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Edexcel

Mark Scheme Results)

Pearson Edexcel Advanced Level In Chemistry (9CH0) Paper 01 Advanced Inorganic and Physical Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Answer	Mark
1(a)	**The only correct answer is A** ***B*** *is not correct because oxygen atoms do not have this number of protons* ***C*** *is not correct because oxygen atoms do not have this number of protons* ***D*** *is not correct because oxygen atoms do not have this number of protons*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is D** ***A*** *is not correct because there are no peaks for bromine molecules* ***B*** *is not correct because the peak for the* ^{79}Br-$^{81}Br^{+}$ *molecular ion is missing* ***C*** *is not correct because the peak for the* ^{79}Br-$^{81}Br^{+}$ *molecular ion is not twice the height of the other molecular ion peaks*	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is C** ***A*** *is not correct because this is only the number of electrons in the 3p orbitals of the chlorine atom* ***B*** *is not correct because this is only the number of electrons in the 3p orbitals of the chloride ion* ***D*** *is not correct because this is the total number of electrons in the chloride ion, not just those in the p orbitals*	**(1)**

Question Number	Answer	Mark
1(d)	**The only correct answer is A** ***B*** *is not correct because oxygen has more protons to exert an attractive force to reduce the ionic radius* ***C*** *is not correct because sodium has more protons to exert an attractive force to reduce the ionic radius* ***D*** *is not correct because aluminium has more protons to exert an attractive force to reduce the ionic radius*	**(1)**

(Total Question 1 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	• equation	<u>Example of equation</u> $Cl_2 + 2KBr \rightarrow Br_2 + 2KCl$ Accept ionic equation $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An answer that makes reference to the following points: • **(M1)** the precipitate is a mixture of silver chloride and silver bromide **or** not all of the bromide ions were oxidised **(1)** • **(M2)** silver chloride/AgCl dissolves in dilute ammonia **(1)** • **(M3)** silver bromide/AgBr does not dissolve in dilute ammonia **(1)**	Allow Some bromide ions are still present/bromide ions were in excess/both chloride and bromide ions are present Do not award references to Cl^- dissolving Silver bromide only dissolves in concentrated ammonia	**(3)**

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)	An answer that makes reference to the following point: • iodine is a weaker oxidising agent than chlorine **or** iodine cannot oxidise bromide ions **or** iodine is a stronger reducing agent	 Accept reverse arguments Ignore Just references to reactivity/displacement e.g. iodine is less reactive/cannot displace	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	• balanced equation	<u>Example of equation</u> $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii) **Clip with 2(b)(i)**	An explanation that makes reference to the following points: • oxidation number for chlorine changes from 0 to -1 so it is **reduced** **(1)** • oxidation number for chlorine changes from 0 to +5 so it is **oxidised** **(1)**	Ignore general definitions of disproportionation Accept oxidation numbers and their changes shown with equation Allow 1 out of 2 marks for three correct oxidation numbers of the chlorine	**(2)**

(Total Question 2 = 8 marks)

Question Number	Answer	Mark
3(a)(i)	**The only correct answer is D** ***A*** *is not correct because the measurement uncertainty is doubled as there are two burette readings* ***B*** *is not correct because this gives the largest measurement uncertainty* ***C*** *is not correct because the measurement uncertainty is doubled as the pipette is used twice*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	• calculation of Q **(1)** • calculation of enthalpy change **(1)** • answer to nearest whole number **and** with negative sign **(1)**	<u>Example of calculation</u> Q=(100 x 4.18 x 6.5=) = 2717 (J) / 2.717 kJ ΔH= 2.717 ÷ 0.05= (−)54.340 = −54 (kJ mol^{-1}) Allow TE at each stage Correct answer with no working scores (3)	**(3)**

Question Number	Answer	Mark
3(b)(i)	**The only correct answer is B** ***A*** *is not correct because there is no extrapolation to the largest temperature increase carried out* ***C*** *is not correct because the extrapolation is at the wrong time* ***D*** *is not correct because the extrapolation extends beyond the time of addition of alkali*	**(1)**

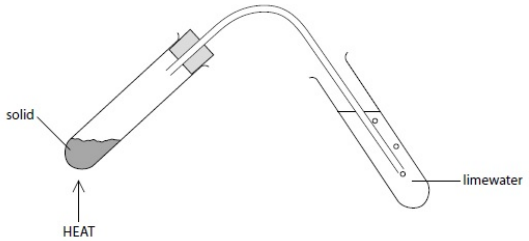
Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to • ethanoic acid is a weak(er) acid / only partially ionised/dissociated **(1)** • (some) **energy** is used to fully/completely ionise the ethanoic acid **(1)**	 Allow hydrochloric acid is a strong(er) acid/fully ionised Do not award 'more NaOH will react so more energy given off'	**(2)**

(Total Question 3 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	An answer that makes reference to the following point: • (Identity of gas is) oxygen/O_2 **and** (test result is that the splint) relights	 Do not award just 'O' Allow 'rekindle'/'reignites'	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to the following point: • (Identity of gas is) nitrogen dioxide **and** (appearance is) brown (gas/fumes)	If name and formula given then both must be correct Allow NO_2 Do not award NO or N_2O_4 Do not award if liquid referred to Do not award if two gases are given unless one of the gases stated is colourless oxygen Ignore shades of colour	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	• equation	<u>Example of equation</u> $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ Accept multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iv)	An description that makes reference to following points: • use of a delivery tube to bubble gas into limewater **(1)** • compare the time taken for the limewater to go cloudy **(1)**	Allow annotated diagrams to illustrate the marking points Example of a diagram that could be given credit  Do not award if the apparatus setting would not be feasible such as • missing cork/bung or gaps around delivery tube • horizontal tube with limewater in • bung in the test tube with limewater Allow TE from an incorrect/unsuitable method Allow Any length of time, e.g. 10 minutes	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to • the magnesium ion/cation is smaller (than the barium ion/cation) **(1)** • which polarises the (large) carbonate (ion)/anion **(1)** • and weakens the carbon-oxygen bond (C-O/C=O) bonds **(1)**	Accept reverse arguments Penalise omission of ion once only Allow magnesium ion/cation has a higher charge density Do not award reference to just atom Accept 'which distorts the carbonate electron cloud' Do not award if molecules of carbonate are referred to Allow 'weakens the bonds **in** the carbonate ion' Allow 'less energy needed to break the C-O bond' Do not award if the bonds referred to are the ionic bonds between the metal ion and the carbonate ion	**(3)**

(Total Question 4 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	An answer that makes reference to the following point: • the two negative ions repel each other	 Reference to both charge and repulsion needed	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An explanation that makes reference to the following points: • equation with oxidation of iron(II) ions **(1)** • equation with reduction of iron(III) ions **(1)** • (catalysis is possible because) variable oxidation state/iron has more than one oxidation state/number **or** both steps now involve oppositely charged ions **(1)**	<u>Example of equations</u> $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$ $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ Allow multiples Ignore state symbols even if incorrect Allow one mark if the two correct equation are given in the wrong order Allow reference to iron being oxidised and reduced Allow reference to the iron ions being positive and so not repelled	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)	• equation with oxidation of cobalt(II) ions • equation with reduction of cobalt(III) ions	Example of equations $2Co^{2+} + ½O_2 + 2H^+ \rightarrow 2Co^{3+} + H_2O$ $2Co^{3+} + SO_3^{2-} + H_2O \rightarrow 2Co^{2+} + SO_4^{2-} + 2H^+$ Allow multiples Ignore state symbols even if incorrect	**(2)**

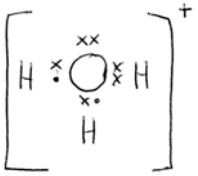
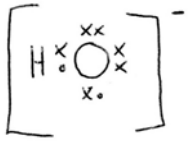
Question Number	Answer	Mark
5(c)	**The only correct answer is C** ***A*** *is not correct because only* Mn^{2+} *is an autocatalyst for this reaction* ***B*** *is not correct because only* Mn^{2+} *is an autocatalyst for this reaction* ***D*** *is not correct because only* Mn^{2+} *is an autocatalyst for this reaction*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(d)	Tungsten • (because) adsorption is too strong and so desorption would be too slow	Ignore references to oxidation or reactivity series or cost Do not award 'a**b**sorption'	**(1)**

(Total Question 5 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	An answer that makes reference to the following points: • **(M1)** (a lower boiling temperature is expected) because water has fewer electrons than hydrogen sulfide **(1)** • **(M2)** water has weaker/less London forces **(1)** • **(M3)** (a higher boiling temperature occurs because) water has hydrogen bonding **(1)** • **(M4)** hydrogen bonding is stronger than London forces and requires more **energy** to break (and results in a higher boiling temperature) **(1)**	Accept water has 10 electrons but hydrogen sulfide has 18 electrons (per molecule) Ignore reference to Mr/size of atom Allow van der Waals'/dispersion forces/ instantaneous dipole-induced dipole Accept reverse arguments Ignore references to permanent dipole-dipole forces	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to the following points: • **(M1)** oxygen is more electronegative than hydrogen **and** carbon **(1)** • **(M2)** which results in a polar bond with oxygen δ− so carbon **and** hydrogen δ+ **(1)** • **(M3)** carbon dioxide is a symmetrical/linear molecule and so the dipole moments/vectors cancel **(1)** • **(M4)** the lone pairs of electrons of oxygen/ the V-shape of the water molecule mean that the dipole moments/ vectors do not cancel **(1)**	Accept supporting diagrams which illustrate the following: Accept electronegativity values stated Allow oxygen has a greater force of attraction for the bonded electron pairs than hydrogen **or** carbon Penalise the failure to refer to carbon and hydrogen once only Allow 'symmetrical so dipoles/ polar bonds cancel' Allow angular/bent for V-shape Penalise reference to just 'charges' once only in M3 and M4 if dipoles not stated or shown in the answer	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(c)	Two diagrams • oxonium ion **(1)** • hydroxide ion **(1)**	Examples of suitable diagrams   Ignore inner 'shell' of two electrons Ignore missing brackets Ignore covalent circles Penalise all dots or all crosses or use of other symbols for electrons once only Penalise omission of charges once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	• square root of K_w at 310K to get $[H^+]$ **(1)** • calculation of pH to 2 decimal places **(1)**	Example of calculation: $[H^+] = (\sqrt{2.40 \times 10^{-14}}) = 1.549..x10^{-7}$ (mol dm^{-3}) $pH = (-\log 1.549..x10^{-7})$ $= (6.809894379) = 6.81$ Correct answer with no working scores (2) Allow TE from incorrect $[H^+]$ as long as answer is in the pH range 6.00 – 7.00 inclusive	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An answer that makes reference to the following points: • **(M1)** neutral **(1)** • **(M2)** because $[H^+(aq)] = [OH^-(aq)]$ /equal amounts of H^+ and OH^- ions **(1)**	Acidic or alkaline scores (0) Allow both $[H^+]$ and $[OH^-]$ have increased equally (from 298 K to 310 K) M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	An answer that makes reference to the following point: • positive / + sign because K_w increases as the temperature increases	Allow 'positive because' bond breaking requires energy or equilibrium shifts to the right or there is greater/more ionisation/dissociation Ignore 'endothermic'	**(1)**

(Total Question 6 = 15 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*7</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning.
For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

More than one indicative marking point may be made within the same comment or explanation
</td>
<td>(6)</td>
</tr>
</table>

	<table><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> **Indicative content** Similarities • **(IP1)** the differences in energy levels determines the colour of the flame test and complex ion Differences Flame test • **(IP2) heat** (energy) results in electron promotion • **(IP3)** return of an (excited) electron to a lower (energy) state Complex ion • **(IP4)** d orbital**s** are split (in energy by the ligands) • **(IP5) light** (energy) is needed for electron promotion • **(IP6)** the colour not absorbed is the colour seen		Deduct a reasoning mark if no comparison made Penalise the use of 'atom' instead of ion once only against any indicative point Ignore incorrect colours This can be mentioned separately or as a comparison Allow electrons excited by **heat** Allow electron is 'de-excited' to a lower (energy) state Do not award if d-d transitions stated Allow d subshell splitting Do not award singular "d orbital" splitting Accept "The colour seen is complimentary to that absorbed" Allow 'colour reflected is the colour seen' Do not award if colour attributed to 'fall' of electron to lower energy d orbital Do not award 'emission of light'	

(Total Question 7 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	An answer that makes reference to the following points: • identification and correction of the first error **(1)** • identification and correction of the second error **(1)**	Allow corrections to be made on the diagram Error 1 – arrow for enthalpy change of formation should go down/be reversed Error 2 – the word 'half ' should be deleted from the enthalpy change of atomisation of hydrogen	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	• calculation of first electron affinity of hydrogen	<u>Example of calculation</u> 1st EA= −(218+496+107)−56 +804 = −73 (kJ mol^{-1}) Allow a TE 1st EA = +39(kJ mol^{-1}) if the first arrow reversed direction is not identified	**(1)**

Question Number	Answer	Additional Guidance	Mark
Penalise incorrect or missing units in (b)(i) and (b)(ii) once only			
8(b)(i)	• calculation of Δ*G* **(1)** • Δ*G* is negative/ <0 and so reaction is feasible **(1)**	Example of calculation $\Delta G = -56 - \left(298 \times \frac{-76.5}{1000}\right)$ $= -33.203$ (kJ mol^{-1}) or $\Delta G = -56000 - (298 \times -76.5)$ $= -33203$ (J mol^{-1}) Ignore SF except 1 Allow ≤0 and so reaction is feasible Standalone mark Allow TE on own Δ*G* calculated value	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	• calculation of *T*	Example of calculation Δ*G* = 0, so $\Delta H = T\Delta S_{(system)}$ or $T = \Delta H/\Delta S_{(system)}$ T = 56/0.0765 = 732 K **or** T = 56000/76.5 = 732 K **or** T = 459°C Ignore SF except 1 SF Do not award −732K TE on incorrect values penalised already in (b)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(c)	• reduction half-equation	<u>Example of half equation</u> $\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$ Allow multiples Ignore state symbols even if incorrect	**(1)**

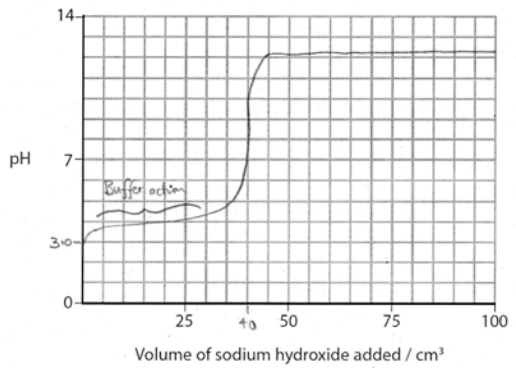
Question Number	Answer	Mark
8(d)	**The only correct answer is B** (-804, -711, -2718) ***A*** *is not correct because the lattice energy of magnesium hydride is not exothermic enough* ***C*** *is not correct because the lattice energy of potassium hydride should be less exothermic than sodium hydride and also that the lattice energy of magnesium hydride is not exothermic enough* ***D*** *is not correct because the lattice energy of potassium hydride should be less exothermic than sodium hydride*	**(1)**

(Total Question 8 = 8 marks)

Question Number	Answer	Mark
9(a)	**The only correct answer is D** (resists changes in pH if small quantities of acid or base are added) **A** *is not correct because buffer solutions can be alkaline or acidic* **B** *is not correct because buffers do not always contain equal numbers of moles of the acid and its conjugate base* **C** *is not correct because a buffer does not prevent any change in pH*	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)	• **(M1)** calculation of $[H^+]$ **(1)** • **(M2)** rearrangement of K_a and calculation of ethanoate concentration **(1)** • **(M3)** calculation of the number of moles of ethanoate in the buffer volume **(1)** • **(M4)** calculation of the mass of sodium ethanoate in the buffer volume **(1)** • **(M5)** answer to 2/3 SF **(1)**	Example of calculation $[H^+] = 10^{-3.9} = 1.2589..\text{x } 10^{-4}$ (mol dm^{-3}) $[CH_3COO^-] = (\underline{1.74 \text{ x } 10^{-5} \text{ x } 0.800}) =$ $1.2589..\text{ x } 10^{-4}$ =0.11057.. (mol dm^{-3}) n=(0.11057.. x 0.05 =) 5.5285..x 10^{-3} (mol) m=(5.5285..x 10^{-3} x 82=) 0.453339.. m=0.45/ 0.453 (g) Award this mark only if there has been some attempt at calculation using an M_r TE at each stage If Henderson-Hasselbalch equation used **(M1)** for calculation of pK_a = 4.759 **(M2)** for rearrangement and calculation of ethanoate concentration Remaining marking points as above	**(5)**

Question Number	Answer	Additional Guidance	Mark
9(c)	An answer that makes reference to the following points: • carbon dioxide dissolved in the blood forms carbonic acid (and so this concentration increases) **(1)** • the equilibrium will shift to the right and produces more H^+/acid ions **(1)** • the (high) concentration of hydrogencarbonate ions suppress the ionisation of carbonic acid (to help to control pH) **or** the (large) reservoir/excess of hydrogencarbonate ions combine with the H^+ ions (to help to control blood pH) **(1)**	Can be shown in an equation Do not award 'CO_2 reacts with H^+ to form carbonic acid' Allow Carbonic acid (partially) dissociates to produce H^+ Do not award 'CO_2 reacts with H^+ so equilibrium shifts to the right to produce more H^+' Ignore general comments about the effects of adding acid and/or alkali to a buffer which do not relate to carbon dioxide	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(d)(i)	• general shape of weak acid-strong base curve **(1)** • curve starts at pH of 3.0 and ends at pH of 12-13 **(1)** • vertical part of the curve at 40 cm^3 **(1)** • labelling of area indicating buffer action **(1)**	<u>Exemplar graph</u>  Ignore missing initial rise in pH Vertical part must cover 3-5 pH units between 6 – 11 The curve should reach pH~12-13 by 10cm^3 after vertical section The curve must start at zero and continue to 100 cm^3 Allow buffering area to be labelled anywhere between ~5 and 35 cm^3 inclusive	**(4)**

Question Number	Answer	Additional Guidance	Mark
9(d)(ii)	An answer that makes reference to • determine the pH at the point when half of the acid is neutralised **(1)** • $K_a = 10^{-pH}$ / $K_a = 10^{-pK_a}$ **(1)**	Standalone marks Allow 'pH at half-equivalence point' Allow 'pH at half neutralisation point' Accept description in words such as inverse log of minus pH or value is pK_a and so inverse log of minus value gives K_a Allow pK_a = -log K_a Ignore any calculation	**(2)**

(Total Question 9 = 15 marks)

Question Number	Answer	Additional Guidance	Mark
10(a)(i)	• **(M1)** calculation of mole fractions **(1)** • **(M2)** calculation of partial pressures **(1)** • **(M3)** expression of K_p **(1)** • **(M4)** calculation of value of K_p **(1)** • **(M5)** units **(1)**	Example of calculation X_{SO_2} = 0.0160 ÷ 0.8 = 0.02(0) X_{O_2} = 0.0120 ÷ 0.8 =0.015 X_{SO_3} = 0.772 ÷ 0.8 =0.965 P_{SO_2} = 0.02(0) x 2.40 = 0.048 P_{O_2} = 0.015 x 2.40 = 0.036 P_{SO_3} = 0.965 x 2.40 =2.316 $K_p = \frac{(\boldsymbol{P}_{SO_3})^2}{(\boldsymbol{P}_{SO_2})^2 \times \mathbf{P}_{O_2}}$ Do not award square brackets $K_p = \frac{2.316^2}{0.048^2 \times 0.036} =$ K_p= 64668.4..../6.46684.. x 10^4 K_p= 65000/6.5 x 10^4/64700/6.47 x 10^4 Ignore SF except 1 atm^{-1} Correct final answer without working scores (5)	**(5)**

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	• calculation of the number of molecules	Example of calculation N=(n x L = 0.0160 x 6.02 x 10^{23}) = 9.632 x 10^{21} Ignore SF except 1SF Do not award if any units are given	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(iii)	An answer that makes reference to the following points: • to ensure that K_p stays the same/ quotient stays the same **or** only temperature changes the value of K_p **(1)** • the number of (sulfur dioxide) molecules decreases **Either** because the equilibrium shifts to the right or because one of the denominators (oxygen) has increased so the other denominator (sulfur dioxide) has to decrease **(1)**	Standalone marks Allow concentration changes have no effect on the value of K_p Allow 'moles' for molecules	**(2)**

Question Number	Answer	Additional Guidance	Mark
10(b)	An explanation that makes reference to the following points: • equilibrium position shifts to the left **(1)** • (because) the hydroxide ions combine with/neutralise the H^+ ions to remove them from the equilibrium **(1)**	'Equilibrium moves to the right' scores (0) Allow Hydroxide ions react with H^+ ions to make water/ hydroxide ions react with H^+ ions to reduce their number/concentration Ignore reference to 'more products formed'	**(2)**

Question Number	Answer	Mark
10(c)	**The only correct answer is D** $K_c = \frac{[H_2O]^4}{[H_2]^4}$ **A** is not correct because the solids should not be included in the expression and the powers of the remaining substituents have been omitted **B** is not correct because the solids should not be included in the expression **C** is not correct because the powers of the substituents have been omitted	**(1)**

(Total Question 10 = 11 marks)

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