

# Markscheme

November 2020

Chemistry

Standard level

Paper 2

15 pages

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## Subject Details: Chemistry Standard level Paper 2 Markscheme

Candidates are required to answer **ALL** questions. Maximum total = [50 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.

Question			Answers	Notes	Total
1.	a	i	$1s^2 2s^2 2p^6 3s^2 3p^5$ ✓	Do <b>not</b> accept condensed electron configuration.	1
1.	a	ii	$Cl^-$ <b>AND</b> more «electron–electron» repulsion ✓	Accept $Cl^-$ <b>AND</b> has an extra electron.	1
1.	a	iii	Cl has a greater nuclear charge/number of protons/ $Z_{eff}$ «causing a stronger pull on the outer electrons» ✓  same number of shells <b>OR</b> same «outer» energy level <b>OR</b> similar shielding ✓		2
1.	a	iv	«two major» isotopes «of atomic mass 35 and 37» ✓		1
1.	a	v	«diatomic» molecule composed of «two» chlorine-37 atoms ✓  chlorine-37 is the least abundant «isotope» <b>OR</b> low probability of two $^{37}Cl$ «isotopes» occurring in a molecule ✓		2

Question			Answers	Notes	Total
1.	b	i	« $\frac{2.67 \text{ g}}{86.94 \text{ g mol}^{-1}} = \text{ » } 0.0307 \text{ «mol» } \checkmark$		1
1.	b	ii	« $n_{\text{HCl}} = 2.00 \text{ mol dm}^{-3} \times 0.2000 \text{ dm}^3$ » = 0.400 mol $\checkmark$ « $\frac{0.400}{4} = \text{ » } 0.100 \text{ mol AND MnO}_2$ is the limiting reactant $\checkmark$	Accept other valid methods of determining the limiting reactant in M2.	2
1.	b	iii	«0.0307 mol $\times 4 = 0.123 \text{ mol}$ » «0.400 mol – 0.123 mol $\Rightarrow 0.277 \text{ «mol» } \checkmark$		1
1.	b	iv	«0.0307 mol $\times 22.7 \text{ dm}^3 \text{ mol}^{-1} = \text{ » } 0.697 \text{ «dm}^3\text{ » } \checkmark$	Accept methods employing $pV = nRT$ .	1
1.	b	v	MnO <sub>2</sub> : +4 $\checkmark$ MnCl <sub>2</sub> : +2 $\checkmark$		2
1.	b	vi	oxidizing agent <b>AND</b> oxidation state of Mn changes from +4 to +2/decreases $\checkmark$		1

Question			Answers	Notes	Total
1.	c	i	partially dissociates/ionizes «in water» ✓		1
1.	c	ii	ClO <sup>-</sup> ✓		1
1.	c	iii	«[H <sup>+</sup> ] = 10 <sup>-3.61</sup> => 2.5 × 10 <sup>-4</sup> «mol dm <sup>-3</sup> » ✓		1
1.	d	i	«free radical» substitution/S <sub>R</sub> ✓	<i>Do not accept electrophilic or nucleophilic substitution.</i>	1
1.	d	ii	chloroethane <b>AND</b> C–Cl bond is weaker/324 kJ mol <sup>-1</sup> than C–H bond/414 kJ mol <sup>-1</sup> <b>OR</b> chloroethane <b>AND</b> contains a polar bond ✓	<i>Accept “chloroethane <b>AND</b> polar”.</i>	1
1.	d	iii	CH <sub>3</sub> CH <sub>2</sub> Cl(l) + OH <sup>-</sup> (aq) → CH <sub>3</sub> CH <sub>2</sub> OH(aq) + Cl <sup>-</sup> (aq) <b>OR</b> CH <sub>3</sub> CH <sub>2</sub> Cl(l) + NaOH(aq) → CH <sub>3</sub> CH <sub>2</sub> OH(aq) + NaCl(aq) ✓	<i>Accept use of C<sub>2</sub>H<sub>5</sub>Cl and C<sub>2</sub>H<sub>5</sub>OH /C<sub>2</sub>H<sub>6</sub>O in the equation.</i>	1
1.	d	iv	hydroxide «ion»/OH <sup>-</sup> ✓	<i>Do <b>not</b> accept NaOH.</i>	1

(continued...)

(Question 1d continued)

Question			Answers	Notes	Total
1.	d	v	$  \begin{array}{ccccccc}  & \text{H} & \text{H} & & \text{H} & \text{H} & \\  &   &   & &   &   & \\  \text{H} & - \text{C} & - \text{C} & - \text{O} & - \text{C} & - \text{C} & - \text{H} \\  &   &   & &   &   & \\  & \text{H} & \text{H} & & \text{H} & \text{H} &   \end{array}  $ / CH <sub>3</sub> CH <sub>2</sub> OCH <sub>2</sub> CH <sub>3</sub> ✓	Accept (CH <sub>3</sub> CH <sub>2</sub> ) <sub>2</sub> O.	1
1.	d	vi	2 «signals» ✓ 0.9–1.0 «ppm» <b>AND</b> 3.3–3.7 «ppm» ✓	Accept any values in the ranges. Award [1 max] for two incorrect chemical shifts.	2
1.	e	i	«M(CCl <sub>2</sub> F <sub>2</sub> ) => 120.91 «g mol <sup>-1</sup> » ✓ $  \frac{2 \times 35.45 \text{ g mol}^{-1}}{120.91 \text{ g mol}^{-1}} \times 100 \% \Rightarrow 58.64 \% \text{ } \checkmark  $	Award [2] for correct final answer.	2

(continued...)

(Question 1e continued)

Question			Answers	Notes	Total
1.	e	ii	<p>Any of:                      research «collaboration» for alternative technologies «to replace CFCs»  <b>OR</b>                      technologies «developed»/data could be shared  <b>OR</b>                      political pressure/Montreal Protocol/governments passing legislations ✓</p>	<p><i>Do <b>not</b> accept just “collaboration”.</i></p> <p><i>Do <b>not</b> accept any reference to CFC as greenhouse gas or product of fossil fuel combustion.</i></p> <p><i>Accept reference to specific measures, such as agreement on banning use/manufacture of CFCs.</i></p>	1



Question		Answers	Notes	Total
2.	a	<i>Electron domain geometry: tetrahedral ✓</i> <i>Molecular geometry: bent/V-shaped ✓</i>		2
2.	b	B <b>AND</b> C=O absorption/1750 «cm <sup>-1</sup> » <b>OR</b> B <b>AND</b> absence of O-H /3200–3600 «cm <sup>-1</sup> absorption» ✓	<i>Accept any value between 1700–1750 cm<sup>-1</sup>.</i>	1

Question	Answers	Notes	Total
<p>2. c</p>	<p>Accept any two <math>C_3H_6O</math> isomers except for propanone and propen-2-ol:</p> <div style="display: flex; flex-wrap: wrap; justify-content: space-around;"> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{H} \\   &amp; &amp;   \\ \text{C} = \text{C} - \text{O} - \text{C} - \text{H} \\   &amp;   &amp;   \\ \text{H} &amp; \text{H} &amp; \text{H} \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} \text{H} &amp; \text{H} &amp; \text{O} \\   &amp;   &amp;    \\ \text{H} - \text{C} - &amp; \text{C} - &amp; \text{C} - \text{H} \\   &amp;   &amp; \\ \text{H} &amp; \text{H} &amp; \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} &amp; \text{H} &amp; \text{H} \\ &amp; / &amp; / \\ \text{O} &amp; &amp; \text{C} \\   &amp; &amp;   \\ \text{C} &amp; - &amp; \text{C} \\ / &amp; &amp;   \\ \text{H} &amp; &amp; \text{H} \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} &amp; \text{H} &amp; &amp; \text{H} \\ &amp;   &amp; &amp;   \\ \text{H} - &amp; \text{C} &amp; - &amp; \text{C} - \text{O} - \text{H} \\ &amp;   &amp; &amp;   \\ &amp; \text{H} &amp; &amp; \text{H} \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{H} \\   &amp; &amp;   \\ \text{C} - \text{O} &amp; &amp; \text{C} \\   &amp; &amp;   \\ \text{H} &amp; &amp; \text{H} \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{H} \\   &amp; &amp;   \\ \text{C} = \text{C} - &amp; \text{C} - \text{O} - \text{H} \\   &amp;   &amp;   \\ \text{H} &amp; \text{H} &amp; \text{H} \end{array}</math> </div> <div style="text-align: center; margin: 10px;"> <math display="block">\begin{array}{c} \text{H} &amp; \text{H} &amp; \text{H} \\   &amp;   &amp;   \\ \text{H} - \text{C} - &amp; \text{C} = &amp; \text{C} - \text{O} - \text{H} \\   &amp; &amp; \\ \text{H} &amp; &amp; \end{array}</math> </div> </div> <p style="text-align: right; margin-top: 20px;">✓✓</p>	<p>Penalize missing hydrogens in displayed structural formulas once only.</p>	<p>2</p>

Question			Answers	Notes	Total
2.	d		B <b>AND</b> $K_c$ is greater than 1/large ✓		1

Question		Answers	Notes	Total
3.	a	<p><i>Bonds broken:</i> <math>8(\text{C-H}) + 2(\text{C-C}) + 5(\text{O=O}) / 8 \times 414 \text{ «kJ mol}^{-1}\text{»} + 2 \times 346 \text{ «kJ mol}^{-1}\text{»} + 5 \times 498 \text{ «kJ mol}^{-1}\text{»} / 6494 \text{ «kJ»} \checkmark</math></p> <p><i>Bonds formed:</i> <math>6(\text{C=O}) + 8(\text{O-H}) / 6 \times 804 \text{ «kJ mol}^{-1}\text{»} + 8 \times 463 \text{ «kJ mol}^{-1}\text{»} / 8528 \text{ «kJ»} \checkmark</math></p> <p>«Enthalpy change = bonds broken – bonds formed = <math>6494 \text{ kJ} - 8528 \text{ kJ} = -2034 \text{ «kJ»} \checkmark</math></p>	<p><i>Award [3] for correct final answer.</i></p>	3
3.	b	<p><math>4(-241.8 \text{ «kJ»}) \textbf{AND} 3(-393.5 \text{ «kJ»}) \textbf{AND} \textbf{«1»}(-105 \text{ «kJ»}) \checkmark</math></p> <p>«<math>\Delta H^\ominus = 4(-241.8 \text{ «kJ»}) + 3(-393.5 \text{ «kJ»}) - \textbf{«1»}(-105 \text{ «kJ»}) = -2043 \text{ «kJ»} \checkmark</math></p>	<p><i>Award [2] for correct final answer.</i></p> <p><i>Award [1 max] for <math>-2219 \text{ «kJ»}</math>.</i></p>	2

Question		Answers	Notes	Total
4.	a	provides an alternative pathway/mechanism <b>AND</b> lower $E_a$ ✓	<i>Accept description of how catalyst lowers <math>E_a</math> (e.g. "reactants adsorb on surface «of catalyst»", "reactant bonds weaken «when adsorbed»").</i>	1
4.	b	more/greater proportion of molecules with $E \geq E_a$ ✓  greater frequency/probability/chance of collisions «between the molecules» <b>OR</b> more collision per unit of time/second ✓		2
4.	c	hydrogen bonding/bonds «and dipole–dipole and London/dispersion forces are present in» propan-2-ol ✓  dipole–dipole «and London/dispersion are present in» propanone ✓  propan-2-ol less volatile <b>AND</b> hydrogen bonding/bonds stronger «than dipole–dipole » <b>OR</b> propan-2-ol less volatile <b>AND</b> «sum of all» intermolecular forces stronger ✓		3

Question			Answers	Notes	Total
4.	d	i			1
4.	d	ii	Bi/Cu/Ag/Pd/Hg/Pt/Au ✓	Accept Sb <b>OR</b> As.	1
4.	d	iii	electrostatic attraction ✓ between «a lattice of» metal/positive ions/cations <b>AND</b> «a sea of» delocalized electrons ✓	Accept “mobile/free electrons”.	2

(continued...)

(Question 4d continued)

Question			Answers	Notes	Total
4.	d	iv	<p>Any of:</p> <p>malleability/hardness</p> <p><b>OR</b></p> <p>«tensile» strength/ductility</p> <p><b>OR</b></p> <p>density</p> <p><b>OR</b></p> <p>thermal/electrical conductivity</p> <p><b>OR</b></p> <p>melting point</p> <p><b>OR</b></p> <p>thermal expansion ✓</p>	<p><i>Do not accept corrosion/reactivity or any chemical property.</i></p> <p><i>Accept other specific physical properties.</i></p>	1