Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2022

Chemistry

Standard level

Paper 2

13 pages

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 <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.

Question			Answers	Notes	Total
1.	a	i	2 Mg(s) + O_2(g) $\rightarrow$ 2 MgO(s) ✓	*Do not accept equilibrium arrows.* *Ignore state symbols*	1
1.	a	ii	s ✓	*Do not allow group 2*	1
1.	a	iii	aluminium/Al ✓		1
1.	b	i	⟨⟨$\frac{53.726\ \text{g} - 47.372\ \text{g}}{24.31\ \text{g mol}^{-1}} = \frac{6.354\ \text{g}}{24.31\ \text{g mol}^{-1}}$⟩⟩ = 0.2614 «mol» ✓		1
1.	b	ii	mass of product « $= 56.941\ \text{g} - 47.372\ \text{g}$» = 9.569 «g» ✓ ⟨⟨$100 \times \frac{2 \times 0.001\text{g}}{9.569\ \text{g}} = 0.0209$⟩⟩ = 0.02 «%» ✓	*Award **[2]** for correct final answer* *Accept 0.021%*	2
1.	b	iii	⟨⟨ $0.2614\ \text{mol} \times (24.31\ \text{g mol}^{-1} + 16.00\ \text{g mol}^{-1}) = 0.2614\ \text{mol} \times 40.31\ \text{g mol}^{-1}$⟩⟩ = 10.536 «g» ✓ ⟨⟨$100 \times \frac{9.569\ \text{g}}{10.536\text{g}} = 90.822$⟩⟩ = 91 «%» ✓	*Award «0.2614 mol x 40.31 g mol^{-1}»* *Accept alternative methods to arrive at the correct answer.* *Accept final answers in the range 91-92%* ***[2]** for correct final answer.*	2

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**c**	**i**	yes ***AND*** «each Mg combines with $^2/_3$ N, so» mass increase would be $14x^2/_3$ which is less than expected increase of 16x ***OR*** 3 mol Mg would form 101g of Mg_3N_2 but would form 3 x MgO = 121 g of MgO ***OR*** 0.2614 mol forms 10.536 g of MgO, but would form 8.796 g of Mg_3N_2 ✓	*Accept Yes **AND** "the mass of N/N_2 that combines with each g/mole of Mg is lower than that of O/O_2"* *Accept YES **AND** "molar mass of nitrogen less than of oxygen".*	**1**
1.	**c**	**ii**	incomplete reaction ***OR*** Mg was partially oxidised already ***OR*** impurity present that evaporated/did not react ✓	*Accept "crucible weighed before fully cooled".* *Accept answers relating to a higher atomic mass impurity consuming less O/O_2.* *Accept "non-stoichiometric compounds formed".* *Do **not** accept "human error", "wrongly calibrated balance" or other non-chemical reasons.* *If answer to (b)(iii) is >100%, accept appropriate reasons, such as product absorbed moisture before being weighed*.	**1**

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**d**	**i**	«1» $Mg_3N_2(s)$ + **6** $H_2O(l)$ → **3** $Mg(OH)_2(s)$ + **2** $NH_3(aq)$ ✓		**1**
1.	**d**	**ii**	*Mg_3N_2:* -3 ***AND*** *NH_3:* -3 ✓	*Do not accept 3 or 3-*	**1**
1.	**d**	**iii**	*Acid–base:* yes ***AND*** N^{3-} accepts H^+/donates electron pair«s» ***OR*** yes ***AND*** H_2O loses H^+ «to form OH^-»/accepts electron pair«s» ✓ *Redox:* no ***AND*** no oxidation states change ✓	*Accept "yes **AND** proton transfer takes place"* *Accept reference to the oxidation state of specific elements not changing. Accept "not redox as no electrons gained/lost".* *Award **[1 max]** for Acid–base: yes **AND** Redox: no without correct reasons, if no other mark has been awarded*	**2**
1.	**e**	**i**	*Protons:* 7 ***AND*** *Neutrons:* 7 ***AND*** *Electrons:* 10 ✓		**1**
1.	**e**	**ii**	<u>isotope</u>«s» ✓		**1**
1.	**e**	**iii**	nitride ***AND*** smaller nuclear charge/number of protons/atomic number ✓		**1**

(continued…)

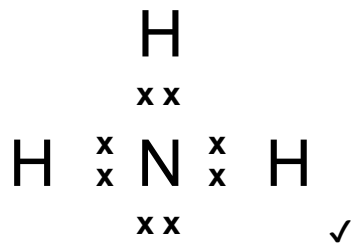
(Question 1 continued)

Question			Answers	Notes	Total
1.	**f**		*Any two of:* subatomic particles «discovered» ***OR*** particles smaller/with masses less than atoms «discovered» ***OR*** «existence of» isotopes «same number of protons, different number of neutrons»✓ charged particles obtained from «neutral» atoms ***OR*** atoms can gain or lose electrons « and become charged» ✓ atom «discovered» to have structure ✓ fission ***OR*** atoms can be split ✓	*Accept atoms can undergo fusion «to produce heavier atoms»* *Accept specific examples of particles.* *Award **[2]** for "atom shown to have a nucleus with electrons around it" as both M1 and M3.*	**2**

(continued…)

(Question 1 continued)

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>1.</td><td>g</td><td></td><td>
<table>
<tr><th>Substance</th><th>Bond type</th><th>How the valence electrons produce these bonds</th></tr>
<tr><td>Magnesium</td><td>metallic AND</td><td>delocalized «throughout lattice attracted to cations» ✓
Accept reference to “sea”/flux of electrons
«attracted to cations»</td></tr>
<tr><td>Oxygen</td><td>covalent
AND</td><td>shared «between atoms» ✓</td></tr>
<tr><td>Magnesium oxide</td><td>ionic ✓</td><td>transferred «from magnesium to oxygen»
OR
lost by magnesium AND
gained by oxygen ✓</td></tr>
</table>
</td><td>Award [1] for all bonding types correct.
Award [1] for each correct description.
Apply ECF for M2 only once.</td><td>4</td></tr>
</table>

Question			Answers	Notes	Total
2.	**a**		2p ↑ ↑ ↑ 2s ↑↓ 1s ↑↓ ✓	*Accept **all** 2p electrons pointing downwards.* *Accept half arrows instead of full arrows.*	**1**
2.	**b**		 ✓	Accept lines or dots or crosses for electrons, or a mixture of these	**1**
2.	**c**	**i**	$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$ ✓		**1**
2.	**c**	**ii**	shifts to the side with fewer moles «of gas» *OR* shifts to right as there is a reduction in volume✓ «value of » K_c unchanged ✓	*Accept "K_c only affected by changes in temperature".*	**2**

(continued…)

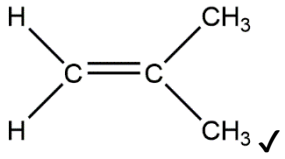
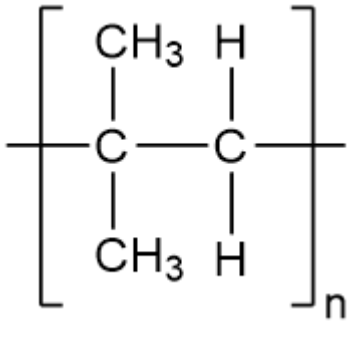
(Question 2 continued)

Question			Answers	Notes	Total
2.	**c**	**iii**	same/unaffected/unchanged ✓		**1**
2.	**d**	**i**	*bonds broken*: N≡N + 3(H-H) / «1 mol×»945 «kJ mol^{-1}» + 3«mol»×436 «kJ mol^{-1}» / 945 «kJ» + 1308 «kJ» / 2253 «kJ» ✓ *bonds formed*: 6(N-H) / 6«mol»×391 «kJ mol^{-1}» / 2346 «kJ» ✓ ΔH = «2253 kJ - 2346 kJ = » -93 «kJ» ✓	*Award **[2 max]** for (+)93 «kJ»*	**3**
2.	**d**	**ii**	-92.4 «kJ» ✓		**1**
2.	**d**	**iii**	«N-H» bond enthalpy is an average «and may not be the precise value in NH_3» ✓	*Accept it relies on average values not specific to NH_3*	**1**
2.	**e**	**i**	conjugate «acid and base» ✓		**1**
2.	**e**	**ii**	amount of ammonia ⟨⟨$= \frac{P.V}{R.T} = \frac{100.0\ kPa \times 900.0\ dm^3}{8.31\ J\ K^{-1}mol^{-1} \times 300.0\ K}$⟩⟩ = 36.1 «mol» ✓ concentration ⟨⟨$= \frac{n}{V} = \frac{36.1}{2.00}$⟩⟩ = 18.1 «mol dm^{-3}» ✓	*Award **[2]** for correct final answer.*	**2**
2.	**e**	**iii**	$[OH^-]$ ⟨⟨$= \frac{K_w}{[H^+]} = \frac{10^{-14}}{10^{-9.3}} = 10^{-4.7}$⟩⟩ $= 2.0 \times 10^{-5}$ ⟨⟨mol dm^{-3}⟩⟩ ✓		**1**

Question			Answers	Notes	Total
3.	a		$Mg^{2+} + 2\ e^- \rightarrow Mg$ ✓	*Do **not** penalize missing charge on electron.* *Accept equation with equilibrium arrows.*	1
3.	b		***Alternative 1*** put Mg in $Zn^{2+}(aq)$ ✓ Zn/«black» layer forms «on surface of Mg» ✓ ***Alternative 2*** place both metals in acid ✓ bubbles evolve more rapidly from Mg ***OR*** Mg dissolves faster ✓ ***Alternative 3*** construct a cell with Mg and Zn electrodes ✓ bulb lights up ***OR*** shows (+) voltage ***OR*** size/mass of Mg(s) decreases <<over time>> ***OR*** size/mass of Zn increases <<over time>>	*Award **[1 max]** for "no reaction when Zn placed in $Mg^{2+}(aq)$".* *Accept "electrons flow from Mg to Zn".* *Accept Mg is negative electrode/anode* ***OR*** Zn is positive electrode/cathode *Accept other correct methods.*	2

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**c**	**i**	propanone ✓	*Accept 2-propanone and propan-2-one.*	**1**
3.	**c**	**ii**	hydrogen bonds ✓		**1**
3.	**d**	**i**	 ✓		**1**
3.	**d**	**ii**	 ✓	*Do **not** penalize missing brackets or n. Do **not** award mark if continuation bonds are not shown.*	**1**
3.	**e**		no change «in colour/appearance/solution» ✓		**1**

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**f**	**i**	«nucleophilic» substitution ***OR*** SN2 ✓	*Accept "hydrolysis".* *Accept SN1*	**1**
3.	**f**	**ii**	energy/E ≥ activation energy/E_a ✓ correct orientation «of reacting particles» *OR* correct geometry «of reacting particles» ✓		**2**
3.	**f**	**iii**	decreases/less polar ***AND*** electronegativity «of the halogen» decreases ✓	*Accept "decreases" **AND** a correct comparison of the electronegativity of two halogens.* *Accept "decreases" **AND** "attraction for valence electrons decreases".*	**1**