host matches guest/xenobiotic AND binds ✓</p>		1

Option C — Energy

Question			Answers	Notes	Total
11.	(a)	(i)	$6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g})$ ✓		1
11.	(a)	(ii)	conjugated «electronic» structure/delocalized «pi» electrons/alternate «single and» double bonds ✓	Accept “many/delocalized double bonds”. Do not accept “tetrapyrrole group” alone without reference to idea of conjugation.	1
11.	(a)	(iii)	reduces/sequesters CO_2 /carbon dioxide «concentration from atmosphere» ✓ «planting» more plants/trees ✓	Do not accept “carbon capture” alone for M1. Do not accept just “plants/trees” alone for M2.	2
11.	(b)	(i)	« $(2 \times 1367 / -2803) \times 100 =$ » 97.54% OR 2.46% loss «in energy efficiency» ✓		1
11.	(b)	(ii)	liquid OR easier ignition OR more volatile ✓	Accept “complete combustion more likely” OR “better octane rating” OR “engine must be converted in order to use glucose”. Do not accept “less viscous”.	1

Question			Answers	Notes	Total
12.	(a)	(i)	reflects «sun» light ✓	<p>Accept “results in global dimming” OR “reduces the amount of energy reaching the Earth” OR “acts as nucleation points for cloud formation”.</p> <p>Do not accept answers that only indicate increases in global temperatures.</p>	1
12.	(a)	(ii)	electrical/electricity ✓	Accept “heat/thermal”.	1

Question		Answers	Notes	Total
12.	(b)	<p><i>Fractional distillation (Any one of):</i> separates compounds according to boiling points/vapor pressure OR physical process OR involves breaking intermolecular forces OR separates based on molar masses OR does not use catalyst ✓</p> <p><i>Cracking (Any one of):</i> shorter hydrocarbon chains formed/lower molar masses OR increased branching formed OR increased aromatic ring formation OR produces alkenes/unsaturated hydrocarbons OR chemical process OR new compounds formed/breaking «and remaking»/changing covalent bonds OR uses catalyst ✓</p>	<p><i>M1 is for Fractional distillation.</i></p> <p><i>M2 is for Cracking.</i></p>	2

Question			Answers	Notes	Total
12.	(c)	(i)	<p>ALTERNATIVE 1 5470 «kJ» produced when 8 «mol» produced ✓ «8 x 44.01 => 352 «g» to produce 5470 «kJ» ✓ 1 «kJ» would release «352/5470 => 0.0644 «g» ✓</p> <p>ALTERNATIVE 2 1 «kJ»/5470«kJ=> 1.828x10⁻⁴ ✓ 8/5470 «mol => 0.001463 mol ✓ «8/5470 «mol» x 44.01 «gmol⁻¹ => 0.0644 «g» ✓</p>	<p>Award [3] for correct final answer.</p> <p>Accept "0.0643 «g»".</p>	3
12.	(c)	(ii)	<p>many fluctuations of temperature have occurred in the «geological» past OR different global models produce different outcomes OR industrial emissions are less than natural ones ✓</p>	<p>Do not accept statements about current temperatures.</p>	1

Question		Answers	Notes	Total
13.	(a)	<p><i>Similarity:</i> increase binding energy «per nucleon» OR «can» produce chain reactions ✓</p> <p><i>Difference:</i> fusion forms one product/products with a greater «atomic» mass AND fission multiple products/products with a lower mass OR fission produces «long lived» radioactive products/nuclear waste AND fusion does not ✓</p>	<p><i>Similarity:</i> Accept “converts mass to energy”. Accept “produces ionizing radiation”. Accept “produces heat”. Accept “produces mass defect”.</p> <p><i>Difference:</i> Accept “fission requires critical mass AND fusion does not”. Accept “fuel for fission is radioactive AND fuel for fusion is not”. Accept “fuel for fission are heavy elements/U/Th/Pu AND fuel for fusion are light elements/H/He/Li”.</p>	2
13.	(b)	mass spectrometry/spectroscopy/MS ✓	<p>Accept “alpha spectrometry” OR “fluorometry” OR “Kinetic phosphoresce analysis”.</p>	1

Question			Answers	Notes	Total
13.	(c)	(i)	X: ${}^1_0\text{n}$ /neutron ✓ Y: ${}^{239}\text{Pu}$ /Pu-239/plutonium-239 ✓	Do not accept “N” for “neutron” for M1. Do not accept “plutonium/Pu” alone for M2.	2
13.	(c)	(ii)	time for half the number of atoms/nuclei/mass to decay ✓	Accept “time for the radioactivity «produced by that decay» to fall by half”. Do not accept “molecules” for “atoms/nuclei”.	1

Option D — Medicinal chemistry

Question	Answers	Notes	Total
14.	<p><i>Oral:</i> low/lower «bioavailability» AND drugs pass through digestive system «and breakdown» ✓</p> <p><i>Intravenous:</i> high/higher «bioavailability» AND «more» direct route to bloodstream ✓</p>	<p>Accept “low/lower AND drugs not easily absorbed from digestive system” OR “low/lower AND drugs broken down in digestive system” OR “low/lower AND drugs affected by acid” for M1.</p> <p>Do not penalize use of “slow” for “low/lower” or “fast” for “high/higher”.</p> <p>Accept “100% bioavailability” for “high/higher” within Intravenous answer in M2.</p> <p>Award [1] max for “oral drugs have slower absorption/distribution than Intravenous drugs” OR “Oral: low/lower «bioavailability» AND intravenous: high/higher «bioavailability»”.</p>	2

Question		Answers	Notes	Total
15.		<p>Any two of:</p> <p>reduce fever/antipyretic ✓</p> <p>anti-inflammatory ✓</p> <p>anti-coagulant/reduces blood clotting/blood thinner</p> <p>OR</p> <p>prevent cardiovascular disease/stroke ✓</p>	<p>Accept "prevents/reduces «risk of» heart attack" for M3.</p> <p>Accept "prevents heart disease" for M3.</p> <p>Accept "may reduce colon/colorectal cancer" for M3.</p>	2 max
16.		<p>bacterial resistance «to older penicillin's/antibiotics» ✓</p> <p>prevent penicillinase/beta-lactamase/enzyme in bacterium to deactivate/open penicillin/beta-lactam ring ✓</p>	<p>Accept "antibiotic resistant bacteria" but not "antibiotic resistance" for M1.</p> <p>Accept "reduce allergic reactions from penicillin" for M2.</p> <p>Award [1 max] for "increased efficiency/bioavailability"</p> <p>OR</p> <p>"increased stability in GIT".</p> <p>Do not accept "bacterial tolerance".</p>	2
17.	(a)	<p>«temporarily» binding to receptors in the nervous system/spinal cord/brain ✓</p> <p>preventing transmission of pain impulses ✓</p>	<p>Accept "bonding" for "binding" in M1.</p> <p>Accept "without depressing the central nervous system" for M2.</p>	2

Question			Answers	Notes	Total
17.	(b)		codeine binds less to opioid receptors «than morphine» OR codeine must be metabolized «to morphine by enzymes» ✓	Accept “bonding” for “binding” in M1. Accept correct name of inhibitor “fluoxetine” OR “citalopram”.	1
18.	(a)	(i)	$\text{Al(OH)}_3(\text{s}) + 3\text{HCl}(\text{aq}) \rightarrow \text{AlCl}_3(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$ OR $\text{Al(OH)}_3(\text{s}) + 3\text{H}^+(\text{aq}) \rightarrow \text{Al}^{3+}(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$ ✓		1
18.	(a)	(ii)	« $100 \text{ cm}^3 / 1000 \text{ cm}^3 \times 5.00 \times 10^{-3} \text{ mol dm}^{-3} =$ » 5.00×10^{-4} «mol HCl» ✓ « $5.00 \times 10^{-4} \text{ mol HCl} / 3 \times 78.01 \text{ g mol}^{-1} \text{ Al(OH)}_3 =$ » 0.0130 «g Al(OH) ₃ » ✓	Award [2] for correct final answer.	2
18.	(b)		blocks/binds to H2/histamine receptors «in cells of stomach lining» OR prevents histamine binding to H2/histamine receptors «and triggering acid secretion» ✓ prevents «parietal cells from» releasing/producing acid ✓	Do not accept “antihistamine” by itself. Accept “H2-receptor antagonist/H2RA” OR “blocks/inhibits action of histamine” for M1. Do not accept “blocks receptors” alone for M1. Do not accept “proton pump/ATPase inhibitor”.	2

Question		Answers	Notes	Total
19.		<p><i>Any two of:</i></p> <p>alters «viral» enzyme AND prevent virus from entering the cell ✓.</p> <p>alter the cell DNA AND virus cannot multiply ✓</p> <p>block «cell» enzyme activity AND prevent virus multiplication ✓</p> <p>alters «viral» enzyme AND prevents release of «new» viral particles «from the cell» ✓</p>	<p><i>Do not accept “just interferes with viral reproductive cycle”.</i></p> <p><i>Award [1 max] for two partial answers.</i></p>	2 max

Question	Answers	Notes	Total
20.	high-level has large amounts of «ionizing» radiation ✓ high-level has long half-lives OR high-level last longer/persists ✓	Accept converse statements for low-level. Accept “high radioactivity for high-level” for M1. Do not accept “high-level has ionizing radiation” alone for M1. Do not accept answers based on storage or disposal differences alone. Accept “high-level releases heat” for M2. Do not accept “high-level has more penetrating radiation” OR “high-level has higher frequency radiation” for M1.	2

Question		Answers	Notes	Total
21.	(a)	<p><i>Any one of:</i></p> <p>«most are» toxic «to living organisms» OR incomplete combustion/incineration can produce toxic products/dioxins/phosgene OR 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 OR 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> <p><i>Do not accept “increases acid rain/acidity/acid deposition”.</i></p>	1 max
21.	(b)	<p>use solvent-free synthetic methods OR use water/supercritical carbon dioxide/non-toxic/low-toxic/biodegradable compounds as a solvent OR recover/reuse solvents OR use a non-chlorinated solvent ✓</p>	<p><i>Accept arguments based on atom economy.</i></p> <p><i>Do not accept “use solvents safer for environment” alone.</i></p>	1