Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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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		«$\frac{8.802\ \text{g}}{44.01\ \text{g mol}^{-1}}$ =» 0.2000 «mol of C/CO_2» ***AND*** «$\frac{3.604\ \text{g}}{18.02\ \text{g mol}^{-1}}$ =» 0.2000 «mol of H_2O» / 0.4000 «mol of H» ***OR*** «$\frac{8.802\ \text{g}}{44.01\ \text{g mol}^{-1}} \times 12.01\ \text{g mol}^{-1}$ =» 2.402 «g of C» ***OR*** «$\frac{3.604\ \text{g}}{18.02\ \text{g mol}^{-1}} \times 2 \times 1.01\ \text{g mol}^{-1}$ =» 0.404 «g of H» ✓ «4.406 g – 2.806 g» = 1.600 «g of O» ✓ « $\frac{2.402\ \text{g}}{12.01\ \text{g mol}^{-1}} = 0.2000\ \text{mol C}$; $\frac{0.404\ \text{g}}{1.01\ \text{g mol}^{-1}} = 0.400\ \text{mol H}$; $\frac{1.600\ \text{g}}{16.00\ \text{g mol}^{-1}} = 0.1000\ \text{mol O}$» C_2H_4O ✓	*Award **[3]** for correct final answer.*	**3**

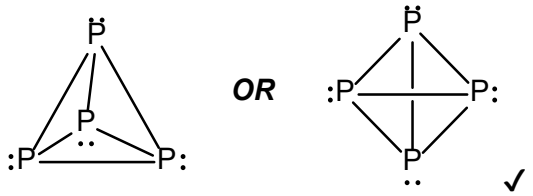
<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>1.</td><td>b</td><td></td><td>« $\frac{88.12\,\text{g mol}^{-1}}{44.06\,\text{g mol}^{-1}} = 2$» $C_4H_8O_2$ ✓</td><td>C_2S_2 if CS used.</td><td>1</td></tr>
<tr><td>1.</td><td>c</td><td></td><td>
<table>
<tr><th>Spectrum</th><th>Identity</th><th>Reason</th></tr>
<tr><td>A</td><td>Propan-1-ol</td><td>absence of carbonyl/C=O «absorption»/ no peak in 1700 - 1750 «cm^{-1}» range
OR
presence of hydroxyl/O-H in alcohols «absorption»/peak in 3200 – 3600 «cm^{-1}» range ✓</td></tr>
<tr><td>B</td><td>Propanoic acid</td><td>ALTERNATIVE 1:
carbonyl/C=O AND hydroxyl/O-H «in carboxylic acids absorptions»
OR
«strong» peaks in 2500 – 3000 «cm^{-1}» AND 1700 – 1750 «cm^{-1}» ranges ✓

ALTERNATIVE 2:
O-H in carboxylic acids «absorption» AND 2500 – 3000 «cm^{-1}» range ✓

ALTERNATIVE 3:
strong/broad «peak» AND 2500 – 3000 «cm^{-1}» range ✓</td></tr>
</table>
</td><td>Award [1 max] for correctly identifying all 3 compounds without valid reasons given.
Accept specific values of wavenumbers within each range.</td><td>3</td></tr>
</table>

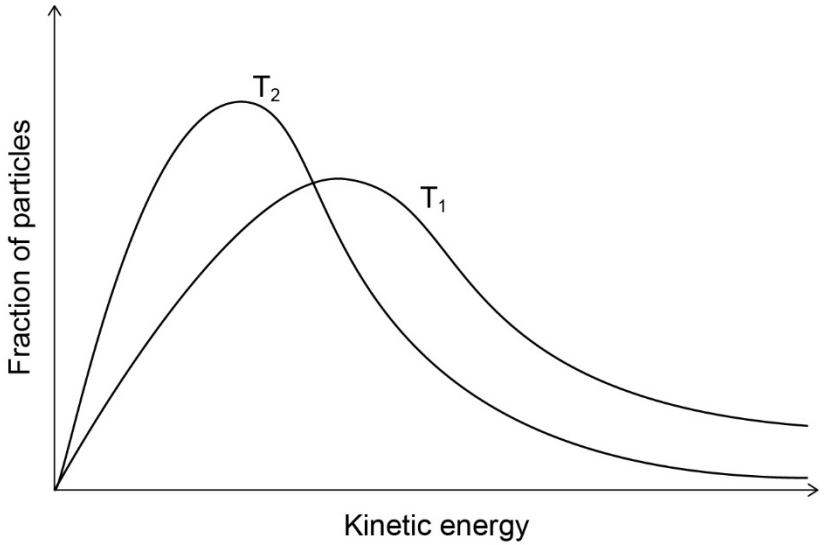
			C	Propanal	presence of carbonyl/C=O **«**absorption**»**/ peak in 1700 – 1750 **«**cm^{-1}**»** range ***AND*** absence of hydroxyl/O-H **«**in carboxylic acids absorption**»/** no **«**broad**»** peak in 2500 – 3000 **«**cm^{-1}**»** range ✓		

Question			Answers	Notes	Total
2.			increasing number of protons ***OR*** increasing nuclear charge ✓ **«**atomic**»** radius/size decreases ***OR*** same number of shells/electrons occupy same shell ***OR*** similar shielding **«**by inner electrons**»** ✓		**2**

3.	**a**	**i**	 ***OR*** ✓	*Accept any diagram with each P joined to the other three.* *Accept any combination of dots, crosses and lines.*	**1**
3.	**a**	**ii**	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(l)$ ✓		**1**
3.	**b**	**i**	*Electron domain geometry:* tetrahedral ✓ *Molecular geometry:* trigonal pyramidal ✓ *Bond angle:* 100**«**°**»** ✓	*Accept any value or range within the range 91−108**«**°**»** for **M3**.*	**3**

Question			Answers	Notes	Total
3.	b	ii	polar ***AND*** unsymmetrical distribution of charge ***OR*** polar ***AND*** dipoles do not cancel ***OR*** **«**polar as**»** dipoles **«**add to**»** give a **«**partial**»** positive **«**charge**»** at P and a **«**partial**»** negative **«**charge**»** at the opposite/Cl side of the molecule ✓	*Accept "polar **AND** unsymmetrical molecule".*	**1**
3.	c	i	**«**$-398.9\,kJ\,mol^{-1} - (-306.4\,kJ\,mol^{-1}) =$**»** -92.5 **«**$kJ\,mol^{-1}$**»** ✓		**1**
3.	c	ii	**«**$K_c =$**»** $\frac{[PCl_5]}{[PCl_3]\,[Cl_2]}$ ✓		**1**
3.	c	iii	**«**shifts**»** left/towards reactants ***AND*** **«**forward reaction is**»** exothermic/ΔH is negative ✓		**1**

Question			Answers	Notes	Total
4.	a	i	«nucleophilic» substitution/S_N2 ✓	*Do not accept if "electrophilic" or "free radical" substitution is stated.*	1
4.	a	ii	«acts as a» nucleophile/Lewis base ***OR*** donates/provides lone pair «of electrons» ***OR*** attacks the «partially» positive carbon ✓		1
4.	a	iii	bond enthalpy C–I lower than C–Cl ***OR*** C–I bond weaker than C–Cl ✓ «weaker bond» broken more easily/with less energy ***OR*** lower E_a «for weaker bonds» ✓	*Accept the bond enthalpy values for C–I and C–Cl for **M1**.*	2

Question			Answers	Notes	Total
4.	b	i	 peak at T_1 to right of ***AND*** lower than T_2 ✓ lines begin at origin ***AND*** T_1 must finish above T_2 ✓		**2**

Question			Answers	Notes	Total
4.	b	ii	«rate is» lower ***AND*** «average» kinetic energy of molecules is lower ***OR*** «rate is» lower ***AND*** less frequent collisions ***OR*** «rate is» lower ***AND*** fewer collisions per unit time ✓ «rate is» lower ***AND*** fewer/smaller fraction of molecules/collisions have the E ≥ E_a ✓	*Lower **«rate»** needs to be mentioned once only.* *Do **not** accept "fewer collisions" without reference to time/frequency/probability for **M1**.*	**2**

5.		**a**	$H_3PO_4\,(aq) + NaOH\,(aq) \rightarrow NaH_2PO_4\,(aq) + H_2O\,(l)$ ✓	*Accept net ionic equation.*	**1**
5.		**b**	$H_2PO_4^-\,(aq) + H^+\,(aq) \rightarrow H_3PO_4\,(aq)$ ✓ $H_2PO_4^-\,(aq) + OH^-\,(aq) \rightarrow HPO_4^{2-}\,(aq) + H_2O\,(l)$ ✓	*Accept reactions of $H_2PO_4^-$ with any acidic, basic or amphiprotic species, such as H_3O^+, NH_3 or H_2O.* *Accept $H_2PO_4^-\,(aq) \rightarrow HPO_4^{2-}\,(aq) + H^+\,(aq)$ for **M2**.*	**2**

Question			Answers	Notes	Total
5.	**c**		«$NaOH \frac{28.40\ cm^3}{1000} \times 0.5000\ mol\ dm^{-3} = 0.01420\ mol$» «$\frac{0.01420\ mol}{3}$ =» 0.004733 «mol» ✓ «$\frac{0.004733\ mol}{\frac{25.00\ cm^3}{1000}}$ =» 0.1893 «$mol\ dm^{-3}$» ✓	*Award **[2]** for correct final answer.*	**2**
5.	**d**		«OH^- is a» proton acceptor ✓		**1**

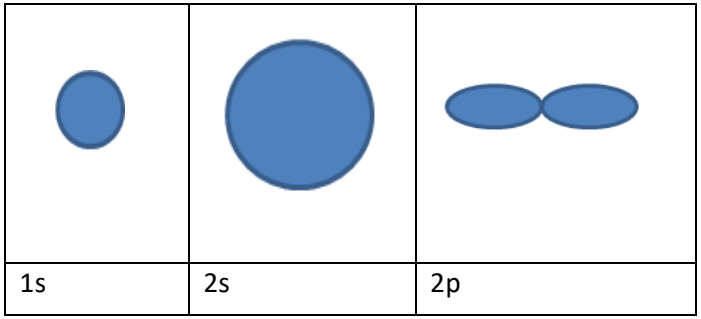
6	**a**		«amount of» oxygen used to decompose the organic matter in water ✓		**1**
6.	**b**		«$\frac{0.0001\ g}{0.1240\ g} \times 100\ \%$ =» 0.08 «%» ***OR*** «$\frac{0.4\ cm^3}{1000.0\ cm^3} \times 100\ \%$ =» 0.04 «%» ✓ «0.08 % + 0.04 % =» 0.12/0.1 «%» ✓	*Award **[2]** for correct final answer.* *Accept fractional uncertainties for **M1**, i.e., 0.0008 **OR** 0.0004.*	**2**

Question			Answers	Notes	Total
6.	c	i	«$\frac{37.50\,\text{cm}^3}{1000} \times 5.000 \times 10^{-4}\,\text{mol dm}^{-3}$ =» 1.875×10^{-5} «mol» ✓		1
6.	c	ii	1:4 ✓	*Accept "4 mol $S_2O_3^{2-}$:1 mol O_2", but not just 4:1.*	1
6.	c	iii	«$1.875 \times 10^{-5}\,\text{mol} \times \frac{1}{4}$ =» 4.688×10^{-6} «mol» ✓ «$\frac{4.688 \times 10^{-6}\,\text{mol}}{\frac{25.00\,\text{cm}^3}{1000}}$ =» 1.875×10^{-4} «mol dm^{-3}» ✓	*Award **[2]** for correct final answer.*	2
6.	c	iv	$MnO_2(s) + 2e^- + 4H^+(aq) \rightarrow Mn^{2+}(aq) + 2H_2O(l)$ ✓		1

7.		a	«$q = mc\Delta T = 20.0\,\text{g} \times 4.18\,\text{J g}^{-1}\,^\circ\text{C}^{-1} \times 57.3\,^\circ\text{C}$ =» 4790 «J» ✓ «$\Delta H_c = -\frac{4790\ \text{J}}{\frac{1000}{8.75 \times 10^{-4}\ \text{mol}}}$ =» -5470 «kJ mol^{-1}» ✓	*Award **[2]** for correct final answer.* *Accept answers in the range –5470 to -5480 «kJ mol^{-1}».* *Accept correct answer in any units, e.g. – 5.47 «MJ mol^{-1}» or 5.47 x 10^6«J mol^{-1}».*	2

Question			Answers	Notes	Total
7.	**b**		$Cl\cdot + C_2H_6 \rightarrow \cdot C_2H_5 + HCl$ ✓ $\cdot C_2H_5 + Cl_2 \rightarrow Cl\cdot + C_2H_5Cl$ ✓ $\cdot C_2H_5 + Cl\cdot \rightarrow C_2H_5Cl$ ***OR*** $Cl\cdot + Cl\cdot \rightarrow Cl_2$ ***OR*** $\cdot C_2H_5 + \cdot C_2H_5 \rightarrow C_4H_{10}$ ✓	*Do not penalize incorrectly placed radical sign, eg* $C_2H_5\cdot$**.**	**3**

8.	**a**		*Most* $^4He^{2+}$ *passing straight through:* most of the atom is empty space ***OR*** the space between nuclei is much larger than $^4He^{2+}$ particles ***OR*** nucleus/centre is **«**very**»** small **«**compared to the size of the atom**»** ✓ *Very few* $^4He^{2+}$ *deviating largely from their path:* nucleus/centre is positive **«**and repels $^4He^{2+}$ particles**»** ***OR*** nucleus/centre is **«**more**»** dense/heavy **«**than $^4He^{2+}$ particles and deflects them**»** ***OR*** nucleus/centre is **«**very**»** small **«**compared to the size of the atom**»** ✓	*Do* ***not*** *accept the same reason for both* ***M1*** *and* ***M2****.* *Accept "most of the atom is an electron cloud" for* ***M1****.* *Do* ***not*** *accept only "nucleus repels* $^4He^{2+}$ *particles" for* ***M2****.*	**2**

Question			Answers	Notes	Total
8.	b	i	 1s ***AND*** 2s as spheres ✓ one or more 2p orbital(s) as figure(s) of 8 shape(s) of any orientation (p_x, p_y p_z) ✓		**2**
8.	b	ii	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ ***OR*** [Ar] $4s^1 3d^{10}$ ✓	*Accept configuration with 3d before 4s.*	**1**