Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2023

Chemistry

Standard level

Paper 2

11 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.

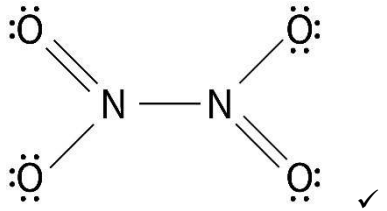
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

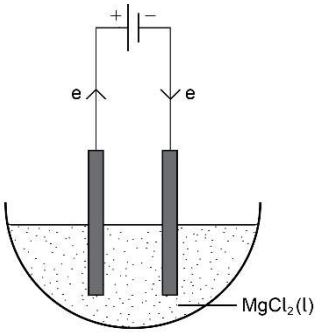
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the "Notes" column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the "Notes" column.

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)		«n(C) =» 4.05 «mol» ***AND*** «n(O) =» 2.70 «mol» ✓ «% H =» 8.2% ***OR*** «n(H) =» 8.12 «mol»✓ «empirical formula =» $C_3H_6O_2$ ✓	*Award **[2]** for the simplest ratio "1.5 C: 3 H: 1 O".*	**3**
1.	(b)		*m/z 74:* molecular ion / M^+ / $C_3H_6O_2^+$ ✓ *m/z 45:* $COOH^+$ / $C_2H_5O^+$ ✓	*Accept **loss** of CH_3CH_2 / C_2H_5 / CHO for m/z 45.*	**2**
1.	(c)		$C_3H_6O_2$ ✓	*Accept C_2H_5COOH / CH_3CH_2COOH.*	**1**
1.	(d)		*A:* O-H «in carboxylic acids» ✓ *B:* C=O ✓		**2**

Question			Answers	Notes	Total
2.	(a)	(i)	reaction hardly proceeds ***OR*** reverse reaction/formation of NO_2 is favoured ***OR*** «concentration of» reactants greater than «concentration of» products «at equilibrium» ✓	*Accept equilibrium lies to the left.*	**1**
2.	(a)	(ii)	«$K_c = \frac{1}{0.0665}$ =» 15.0 ✓		**1**
2.	(a)	(iii)	« $\Delta H^{\ominus}$ = 2(33.18) – 9.16 =» «+» 57.20 «kJ mol^{-1}» ✓		**1**
2.	(b)		 ✓	*Accept any combination of dots, crosses or lines to represent electron pairs.*	**1**
2.	(c)	(i)	it has resonance structures ✓	*Accept bond order = 1.5.* *Accept delocalized electrons «in NO bonds».*	**1**
2.	(c)	(ii)	110-120° ✓	*Accept any value in the range given. (Bond angle is actually 112.3°.)*	**1**
2.	(d)		$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$ ✓	*Accept $N_2O_4(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$.*	**1**

Question			Answers	Notes	Total
3.	(a)	(i)	magnesium/Mg «metal» ✓	*Do **not** accept magnesium ions/Mg^{2+}.*	1
3.	(a)	(ii)	 electron flow from anode to battery ***OR*** from battery to cathode ✓	*Do **not** award mark if electrons are shown in electrolyte.*	1
3.	(a)	(iii)	layers «of carbon atoms in a giant structure» ✓ delocalized electrons «flow along layers» ✓	*Accept suitable diagram for M1.* *Accept two-dimensional network for M1.* *Accept electrons are mobile/flow for M2.*	2
3.	(b)	(i)	«$n(S_2O_3^{2-})$ = 0.00500 mol dm^{-3} x 0.0360 dm^3 =» 0.000180 / 1.80 x 10^{-4} «mol» ✓ «$n(O_2)$ =» $\frac{n(S_2O_3^{2-})}{4}$ / 0.0000450 / 4.50 x 10^{-5} «mol» ✓ «$[O_2] = \frac{4.50x10^{-5}\ mol}{0.150\ dm^3}$ =» 0.000300 / 3.00 x 10^{-4} «mol dm^{-3}» ✓	*Award **[3]** for correct final answer.*	3

Question			Answers	Notes	Total
3.	(b)	(ii)	titrate/measure dissolved oxygen in «another» water sample «stored under controlled conditions five days» later ✓ difference between two values «is BOD»✓		2
3.	(b)	(iii)	low levels of «organic/oxygen consuming» water pollution ✓		1

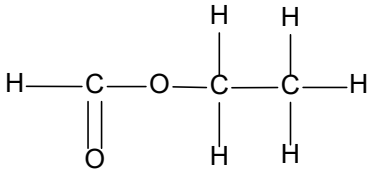
4.	(a)		*Any two of:* «group 15 so Bi has» 5 valence electrons ✓ «period 6 so Bi has» 6 «occupied» electron shells/energy levels ✓ «in p-block so» p orbitals are highest occupied ✓ occupied d/f orbitals ✓ has unpaired electrons ✓ has incomplete shell(s)/subshell(s) ✓	*Award **[1]** for full or condensed electron configuration, [Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^3$. Accept other valid statements about the electron configuration.*	2 max
4.	(b)		«layers of» cations slide over each other without disrupting bonding ***OR*** attraction between metal ions and delocalized electrons/metallic bonding is not disrupted by changing position of metal ions ***OR*** metallic bonds are non-directional ***OR*** changing the shape does not disrupt the bonding ✓		1

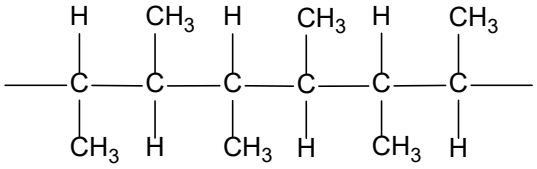
Question			Answers	Notes	Total
4.	**(c)**		«heat energy = 11.98 g x 0.902 J g^{-1} K^{-1} x 22.0 K =» 238 «J» ✓		**1**
4.	**(d)**	**(i)**	mass spectrometry ***OR*** mass spectroscopy ***OR*** mass spectrum ***OR*** MS ✓		**1**
4.	**(d)**	**(ii)**	(0.0034 x 36) + (0.0006 x 38) + (0.996 x 40) ✓ 39.99 ✓	*Do not accept 39.96 which is the data booklet value.* *M2 can only be awarded for answer with 2 decimal places.* *Award **[2]** for correct final answer.*	**2**
4.	**(e)**		$1s^2$ $2s^2 2p^6$ $3s^2 3p^6 3d^7$ ✓		**1**

5.	**(a)**		«$[OH^-]$ = 0.200 mol dm^{-3}» ***ALTERNATIVE 1:*** «pOH = $-\log_{10}(0.200)$ =» 0.699 ✓ «pH = 14.000 – 0.699 =» 13.301 ✓ ***ALTERNATIVE 2:*** «$[H^+] = \frac{1.00x10^{-14}}{0.200}$ = » 5.00 × 10^{-14} «mol dm^{-3}» ✓ «pH = $-\log_{10}(5.00 \times 10^{-14})$» = 13.301 ✓	*Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
5.	(b)		$HCOOH(aq) + NaOH(aq) \rightarrow HCOONa(aq) + H_2O(l)$ ✓	*Accept ionic equation or net ionic equation.*	1
5.	(c)		«n(acid) = $n(OH^-)$» «[acid] = $\frac{0.200\ mol\ dm^{-3} \times 22.5 \times 10^{-3} dm^3}{25.0 \times 10^{-3} dm^3}$» = 0.180 «mol dm^{-3}» ✓		1

6.	(a)		«measure change in» mass ***OR*** pressure ***OR*** volume of gas/CO_2 produced ***OR*** «intensity of» colour ***OR*** «electrical» conductivity ***OR*** pH ✓ with time ✓	*Accept any of the following for M1:* *perform experiment on balance* ***OR*** *use pressure probe* ***OR*** *collect gas/gas syringe* ***OR*** *use colorimeter* ***OR*** *use conductivity meter* ***OR*** *use pH meter* *Do **not** accept "measure rate of change" for M2.*	2
6.	(b)		provides an alternative reaction pathway ***AND*** lower activation energy/E_a ✓ larger fraction/number of molecules with $E \geq E_a$/enough energy «for a successful collision» ✓		2

Question			Answers	Notes	Total
6.	**(c)**		*Structural formula*:  ✓ *Name:* ethyl methanoate ✓		**2**
6.	**(d)**	**(i)**	$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ ✓	*Accept C_2H_6O for ethanol.*	**1**
6.	**(d)**	**(ii)**	«bond breaking» 1 C-C + 5 C-H + 1 C-O + 1 O-H + 3 O=O / 346 + 5(414) + 358 + 463 +3(498) / 4731 «kJ» ✓ «bond forming» 4 C=O + 6 O-H / 4(804) + 6(463) / 5994 «kJ» ✓ ΔH «= 4731– 5994» = −1263 «kJ mol^{-1} » ✓	*Award **[3]** for correct final answer.*	**3**
6.	**(e)**	**(i)**	«electrophilic» addition/A_E ✓	*Do **not** accept nucleophilic addition.*	**1**
6.	**(e)**	**(ii)**	$CH_3CHBrCHBrCH_3$ ✓	*Do **not** accept molecular formula $C_4H_8Br_2$.*	**1**

Question			Answers	Notes	Total
6.	(e)	(iii)	 ✓	*Accept methyl groups on either side.* *Ignore brackets and "n".* *Continuation bonds must be shown.*	1