GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
CHEMISTRY - UNIT 3
2410U20-1

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.

UNIT 3: 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	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1.	(a)			canary yellow / bright yellow	1			1		1
	(b)			$Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$ STATE SYMBOLS MUST BE SHOWN	1			1		1
2.				iron and Haber process / making ammonia / appropriate equation nickel in hydrogenation of alkenes	1			1		
3.				it is soluble because the enthalpy change of hydration is more exothermic (or more negative) than the enthalpy change of lattice making OR calculation of enthalpy of solution as –141 kJ mol^{-1} (1) the enthalpy of solution would be negative / exothermic (1)		1 1		2		
4.				award (1) for every **two** correct • platinum electrode • 1 mol dm^{-3} $H^{+}(aq)$ or any appropriate strong monobasic acid • $H_2(g)$ at 1 atm / 1.01×10^5 Pa • temperature = 298 K / 25°C (units must be included)	2			2		2
5.	(a)			35 and 17.5		1		1	1	1
	(b)			rate at 0.200 = 0.0286 rate at 0.400 = 0.057 ecf from part (a)		1		1	1	1
6.				copper metal, water, nitrogen gas, air		1		1		
				Section A total	**5**	**5**	**0**	**10**	**2**	**6**

Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7.	(a)			a species that accepts H^+ / releases OH^- in a reversible reaction	1			1		
	(b)			a buffer maintains a constant pH upon addition of small amounts of acid or base (1) any **two** of following for (1) each • $NH_4^+ \rightleftharpoons NH_3 + H^+$ • addition of H^+ shifts equilibrium to left / addition of OH^- reacts with H^+ which shifts equilibrium to right to replace the H^+ • salt dissociates completely releasing ammonium ions and ammonia sets up a reversible reaction	3			3		1
	(c)	(i)		pH at half volume for neutralisation = 9.3 (allow 9.25 to 9.32) (1) $K_a = 10^{-9.3} = 5.0 \times 10^{-10}$ (allow 4.79-5.62 $\times 10^{-10}$) (1) allow ecf only for misread pH in the range 9.15 to 9.45		1	1	2	1	1
		(ii)		4-nitrophenol as pH range lies on the steep / vertical part of the curve		1		1		1
				Question 7 total	**4**	**2**	**1**	**7**	**1**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8.	(a)	(i)		nitrogen forms NCl_3; phosphorus forms (PCl_3 and) PCl_5 (1) phosphorus is able to expand its octet but nitrogen is not / phosphorus has <u>available</u> *d*-orbitals whilst there are none in the outer shell of nitrogen (1)	2			2		
		(ii)		aluminium has three outer shell electrons so it is able to form three covalent bonds giving six outer shell electrons or an incomplete outer shell or leaving it electron deficient (1) dot and cross diagram of suitable example e.g. $AlCl_3$ and dot and cross diagram of suitable example that has formed coordinate bond e.g. $AlCl_4^-$ / Al_2Cl_6 (1) DO NOT ACCEPT IONIC COMPOUNDS; COORDINATE BOND MUST BE CLEAR	2			2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Indicative content** PHYSICAL STATE 1. carbon dioxide and carbon monoxide have weak forces between separate molecules (so it is a gas) 2. lead has a relatively low ionisation energy so can form positive ions; its oxides are ionic with strong attraction between ions (so it they are solids) ACID/BASE 3. carbon dioxide is a non-metal / covalent oxide so it is an acidic oxide 4. lead(II) oxide reacts with both acids and bases so it is an amphoteric oxide REDOX 5. stability of +2 oxidation state increases down the group / +4 most stable for top of group and +2 most stable at bottom of group / inert pair effect increases down the group 6. carbon monoxide contains carbon in oxidation state +2 whilst +4 is stable, so carbon will be easily oxidised / so it acts as a reducing agent 7. lead(IV) oxide contains lead in oxidation state +4 whilst +2 is stable, so lead will be easily reduced / so it acts as an oxidising agent Relevant equations: • CO as a reducing agent e.g. $CO + CuO \rightarrow Cu + CO_2$ • PbO_2 as an oxidising agent e.g. $PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$ • CO_2 reacting with a base: $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$ or $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$ • PbO reacting with a base: $PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$ PbO reacting with an acid: $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$	3	3		6		2

				5-6 marks The candidate gives at least four relevant points with at least one from two of the three sections, including point 5 and at least two equations. *The candidate constructs a relevant, coherent and logically structured account including 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** The candidate gives at least three relevant points with at least one from two sections, including two 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** The candidate includes at least two relevant points, including one equation. *The candidate attempts to link relevant points from the indicative content. Coherence is limited by omission and/or inclusion of irrelevant material. 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 8 total	**7**	**3**	**0**	**10**	**0**	**2**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9.	(a)			mass of NO_2 = 25.0 × 0.714 ÷ 100 = 0.1785 (1) moles NO_2 = 0.1785 ÷ 46 = 3.88 × 10^{-3} (1) answer must be to 3 sig figs to gain full marks		2		2	2	
	(b)	(i)		$K_c = \frac{[NO_2]^2}{[N_2O_4]}$ (1) unit mol dm^{-3} (1) allow ecf for unit		2		2	1	
		(ii)	I	concentration of NO_2 = 2 × (0.400 – 0.0581) = 0.6838 (1) value of K_c = 8.05 (1) solvent is CCl_4 (1) (allow ecf)		2	1	3	1	
			II	CS_2 given with any valid reason (1) explanation in terms of position of equilibrium or amount of product formed (1)		1	1	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		catalyst allows a lower temperature to be used (1) this leads to an increased yield (1) (must get first mark)		1	 1	 2		
		(ii)		a higher pressure should be used (1) shifts equilibrium to the right as this has fewer gas molecules (1) a lower temperature should be used (1) shifts equilibrium to the right as this is the exothermic direction (1) (allow one explanation mark if reference to equilibrium shifting to oppose change with no further detail) accept alternative remove product as it forms (1) equilibrium moves further towards the right / product (1)		1 1	1 1	4		
				Question 9 total	**0**	**10**	**5**	**15**	**4**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	(a)			oxidation state of chlorine goes from –1 to to 0 so it is oxidised / oxidation state of nitrogen goes from +5 to +3 so it is reduced		1		1		
	(b)			enthalpy of formation of elements in their standard state is zero	1			1		
	(c)			53 + 0 + [2 × (–286)] – (–173) – [3 × $\Delta_f H^\theta$] = –69 (1) [3 × $\Delta_f H^\theta$] = –277 $\Delta_f H^\theta$ = –92.3 (1)		2		2	2	
	(d)	(i)		ΔS^θ = –90 (1) convert 25°C to 298K (1) ΔG^θ = –69 – 298 × (–90) ÷ 1000 = –42.18 (1)		3		3	2	
		(ii)		the entropy of concentrated hydrochloric acid is lower, so ΔS^θ will be more positive therefore ΔG^θ will be more negative			1	1		
	(e)	(i)		$[H^+] = 10^{-0.3} = 0.50$		1		1	1	
		(ii)		titration gives the more precise value (1) MUST GIVE REASON TO GAIN THIS MARK pH measurements to fewer significant figures / pH gives wide range of possible concentrations (0.45 – 0.56) (1)			2	2		2
				Question 10 total	**1**	**7**	**3**	**11**	**5**	**2**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11.	(a)			moles water = 1.44 ÷ 18.02 = 0.0799 (1) d = 4 (1) [allow ecf]		 1	1 	 2	 2	 2
	(b)	(i)		bromide is present (1) the sample produces an orange-brown solution which could be bromine or iodine but cannot contain iodide as no H_2S produced (1)			1 1	 2		 2
		(ii)		moles Br = 0.0203 (1) [allow moles I = 0.01623 as ecf] moles compound = 5.076×10^{-3} so c = 4 (1) [allow 3.2 as ecf for iodide]		1	 1	 2	 2	 2
	(c)			aluminium is amphoteric	1			1		1
	(d)			6.34 % × 425.62 = 27.0 shows b = 1 (1) 1.63 % × 425.62 = 6.94 so must be Li and only one present (1) therefore formula is $LiAlBr_4.4H_2O$ [allow ecf from earlier parts] (1)		1 1	 1	 3	1 1	
				Question 11 total	**1**	**4**	**5**	**10**	**6**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12.	(a)			award (1) for each **two** correct **A** copper(II) hydroxide / $Cu(OH)_2$ **B** ammonia / NH_3 (allow ammonium hydroxide) **C** $[Cu(NH_3)_4(H_2O)_2]^{2+}$ **D** copper(I) iodide / CuI **E** iodine / I_2 **F** $[CuCl_4]^{2-}$	3			3		3
	(b)			successive ionisation energies increase gradually / the energies of the *d*-orbitals are similar	1			1		
	(c)			Br_2 (1) MUST GIVE REASON TO GAIN THIS MARK bromate is reduced to bromide / bromate is a strong enough oxidising agent to oxidise VO^{2+} as it has a more positive E^{θ} value OR EMF = +0.44 V and this is positive so it is feasible (1) bromate is a strong enough oxidising agent to oxidise the bromide formed in the first step to Br_2 as it has a more positive E^{θ} value OR EMF = +0.35 V and this is positive so it is feasible (1)			1 1 1	3		
	(d)			reaction is first order (1) MUST SHOW WORKING TO GAIN THIS MARK convert any two or more pH values to $[H^+]$ (0.1000, 0.0398, 0.0158, 0.0063 mol dm^{-3} respectively) (1) show that the ratio of concentrations equals ratio of rates OR calculate rate ÷ $[H^+]$ for both concentrations and show it is the same (1)		1	1 1	3	1 1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)			award (1) for appropriate unit conversion (kJ mol^{-1} to J mol^{-1} or reverse for R) rearrangement of equation gives $A = k \div e^{-(79333/RT)}$ (1) $A = 1.864 \times 10^{13}$ (1) $k = 0.167$ (1)	1		 1 1 1	 4	 4	
	(f)			any **three** for (1) each • indicator colour may be difficult to see due to coloured compounds / the vanadium compounds change colour during titration • colour change of transition metals can be used in place of an indicator • for colorimetry find a wavelength OR frequency of light absorbed <u>only by the VO^{2+} / Ce^{4+}</u> • end point is when there is no absorbance at VO^{2+} frequency / <u>Ce^{4+}</u> remains in solution		2	1	3		3
				Question 12 total	**5**	**3**	**9**	**17**	**6**	**6**

UNIT 3: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	5	5	0	10	2	6
7.	4	2	1	7	1	3
8.	7	3	0	10	0	2
9.	0	10	5	15	4	0
10.	1	7	3	11	5	2
11.	1	4	5	10	6	7
12.	5	3	9	17	6	6
Totals	23	34	23	80	24	26