GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
CHEMISTRY - COMPONENT 1
A410U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2017 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark, apart from extended response questions where a level of response mark scheme is applied.

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Extended response questions

A level of response mark scheme is applied. The complete response should be read in order to establish the most appropriate band. Award the higher mark if there is a good match with content and communication criteria. Award the lower mark if either content or communication barely meets the criteria.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

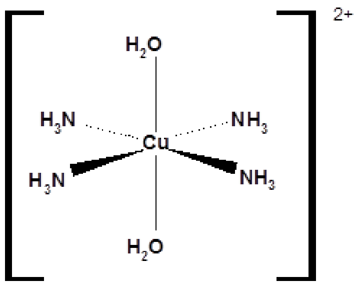
Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

Section A

Question	Marking details	AO1	AO2	AO3	Total	Maths	Prac
		Marks available					
1		1			1		
2	$B^{+}(g) \rightarrow B^{2+}(g) + e^{-}$ **must** include state (g)		1		1		
3	**royal** / **dark** blue (1) do not accept 'blue'  (1)	2			2		1
4	$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ ignore state symbols		1		1		1
5	energy of line = $hf = 6.63 \times 10^{-34} \times 3.28 \times 10^{15} = 2.17 \times 10^{-18}$ J (1) ionisation energy = $2.17 \times 10^{-18} \times 6.02 \times 10^{23} \div 1000$ = 1309 kJ mol^{-1} (1) ecf possible		2		2	2	

6				carbon is more stable as +4 oxidation state (so will be readily oxidised to this oxidation state) (1) e.g. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ (1)	1	1		2		
7				temperature 243 K **and** pressure 1.01×10^5 Pa (1) $pV = nRT$ gives $V = nRT \div p$ $0.267 \times 8.314 \times 243 \div 1.01 \times 10^5 = 5.34 \times 10^{-3}$ m^3 (1) ecf possible		2		2	2	
8				for a reaction to be feasible overall entropy must increase (1) when sodium chloride dissolves ions have greater entropy which overcomes the endothermic change (1) OR for a reaction to be feasible Gibbs free energy must be negative (1) in this case ΔS will be large as ions in solution have a greater entropy and counteract the ΔH (1)	1		1	2		
9				pH in range 2.5-6.5 (must give reason for mark) (1) ammonium ion will release H^+ ions in solution making solution acidic (can show this by equilibrium) (1)		1	1	2		
				Section A total	**5**	**8**	**2**	**15**	**4**	**2**

Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		4.39 % (2) award (1) if answer given to different number of significant figures		2		2	2	
		(ii)		either route acceptable – must include at least **two** advantages of and **one** disadvantage of chosen route; award (1) for each **advantages of steam reforming** • produces more H_2 • higher atom economy / less waste • does not produce CO_2 • waste product can be recycled in water gas shift reaction **disadvantages** • uses non-renewable resource / fossil fuel as starting material • highly endothermic so will need a lot of energy input **advantages of water gas shift reaction** • exothermic so will not need much energy input / energy generated can be used elsewhere • starting material is waste product of another reaction • does not produce CO which is toxic **disadvantages** • produces CO_2 which leads to global warming • produces less H_2 than reforming • lower atom economy that reforming		2	1	3		
	(b)			syngas contains H_2 already which is a product of the WGSR (1) H_2 would shift the equilibrium of the WGSR to the left so less conversion will occur (1)		2		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)	I	catalysts are in a different physical state / phase to the gas reactants	1			1		
			II	gases can be adsorbed onto catalyst (1) this brings the gas reagents together OR the transition metal can oxidise or reduce the gas molecules making them more reactive (1)	2			2		
		(ii)	I	there are the same numbers of gas molecules on both sides of the reaction so pressure does not affect the position of equilibrium		1		1		
			II	higher pressure: increased rate / less time (1) lower pressure: reduced energy costs / reduced equipment costs (to ensure high pressures can operate safely) (1)	2			2		
		(iii)	I	the reaction is exothermic (1) higher temperature shifts equilibrium to left so more reactants remain (1)		2		2		
			II	$K_c = \frac{[CO_2][H_2]}{[CO]\,[H_2O]}$		1		1		
			III	1% CO and 1% H_2O in equilibrium mixture (1) 49% of each product (1) K_c = 49 × 49 ÷ (1 × 1) = 2401		3		3	3	
				Question 10 total	**5**	**13**	**1**	**19**	**5**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			P_4O_{10} + $6H_2O$ → $4H_3PO_4$		1		1		
	(b)			• Na_2O, MgO, Al_2O_3 have giant ionic structures so has strong electrostatic forces between ions (1) • SiO_2 has a giant covalent structure / macromolecule so needs to break strong covalent bonds to melt (1) • P_4O_{10}, SO_2, Cl_2O have covalent molecules and the forces between molecules are weak (1)	3			3		
	(c)	(i)		aluminium oxide is ionic and aluminium chloride is covalent (1) difference in electronegativity between Al and O is greater than that between Al and Cl (1)	1	1		2		
		(ii)		aluminium oxide contains charged ions and aluminium chloride does not (1) ions can flow and carry a charge when molten (1)	2			2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		phosphorus has *d*-orbitals in its outer shell / available but nitrogen does not (1) this allows phosphorus to expand its octet / have more than 8 electrons in its outer shell (1)	2			2		
		(ii)		oxidation state in sodium peroxide is –1 (1) no change in oxidation states so not redox / oxidation state of oxygen in the H_2O_2 is –1 (1)		2		2		
		(iii)		inert pair effect (1) becomes more significant down the group so lead can form +2 but silicon cannot (1)	2			2		
	(e)			PCl_3 has three bonding pairs and one lone pair (1) these arrange themselves as far apart as possible to minimise repulsion / lone pairs repel more than bonded pairs (1) pyramidal shape or diagram (1)	 1 	1 1		3		
	(f)			appropriate diagram / Born-Haber cycle (1) $\Delta_f H^\ominus = 150 + (2 \times 121) + 738 + 1451 + (2 \times -349) - 2493$ (1) –610 (kJ mol^{-1}) (1)		 1 1	1	3	3	
				Question 11 total	**11**	**8**	**1**	**20**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)			alpha radiation unable to penetrate vial walls / absorbed by solvent	1			1		
	(b)			high energy electromagnetic waves	1			1		
	(c)			causes mutations / damages DNA or biological molecules	1			1		
	(d)			germanium 74 **both** needed		1		1		
	(e)	(i)		number of atoms per minute = $2.1 \times 10^5 \times 60 = 1.26 \times 10^7$ (1) number of moles per minute = $1.26 \times 10^7 \div N_A = 2.09 \times 10^{-17}$ (1) mass per minute = $2.09 \times 10^{-17} \times 131 = 2.74 \times 10^{-15}$ g (1) ecf possible throughout		1 1	1	3	3	
		(ii)		caesium-137 (must give reason) (1) it has the second highest radioactivity behind chlorine-38 however it has the longest half-life, so there must be a much greater amount of caesium-137 to produce this amount of radioactivity (1)			2	2	1	
	(f)			award (1) for any **two** of following • after two half-lives some of the longest lived isotope is still present • the decay of a radioisotope may produce another radioactive nucleus which may have a longer half-life • there may be other radioactive nuclei not detected so far or not listed with longer half-lives			2	2		
				Question 12 total	**3**	**3**	**5**	**11**	**4**	**0**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>13</td><td>(a)</td><td>(i)</td><td></td><td>
<table>
<tr><td>volume A / cm^3</td><td>22.35</td><td>22.00</td><td>22.05</td><td>22.00</td></tr>
<tr><td>volume B / cm^3</td><td>11.20</td><td>10.65</td><td>10.55</td><td>10.45</td></tr>
</table>
all values calculated and give to 4 sig figs (1)

22.02 (1)

10.55 (1) ecf possible throughout</td><td></td><td>3</td><td></td><td>3</td><td>1
1</td><td>3</td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>any two for (1) each
• repeat readings in first titration are closer together / concordant / less scatter
• smaller percentage error in measurements in first titration as values are larger
• two colour changes measured / steps to find volume B but only one to find volume A</td><td></td><td></td><td>2</td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td></td><td>(iii)</td><td></td><td>moles HCl = 10.55 × 0.105 / 1000 = 1.11×10^{-3} (1)

moles Na_2CO_3 = 5.54×10^{-4} (1)

mass Na_2CO_3 in original sample = 0.587 g (1)

ecf from part (i) and throughout</td><td></td><td>1</td><td>1
1</td><td>3</td><td>1
1</td><td>3</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Indicative content** 1. Indicators are weak acids or bases where protonated and deprotonated forms are different colours (can show by equation) 2. Indicator changes colour over a range of pH 3. Different indicators change colour over different pH ranges 4. The colour change range must lie within a vertical range of the titration curve for indicator to be useful 5. Equivalence points for sodium hydroxide / sodium carbonate occur at different pH values 6. Equivalence point for sodium carbonate is acidic, with that of sodium hydroxide in the mixture being neutral OR basic (accept either) 7. To select appropriate indicators, calculate OR find experimentally the pH of the equivalence points and their vertical regions 8. Refer to literature values of pH ranges 9. Name appropriate indicators	2	1	3	6		6
				5-6 marks At least **six** relevant points, including **two** of points 3, 4 and 5 *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.* **3-4 marks** At least **four** relevant points, including at least **two** of points 3, 4 and 5 *The candidate constructs a coherent account including many of the key elements of the indicative content. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks** At least **three** relevant points *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		$[H^+]^2 = 1.76 \times 10^{-5} \times 0.1 = 1.76 \times 10^{-6}$ $[H^+] = 1.33 \times 10^{-3}$ mol dm^{-3} (1) pH = – log $[H^+]$ = 2.9 (1)		2		2	2	
		(ii)		use pH probe to measure pH as acid is added (1) plot results to find equivalence point / no sharp increase in pH (1)			2	2		2
				Question 13 total	**2**	**7**	**9**	**18**	**6**	**16**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	(a)	(i)		allows ions to flow without the solutions mixing	1			1		1
		(ii)		award (1) for any **two** of following up to maximum of **six** for (3) H_2(g) / 1 atm pressure / H^+(aq) / 1 mol dm^{-3} concentration / 298 K / platinum electrode / appropriate diagram	3			3		3
		(iii)		lithium metal would react with the solution			1	1		1
	(b)	(i)		Li / Li (s)		1		1		
		(ii)		EMF = 1.09 – (–0.76) (1) = 1.85 V (ignore sign) (1)		2		2		2

<table>
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<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td rowspan="2"></td><td rowspan="2">(b)</td><td rowspan="2">(iii)</td><td rowspan="2"></td><td>Indicative content
1. Chlorine is a stronger oxidising agent than Fe^{3+} as shown by a more positive standard electrode potential
2. Chlorine is able to oxidise Fe to Fe^{3+} as the EMF for this reaction is positive / the standard electrode potential for chlorine is more positive than that for Fe^{3+} to Fe
3. Fe^{3+} is a stronger oxidising agent than iodine so will be reduced to Fe^{2+}
4. The standard electrode potential for Fe^{3+} / Fe^{2+} is more positive than that for I_2 / I^-.
5. Would expect bromine to form $FeBr_3$ as bromine is a stronger oxidising agent than Fe^{3+} (including reference to standard electrode potentials)
6. Prediction may be incorrect as not standard conditions (iron is heated / halogen gases rather than solutions / products solids rather than solutions)

Relevant equations:
• $Fe + I_2 \rightarrow FeI_2$
• $2Fe + 3Cl_2 \rightarrow 2FeCl_3$
• $2Fe + 3Br_2 \rightarrow 2FeBr_3$</td><td>2</td><td>2</td><td>2</td><td>6</td><td></td><td>3</td></tr>
<tr><td colspan="7">5-6 marks
At least five relevant points, including point 5 and either point 1 or point 3, as well as at least two relevant equations.
The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.

3-4 marks
At least four relevant points, including either point 1 or point 3, as well as at least two relevant equations.
The candidate constructs a coherent account including many of the key elements of the indicative content. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.

1-2 marks
At least three relevant points and one relevant equation.
The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.

0 marks
The candidate does not make any attempt or give an answer worthy of credit.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 14 total</td><td>6</td><td>5</td><td>3</td><td>14</td><td>0</td><td>9</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15	(a)			number of electrons = 7.5×10^{22} (1) number of moles of electrons = 0.1246 (1) mass of lithium = 0.1246×6.94 = 0.86 (1) answer must be given to 2 sig figs ecf possible throughout		3		3	3	
	(b)	(i)		heating to constant mass ensures **all** the water has been removed / sample is completely dry	1			1		1
		(ii)		number of moles of $Ca_3(PO_4)_2 = 8.57 \times 10^{-3}$ (1) moles of solid is approximately 0.017088 so c = 1 (1)		1 1	1	3	3	3
		(iii)		13.2 µg dm^{-3} Li = 1.90 µmol dm^{-3} (1) a =1 as the concentration of the solid and the Li is the same (1)		1	1	2	1	1
		(iv)		M_r of unknown metal in overall M_r approximately = 158 – 6.94 – 95 = 56.06 therefore metal must be Fe (1) overall formula is $LiFePO_4$ (1)			2	2		
				Question 15 total	**1**	**6**	**4**	**11**	**7**	**5**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
16	(a)	(i)		concentration of reactants changes over this time (1) so rate changes significantly over this time (1)		1 1		2		2
		(ii)		values measured at lower temperatures are very small (1) percentage errors in these will therefore be larger than in other measurements (1)			1 1	2	1	2
	(b)	(i)		second order		1		1	1	
		(ii)		rate data tells us about the rate determining / slowest step of the reaction mechanism (1) second order shows there are two molecules / the number of molecules involved (in the rate determining step) (1) order with respect to each reactant tells how many of each reactant molecule are present in the rate determining step (1)	1 1		1	3		
		(iii)		k = $Ae^{-E_a/RT}$	1			1	1	
		(iv)		$E_a = -RT \times \log_e(k/A)$ (1) $E_a = -8.314 \times 303 \times \log_e (1.752 \times 10^{-2} / 1.49 \times 10^{11})$ (1) $E_a = 75.0\ \text{kJ mol}^{-1}$ (conversion into kJ from J) (1) ecf possible throughout			3	3	3	
				Question 16 total	**3**	**3**	**6**	**12**	**6**	**4**

COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	5	8	2	15	4	2
10	5	13	1	19	5	0
11	11	8	1	20	3	0
12	3	3	5	11	4	0
13	2	7	9	18	6	16
14	6	5	3	14	0	9
15	1	6	4	11	7	5
16	3	3	6	12	6	4
Totals	36	53	31	120	35	36