

GCE MARKING SCHEME

CHEMISTRY AS/Advanced

SUMMER 2014

GCE CHEMISTRY – CH5

SUMMER 2014 MARK SCHEME

SECTION A

Q.1	(a)	(i)	NH4 ⁺ (aq)	+ OH ⁻ (aq)	→ NH ₃ (aq) +	$H_2O(1)$	
			Acid 1 (1 mark for	Base 2 r each pair)	Base 1	Acid 2	[2]

(b) (i)

	$[\mathrm{NH_4}^+(\mathrm{aq})]/\mathrm{mol}\ \mathrm{dm}^{-3}$	$[NO_2^{-}(aq)]/mol dm^{-3}$	Initial rate/mol dm ⁻³ s ⁻¹
1	0.200	0.010	4.00×10^{-7}
2	0.100	0.010	$2.00 imes 10^{-7}$
3	0.200	0.030	1.20×10^{-6}
4	0.100	0.020	4.00×10^{-7}
	[3]		

(ii)
$$k = 4.00 \times 10^{-7} = 2.0 \times 10^{-4}$$
 (1)
 0.200×0.010 (1)
Units = mol⁻¹ dm³ s⁻¹ (1)

(iv) Increases

If temperature is increased rate increases (1)

and since concentrations do not change the rate constant must increase (or similar) (1) [2]

Total [10]

[2]

[1]

Q.2 (a)
$$K_w = [H^+][OH^-]$$
 (1)
Units = mol² dm⁻⁶ (1)
(1) [2]

(b) (i) In pure water
$$[H^+] = [OH^-] \text{ or } [H^+] = \sqrt{1.0 \times 10^{-14}}$$
 (1)
 $pH = -\log 10^{-7} = 7$ (1) [2]

(ii) Final volume of solution is 1000 cm³ so acid has been diluted by a factor of 100 so final concentration of acid is 0.001

or moles acid =
$$\frac{0.1 \times 10}{1000}$$
 = 0.001 (1)
pH = -log 0.001 = 3 (1) [2]

(c)
$$1.78 \times 10^{-5} = [H^+] \times 0.02 \\ 0.01$$
 (1)

$$[\mathrm{H}^+] = 8.90 \times 10^{-6} \tag{1}$$

$$pH = 5.05$$
 allow 5 or 5.1 (1) [3]

(d) The solution is a buffer (1)

Solution contains a large amount of CH_3COOH and CH_3COO^- ions

(Accept correct equations) (1)

When an acid is added, the CH_3COO^- ions react with the H^+ ions, removing them from solution and keeping the pH constant (1) [3]

Total [12]

Q.3	(a)	H : O : O : H		[1]			
	(b)	$20 \text{ dm}^3 \text{ oxygen} = 0.83 \text{ mol} \tag{1}$					
		Moles $H_2O_2 = 1.67$ and $[H_2O_2] = 1.67 \text{ mol dm}^{-3}$ (1)					
	(c)	 (i) Variable oxidation states / partially filled 3d energy leve adsorb 'molecules' / form complexes (or temporary bo reacting molecules (Accept any two answers) Do not accept 'empty / unfilled d-orbitals' 	•	[2]			
		(ii) 3d orbitals split by ligands (1)					
		Three d-orbitals have lower energy, two have higher en	ergy (1)				
		Electrons absorb (visible light) energy to jump from low higher level (1)	wer level to)			
		The colour is that due to the remaining / non-absorbed to (Appropriate diagrams are acceptable alternatives)	The colour is that due to the remaining / non-absorbed frequencies (Appropriate diagrams are acceptable alternatives)				
		<i>QWC Legibility of text; accuracy of spelling, punctuat grammar, clarity of meaning</i>	tion and	[1]			
	(d)	(i) $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$		[1]			
		(ii) $5H_2O_2 + 6H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 5O_2$	+ 8H ₂ O	[2]			
		(Mark consequentially from (i) – 1 mark if formulae co equation not balanced properly)	rrect but				
		(iii) Moles $MnO_4^- = 0.02 \times 14.8 = 2.96 \times 10^{-4}$ 1000	(1)				
		Moles $H_2O_2 = 7.40 \times 10^{-4}$	(1)				
		Concentration $H_2O_2 = \frac{7.40 \times 10^{-4}}{0.020} = 0.037 \text{ mol dm}^{-3}$	(1)	[3]			
	(e)	Oxidation state of oxygen starts at -1 (in peroxide)(1)Oxidation state in water is -2 (reduced) oxidation state in oxygen is 0 (oxidised)(1)					
			Total	[18]			

SECTION B

Q.4	(a)	(i)	Oxidising agent	[1]			
		(ii)	$A = lead(II) chloride / PbCl_2 $ (1) B = chlorine / Cl_2 (1)	[2]			
		(iii)	$[Pb(OH)_6]^{4-} / [Pb(OH)_4]^{2-} / Na_4[Pb(OH)_6]$ etc.	[1]			
		(iv)	Yellow	[1]			
		(v)	$PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$	[1]			
	(b)	(i)	Each C atom covalently bonded to three other C atoms forming laye (1)				
			Layers held together by weak intermolecular forces (1)				
			BN is isoelectronic with C so it forms similar structures (1)				
			Graphite conducts electricity since electrons are delocalised b each N has a full unbonded p-orbital and each B has an empty unbonded p-orbital so it does not conduct electricity (1	7			
			(Accept electrons are not delocalised in BN so it does not con electricity)	duct			
			<i>QWC The information is organised clearly and coherently, us specialist vocabulary where appropriate</i>	sing [1]			
		(ii)	Wear-resistant coatings/catalyst support/for mounting high po- electronic components / drills in industry / cutting instruments				
	(c)	(i)	$\Delta G = \Delta H - T \Delta S$ ($\Delta G = 0$ for reaction to be spontaneous)) (1)			
			$T = \underline{1.92} \\ 0.0067 $ (1)				
			T = 286.6 K (1)	[3]			
		(ii)	Changes in temperature (above or below 286.6 K) caused the change form making it unstable (and causing it to disintegrate				
				[1]			

(d)	(i)	(At the anode)	$H_2 \longrightarrow 2H^+ + 2e^-$	(1)
		(At the cathode)	$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$	(1)
		(Overall reaction)	$2H_2 + O_2 \longrightarrow 2H_2O$	(1)
				503

- [3]
- (ii) Hydrogen is difficult to store / takes up large volume / too flammable / explosive / produced from fossil fuels which leads to a net energy loss / Pt electrodes very expensive [1]

Total [20]

(a)	(i)						-	(1)
		Warm 30	$Cl_2 + 6NaOH$		5NaCl +	NaClO ₃ -	+ 3H ₂ O	(1)
								[2]
	(ii)	Dispropor	tionation					[1]
(b)	P can	promote 3s	electron to 3d	orbital	(1)		
	N can	not do this	since it is in the	e second	period / 3d or	bitals not a	vailable	(1) [2]
(c)	The te	erms involv	ed are: lattice b	reaking	enthalpy whic	h is endoth	ermic	(1)
	and h	ydration ent	halpy which is	exotherr	nic			(1)
	ΔH so	olution = ΔH	H lattice breakir	ng + ∆H	hydration (or	similar)		(1)
	If ∆H	solution is	negative then tl	he ionic	solid will be s	oluble		(1)
								[4]
	QWC							
						Ĩ		[1]
(d)	(i)	Fe^{3+}, Fe^{2+}	with less positi half-cell (1)	ve stand			ement)	[2]
	(ii)	$Pt(s) Fe^{2}$	⁺ (aq), Fe ³⁺ (aq)	$\ Ce^{4+}(a)$	g), $Ce^{3+}(ag) P$	rt (s)	(1)	
							(1)	[2]
(e)	(i)	-		-		(1)		
		No units		_		(1)		[2]
	(ii)	moles = <u>1</u>	$\frac{.25 \times 32.0}{1000} = 0.0$	04(0)				[1]
	(iii)	[CH ₃ COC	[OH] = 0.04, then	refore 0.0)6 used in rea	ction and		
		[CH ₃ COC	$OCH_3] = 0.06, []$	$H_2O] = ($).06 and			
		[CH ₃ OH]	= 0.083 - 0.06	= 0.023		(1)		
						(1)		[2]
	(iv)		K _c decreases sir	nce the e	quilibrium shi	fts to the le	eft /	F 1 3
		the forwar	rd reaction is ex	kothermi	-			[1]
	(b) (c) (d)	(ii) (b) $P can P can N can N can N can N can N can (c) The ta and h \Delta H so If \Delta H(c) QWC(d) (i)(i)(e) (i)(ii)(ii)$	Warm 3C (ii) Dispropor (b) P can (extend the P can promote 3s N cannot do this and (c) The terms involved and hydration ent Δ H solution = Δ H If Δ H solution is <i>QWC Selection</i> <i>complexity of sub</i> (d) (i) Iodide Only one Fe ³⁺ , Fe ²⁺ (2 nd mark (ii) Pt(s) Fe ² EMF = 1 (e) (i) K _c = [CH ₃ [CH ₃ COC [CH ₃ COC [CH ₃ COC [CH ₃ OH] K _c = 0.06 0.04 =	Warm $3Cl_2 + 6NaOH$ (ii) Disproportionation(b) P can (extend the normal octet o P can promote 3s electron to 3d N cannot do this since it is in the(c) The terms involved are: lattice b and hydration enthalpy which is ΔH solution = ΔH lattice breakin If ΔH solution is negative then t(d) (i) Iodide (1) Only one with less positi Fe^{3+}, Fe^{2+} half-cell (1) $(2^{nd} mark can be obtained)$ (ii) Pt(s) $ Fe^{2+}(aq), Fe^{3+}(aq) $ $EMF = 1.45 - 0.77 = 0$.(e) (i) K _c = [CH_3COOCH_3][H_2G [CH_3COOH][CH_3O] No units(ii) moles = $1.25 \times 32.0 = 0.4$ 1000 (iii) [CH_3COOH] = 0.04, the $[CH_3COOCH_3] = 0.06, [][CH_3OH] = 0.083 - 0.06$ $K_c = 0.06 \times 0.06 = 3.91$ 0.04×0.023	Warm $3Cl_2 + 6NaOH$ (ii) Disproportionation (b) P can (extend the normal octet of electron P can promote 3s electron to 3d orbital N cannot do this since it is in the second (c) The terms involved are: lattice breaking + and hydration enthalpy which is exothern ΔH solution = ΔH lattice breaking + ΔH If ΔH solution is negative then the ionic <i>QWC Selection of a form and style of w</i> <i>complexity of subject matter</i> (d) (i) Iodide (1) Only one with less positive stand Fe^{3^+} , Fe^{2^+} half-cell (1) (2^{nd} mark can be obtained from ca (ii) $Pt(s) Fe^{2^+}(aq), Fe^{3^+}(aq) Ce^{4^+}(aq) EMF = 1.45 - 0.77 = 0.68 V$ (c) (i) $K_c = [CH_3COOCH_3][H_2O]$ [CH_3COOH][CH_3OH] No units (ii) moles = $1.25 \times 32.0 = 0.04(0)$ (iii) [CH_3COOH] = 0.04, therefore 0.0 [CH_3COOCH_3] = 0.06, [H_2O] = (CH_3OH] = 0.083 - 0.06 = 0.023 $K_c = 0.06 \times 0.06 = 3.91$ 0.04×0.023	Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl +$ (ii) Disproportionation (b) P can (extend the normal octet of electrons) by using 3 P can promote 3s electron to 3d orbital (1 N cannot do this since it is in the second period / 3d or (c) The terms involved are: lattice breaking enthalpy which and hydration enthalpy which is exothermic ΔH solution = ΔH lattice breaking + ΔH hydration (order If ΔH solution is negative then the ionic solid will be s <i>QWC Selection of a form and style of writing appropriate complexity of subject matter</i> (d) (i) Iodide (1) Only one with less positive standard potential the F_{0}^{3+} , F_{0}^{2+} half-cell (1) (2^{nd} mark can be obtained from calculation value (ii) $Pt(s) F_{0}^{2+}(aq), F_{0}^{3+}(aq) C_{0}^{4+}(aq), C_{0}^{3+}(aq) F$ EMF = $1.45 - 0.77 = 0.68 V$ (e) (i) $K_{c} = [CH_{3}COOCH_{3}][H_{2}O]$ ICH_{3}COOH][CH_{3}OH] No units (ii) moles = $1.25 \times 32.0 = 0.04(0)$ (iii) [CH_{3}COOH] = 0.04 , therefore 0.06 used in reading [CH_{3}OOCH_{3}] = 0.06 , $[H_{2}O] = 0.06$ and ICH_{3}OOCH_{3}] = 0.06 , $[H_{2}O] = 0.06$ and ICH_{3}OH] = $0.083 - 0.06 = 0.023$ $K_{c} = 0.06 \times 0.06 = 3.91$ 0.04×0.023	Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 -$ (ii) Disproportionation (b) P can (extend the normal octet of electrons) by using 3d orbitals / P can promote 3s electron to 3d orbital (1) N cannot do this since it is in the second period / 3d orbitals not a (c) The terms involved are: lattice breaking enthalpy which is endoth and hydration enthalpy which is exothermic ΔH solution = ΔH lattice breaking + ΔH hydration (or similar) If ΔH solution is negative then the ionic solid will be soluble QWC Selection of a form and style of writing appropriate to pure complexity of subject matter (d) (i) Iodide (1) Only one with less positive standard potential than Fe^{3+} , Fe^{2+} half-cell (1) (2^{nd} mark can be obtained from calculation value and state (ii) Pt(s) $ Fe^{2+}(aq), Fe^{3+}(aq) Ce^{4+}(aq), Ce^{3+}(aq) Pt(s)$ EMF = 1.45 - 0.77 = 0.68 V (c) (i) $K_c = [CH_3COOCH_3][H_2O]$ (1) $[CH_3COOH][CH_3OH]$ No units (1) (ii) moles = $1.25 \times 32.0 = 0.04(0)$ (iii) [CH_3COOH] = 0.04, therefore 0.06 used in reaction and $[CH_3COOCH_3] = 0.06, [H_2O] = 0.06$ and $[CH_3OH] = 0.083 - 0.06 = 0.023$ (1) $K_c = 0.06 \times 0.06 = 3.91$ (1) 0.04×0.023	Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$ (ii) Disproportionation (b) P can (extend the normal octet of electrons) by using 3d orbitals / P can promote 3s electron to 3d orbital (1) N cannot do this since it is in the second period / 3d orbitals not available (c) The terms involved are: lattice breaking enthalpy which is endothermic and hydration enthalpy which is exothermic ΔH solution = ΔH lattice breaking + ΔH hydration (or similar) If ΔH solution is negative then the ionic solid will be soluble QWC Selection of a form and style of writing appropriate to purpose and complexity of subject matter (d) (i) Iodide (1) Only one with less positive standard potential than Fe^{3r} , Fe^{2r} half-cell (1) $(2^{nd}$ mark can be obtained from calculation value and statement) (ii) $Pt(s) \left[Fe^{2r}(aq), Fe^{3r}(aq) \right] \left[Ce^{4r}(aq), Ce^{3r}(aq)\right] Pt (s)$ (1) EMF = 1.45 - 0.77 = 0.68 V (1) (c) (i) $K_e = [CH_3COOCH_3[IH_2O]$ (1) $[CH_3COOH][CH_3OH]$ No units (1) (ii) moles = $1.25 \times 32.0 = 0.04(0)$ (iii) $CH_3COOH] = 0.04$, therefore 0.06 used in reaction and $[CH_3COOCH_3] = 0.06, [H_2O] = 0.06 and$ $[CH_3COOCH_3] = 0.06, [H_2O] = 0.06 and$ $[CH_3OH] = 0.083 - 0.06 = 0.023$ (1) $K_e = 0.06 \times 0.023$ (1) $K_e = 0.06 \times 0.023$ (1)

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