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.

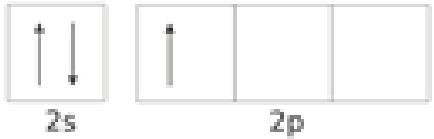
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

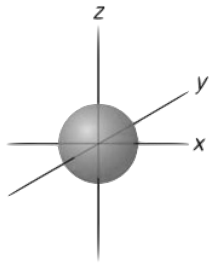
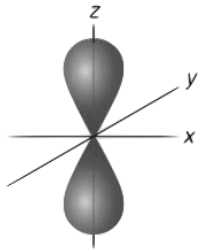
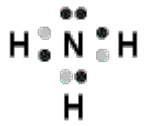
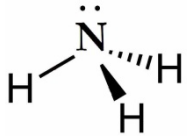
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the "Notes" column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the "Notes" column.

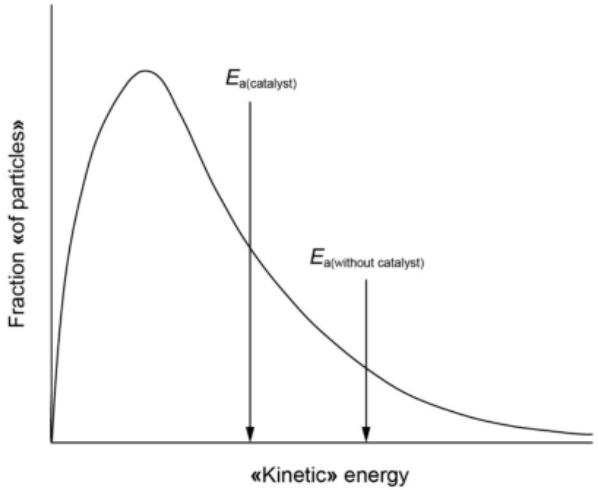
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.

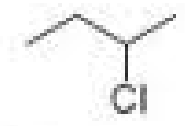
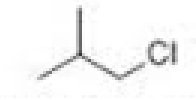
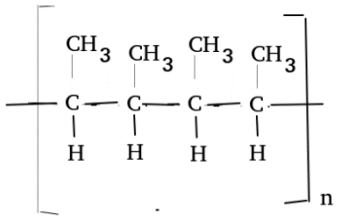
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

Question			Answers	Notes	Total
1.	(a)		$H_2O_{(l)} + HCl_{(g)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$ ✓✓	*One for the equation and one for the state symbols.* *Do not accept* $H_2O_{(l)} + H^+_{(g)} \rightarrow H_3O^+_{(aq)}$ *Do not accept equilibrium sign.*	**2**
1.	(b)		«pH = $-\log_{10}[H^+] = -\log_{10}0.5$ =» 0.30 ✓		**1**
1.	(c)		«Ethanoic acid» p*artially ionizes/dissociates/OWTTE* ***OR*** ***l****ower [H+]* ✓	*Do* ***not*** *accept weak acid only.* *Accept converse argument.*	**1**
1.	(d)		conductivity/conductance meter/probe ***OR*** ammeter «with power supply» ✓	*Ignore any reference to indicators or any chemical methods.* *Accept* Cl^- *or ethanoate ion selective probe.*	**1**
1.	(e)		HCl higher conductivity «due to higher [ion]» ✓	*Accept explanation if alternative given in d.* *Accept converse argument.* *Apply ECF for incorrect method.*	**1**

2.	(a)	(i)	 arrows ***AND*** *identifies 2s* ***AND*** *2p sub orbitals* ✓	*Accept "hooks" to represent the electrons.*	**1**

Question			Answers	Notes	Total
2.	(a)	(ii)	 s ✓  p ✓	*$P_{x,y}$ or $_z$ can be used.* *M2 cannot be awarded if labels of orbital types are missing or incorrect* *Node of p orbital must be at the origin*	**2**
2.	(b)		valence electron further from nucleus/«atomic» radius larger «down the group» ✓ «electron» more shielded/ less attractive force/easier to remove ✓		**2**
2.	(c)	(i)	tetrahedral ✓		**1**
2.	(c)	(ii)	 ✓  ✓	*Accept a combination of dots /crosses /lines in the Lewis structure* *Lone pair not required for shape*	**2**
2.	(c)	(iii)	ammonia has intermolecular/IMF hydrogen bonds «phosphine does not» ✓ phosphine «and ammonia» dipole-dipole/London dispersion forces/instantaneous dipole attractions/Van der Waals forces ✓ hydrogen bonds stronger ✓	*Accept converse argument.* *Award 1 for* stating that NH_3 is more polar than phosphine so the dipole-dipole forces are stronger	**3**
2.	(d)	(i)	«in a closed system» the rate of the forward reaction equals the rate of the reverse reaction. ✓		**1**

Question			Answers	Notes	Total
2.	(d)	(ii)	$[NH_3]^2/([N_2][H_2]^3)$ ✓		1
2.	(d)	(iii)	alternate pathway ***AND*** lowers activation energy/E_a ✓		1
2.	(d)	(iv)	 correct shape curve starting at the origin, without touching the x axis at high energy. ✓ (E_a) catalysed <(E_a) uncatalysed on x axis. ✓	*Ignore any shading under the curve.*	2
2.	(d)	(v)	change in ***AND*** volume ***OR*** pressure ***OR*** temperature ***OR*** concentration of H_2/N_2 /reactants/NH_3 /product ✓	*Do not accept pH.* *Accept any valid method.*	1

Question			Answers	Notes	Total
3.	**(a)**	**(i)**	compounds of the same family ***AND*** general formula ***OR*** compounds of the same family ***AND*** differ by a common structural unit/CH_2 ✓	*Accept contain the same functional group for same family.*	**1**
3.	**(a)**	**(ii)**	 2-chlorobutane ✓  1-chloro-2-methylpropane ✓	*Accept 1-chloromethylpropane for M2, but not* 2-methyl-1-choloropropane*.*	**2**
3.	**(a)**	**(iii)**	 ✓	*Allow any orientation of methyl groups. Ignore square brackets and "n".* Continuation lines must be shown.	**1**

4.	**(a)**		+6/VI ✓	*Do **not** accept 6/6+*	**1**
4.	**(b)**	**(i)**	Zinc more reactive/ <<better>> reducing agent/ <<more>> easily oxidized/loses electrons <<more>> easily. ✓	*Accept "zinc higher in the activity «series»"* *Accept "*zinc has a negative electrode potential/Cu has a positive electrode potential".	**1**

Question			Answers	Notes	Total
4.	**(b)**	**(ii)**	Anode (negative electrode): $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ ✓ Cathode (positive electrode): $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ ✓	*Award **[1 max]** for equilibria.* *Award **[1 max]** for equations at the wrong electrodes.* *State symbols not required for mark.*	**2**
5.	**(a)**	**(i)**	«100-(7.09+5.11+16.22+14.91) =» 56.67 «%» ✓		**1**
5.	**(a)**	**(ii)**	n(N): 7.09g/14.01g mol^{-1}, n(H): 5.11g/1.01 g mol^{-1}, n(S): 16.22g/32.07 g mol^{-1}, n(Co): 14.91g/58.93 g mol^{-1} and n(O): 56.67g/16.00 g mol^{-1} ***OR*** n(N): 0.506, n(H): 5.06, n(S): 0.506, n(Co): 0.253 and n(O): 3.54 ✓ 0.506/0.253, 5.06/0.253, 0.506/0.253, 0.253/0.253, 3.54/0.253 ***OR*** 2.00, 20.0, 2.00, 1.00 14.00 ✓ $N_2H_{20}S_2CoO_{14}$ ✓	*Award **[3]** for the correct final formula* *Accept* $(NH_4)_2Co(SO_4)_2 \cdot 6H_2O$	**3**
5.	**(a)**	**(iii)**	$(NH_4)_2Co(SO_4)_2 \cdot 6H_2O$ ***OR*** $Co(NH_4)_2(SO_4)_2 \cdot 6H_2O$ ✓	*Accept* $(NH_4)_2Co(SO_4)_2(H_2O)_6$.	**1**
5.	**(b)**	**(i)**	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightleftharpoons BaSO_4(s)$ ✓	*Accept single arrow in place of equilibrium sign.*	**1**

Question			Answers	Notes	Total
5.	**(b)**	**(ii)**	«1.20g/395.29 g mol^{-1} salt = 2 x 3.04 $x10^{-3}$ «mol» SO_4^{2-} =» 6.08 x $x10^{-3}$ «mol» ✓ «233.40 g mol^{-1} x 6.08 $x10^{-3}$ =» 1.42«g» ✓ ***OR*** «(1.20g/400) x 2 g mol^{-1} =» 6.00 x 10^{-3} «mol» ✓ «233.40 g mol^{-1} x 6.00 $x10^{-3}$ =» 1.40«g» ✓	*Award **[2]** for correct final answer.* *Accept x2 in any step.* *Award **[1]** for half the answer, 0.70*«g».	**2**

6.	**(a)**	**(i)**	«$\Delta H°rxn$ = $\sum\Delta H°$f (Products) – $\sum\Delta H°$f (Reactants) =» -395.8 - (-296.8)» = –99.0«kJ mol^{-1}» ✓		**1**
6.	**(a)**	**(ii)**	$SO_{2\,(aq)} + H_2O(l) \rightleftharpoons H_2SO_{3\,(aq)}$ ***AND*** $SO_{3\,(aq)} + H_2O\,(l) \rightarrow H_2SO_{4\,(aq)}$ ✓	Accept single arrow for the first equation.	**1**
6.	**(a)**	**(iii)**	significant/large/0.8 difference in <u>electronegativity/</u>oxygen more <u>electronegative</u> ✓ oxygen «dipole partially» negative/sulfur «dipole partially» positive ***OR*** oxygen more negative/higher electron density «around it than sulfur»✓	Accept suitable diagram showing the O–S dipole.	**2**
6.	**(b)**	**(i)**	«q = -mcΔT = 50.00g x 4.18J $K^{-1}g^{-1}$ x (35.0-20.0)°C =» -3140.0 «J» ✓ «(3140/0.1)/1000 =» -31.4 «kJ mol^{-1}» ✓	*Award **[1 max]** for +31.4 kJ mol^{-1}* *Award **[2]** for correct final answer.*	**2**

Question			Answers	Notes	Total
6.	(b)	(ii)	Source of systematic error: heat loss «to the surroundings» ✓ Improvement: insulate reaction apparatus/put a lid on the beaker ***OR*** use a bomb/calibrated calorimeter ***OR*** use of windbreak around the dish/apparatus ✓		**2**
6.	(b)	(iii)	«1.0/15.0 x 100 =» 6.7«%» ✓ ***OR*** $\frac{\sqrt{0.5^2+0.5^2}}{15.0}\times 100\% \approx 5\%$	*Do not allow 6.6%* *Accept "5%" if the formula* $\sqrt{\Sigma(\Delta A)^2}$ *is used.*	**1**
6.	(b)	(iv)	more precise/more divisions per degree «on the thermometer» ***OR*** more precise balance ***OR*** larger quantities of sulfur/water ***OR*** larger temperature change ✓	*Accept burette/pipette «to measure water volume».* *Do **not** accept more repetitions.*	**1**
6.	(b)	(v)	« -297 kJ mol^{-1} - -31.4kJ mol^{-1}/-297 kJ mol^{-1}x 100 =» 89.4 «%» ✓ alternate: « -297 kJ mol^{-1} - -50.0 kJ mol^{-1}/-297 kJ mol^{-1}x 100 =» 83.2 «%» ✓		**1**