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Mark Scheme (Results)
January 2007

GCE

GCE Chemistry (6244/01)

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General Guidance on Marking

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, and for critical and imaginative thinking. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

Using the mark scheme

The mark scheme gives you:

- 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.

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.

/ 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.

[ ] words inside square brackets are instructions or guidance for examiners.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

CQ (consequential) 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.

There is space at the bottom of each page of this mark scheme for examiners to write their notes.

Note:
If a candidate has crossed out an answer and written new text, the crossed out work should be ignored. If the candidate has crossed out work, but written no new text, the crossed out work for that question or part question should be marked, as far as it is possible to do so.

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
1.	**IGNORE s.f. throughout this question**			
	(a) <u>Acid</u> Proton or H^+ donor Or forms H^+ or H_3O^+ **(1)** <u>Weak</u> dissociates to a **small** extent Or ionises to a **small** extent**(1)**	few molecules dissociate Or incomplete dissociation Or partial dissociation	"not fully dissociated" Or "not dissociated fully"	**(2 marks)**
	(b) $2HCOOH(aq) + Na_2CO_3(aq) \rightarrow 2HCOONa(aq) + CO_2(g) + H_2O(l)$ Or $HCOOH(aq) + Na_2CO_3(aq) \rightarrow HCOONa(aq) + NaHCO_3(aq)$ Species + balancing **(1)** State symbols **(1)** *Consequential on correct species*	… → $2HCOONa(aq) + H_2CO_3(aq)$ HCO_2H for the acid HCO_2Na or $HCOO^-Na^+$ for salt		**(2 marks)**

Notes:

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(c)	(i)	one acid: HCOOH Conjugate base: $HCOO^-$ **1 mark for both** other acid: H_3O^+ Conjugate base: H_2O **1 mark for both**	Correct acids and conjugate bases in either order *ACCEPT* HCO_2H and HCO_2^- *OR*  	H^+ for H_3O^+	**(2 marks)**
		(ii)	$(K_a) = \frac{[HCOO^-][H_3O^+]}{[HCOOH]}$ Must use square brackets	$[H^+]$ instead of $[H_3O^+]$ $[HCO_2^-]$ and $[HCO_2H]$		**(1 mark)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(iii) $[H^+]^2 = K_a \times [HCOOH]$ OR $K_a = \frac{[H^+]^2}{[HCOOH]}$ *OR* $[H^+]^2 = 1.60 \times 10^{-4} \times 0.100$ **(1)** $[H^+] = \sqrt{1.60 \times 10^{-4} \times 0.100}$ $= 4.0 \times 10^{-3} (mol\ dm^{-3})$ **(1)** IGNORE sig figs **Max 1 if** $[H^+]^2$ expression incorrect $pH = -\log_{10}[H^+]$ $pH = 2.40$ **(1)** Alternative method $pKa = 3.80$ **(1)** $pH = \frac{1}{2} pKa - \frac{1}{2} \log[acid]$ **(1)** $pH = 1.90 - (-0.50)$ $pH = 2.40$ **(1)**	Any correct expression with $[H^+]^2$ or correct numbers If $[H^+] = \sqrt{(K_a \times c)}$ quoted Scores first two marks pH = 4.8 scores **(2)** as square root has not been taken any *pH* value consequential on $[H^+]$, provided $pH < 7$	pH = 2.39 (is a rounding error) so no third mark pH = 2.39 (is a rounding error) so no third mark	**(3 marks)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(d) (i) $[H^+] = Ka \times \frac{[acid]}{[salt]}$ *OR* $[H^+] = 1.60 \times 10^{-4} \times \frac{0.0500}{0.200}$ **(1)** $= 4.00 \times 10^{-5} (mol\ dm^{-3})$ **(1)** $pH = 4.40$ **(1)** IGNORE sig figs OR $pH = pKa - \log_{10}\left\{\frac{[HCOOH]}{[HCOO^-]}\right\}$ **(1)** $pH = -\log_{10}(1.60 \times 10^{-4}) - \log_{10}\left\{\frac{0.0500}{0.200}\right\}$ **(1)** $pH = 3.80 - (-0.60)$ $pH = 4.40$ **(1)** IGNORE sig figs		$\frac{0.100}{0.400}$ 4.39 (rounding error) so no third mark $\frac{0.100}{0.400}$ 4.39 (rounding error) so no third mark	**(3 marks)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(ii) Addition of H^+ ions: $HCOO^- + H^+ \rightarrow HCOOH$ **(1)** Addition of OH^- ions: $HCOOH + OH^- \rightarrow HCOO^- + H_2O$ **(1)** If the ionisation of sodium methanoate shown with ⇌ then **max (1)** out of 2 for above equations (buffer solution has) high concentrations Or a large reservoir of **both** $HCOOH$ **and** $HCOO^-$ relative to added H^+ / OH^- **(1)** (hence virtually no change in $[H^+]$)	If described in terms of $HA \rightleftharpoons H^+ + A^-$ shifting to left Addition of OH^- ions: $H^+ + OH^- \rightarrow H_2O$ **must be** followed by more dissociation of $HCOOH$ (to restore $[H^+]$) "molecular" equations or equations described in words or notation involving HA, H^+ and A^- . Just "large reservoir of both HCOOH and $HCOO^-$"		**(3 marks)**
				Total 16 Marks

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
2 (a)	**IGNORE s.f. throughout this question**			
(i)	**moles SO_2** (10.0 – 9.00) = 1.00 (mol) **moles O_2** (5.00 – 4.50) = 0.500 (mol) **moles SO_3** 9.00 (mol) all 3 correct → **(2)** 2 correct → **(1)**		Multiples of the stated moles	**(2 marks)**
(ii)	All three ÷ total number of moles **(1)** i.e. $X_{SO_2} = \frac{1.00}{10.5} (= 0.0952)$ or $^2/_{21}$ $X_{O_2} = \frac{0.500}{10.5} (= 0.0476)$ or $^1/_{21}$ $X_{SO_3} = \frac{9.00}{10.5} (= 0.857)$ or $^{18}/_{21}$ or $^6/_7$ *Mark consequential on (a)(i)*		Rounding to 1 sig fig	**(1 mark)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(iii) All three × total pressure **(1)** i.e. $pSO_2 = \frac{1.00}{10.5} \times 2.00$ or $^4/_{21}$ $= 0.190(atm)$ $pO_2 = \frac{0.500}{10.5} \times 2.00$ or $^2/_{21}$ $= 0.0952(atm)$ $pSO_3 = \frac{9.00}{10.5} \times 2.00$ or $^{36}/_{21}$ or $^{12}/_7$ $= 1.71(atm)$ *Mark consequential on (a)(ii)*			**(1 mark)**
	(iv) $K_p = \frac{(1.71)^2}{(0.190)^2 \times (0.0952)}$ $K_p = 851$ **(1)** atm^{-1} **(1)** *Mark consequential on (a)(iii) and (a)(iv)*	Answer with units and no working (2) "Correct answers" between 845 and 855 as this covers rounding up etc	Wrong units e.g. $mol^{-1}\ dm^3$	**(2 marks)**

Notes:

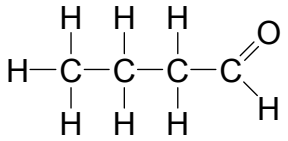
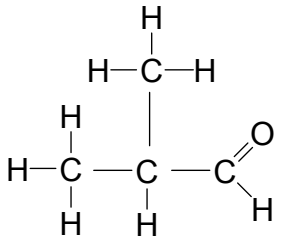
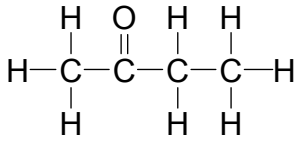
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(b)	(i)	(K_p) decreases			**(1 mark)**
		(ii)	(K_p decreases so) $fraction / quotient \frac{p^2SO_3}{p^2SO_2 \times pO_2}$ has to decrease (to equal new k_p) **(1)** so shifts to **left** hand side **(1) –** this mark only available if (b)(i) answer was k_p decreases. (as p_{SO_3} decreases whereas p_{SO_2} and p_{O_2} increase)		Any Le Chatelier argument (this prevents access to 1st mark) Shifts to right, **even if** answer to (b)(i) was k_p increases	**(2 marks)**

NOTES:

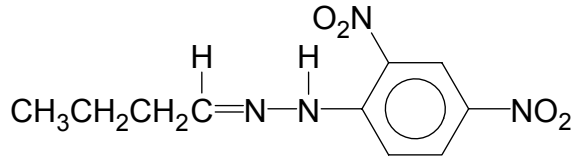
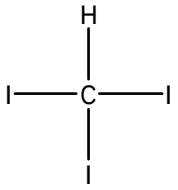
	EXPECTED ANSWER	ACCEPT	REJECT	MARK

	(c)	(i)	No effect/none/zero (effect)			**(1 mark)**
		(ii)	Increases *OR* more SO_3/more sulphur trioxide *OR* increases amount of SO_3/sulphur trioxide			**(1 mark)**
	(d)	(i)	No effect/none/zero (effect)			**(1 mark)**
		(ii)	No effect/none/zero (effect)			**(1mark)**
						Total 13 marks

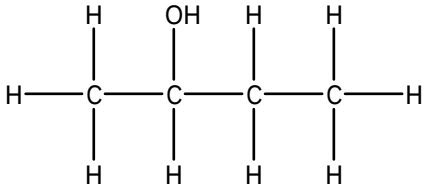
Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
3 (a)	**Compound A**  *OR* a branched chain isomer  **(1)** **Compound B**  **(1)** *Penalise "compressed" formula once only* e.g. $CH_3CH_2CH_2CHO$ $CH_3COCH_2CH_3$		-CH_3 as side chain -COH for aldehyde	**(2 marks)**
				(2 marks)

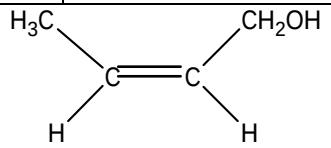
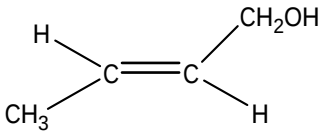
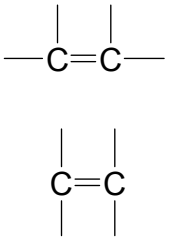
Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(b)   linkage **(1)** Remainder of the molecule **(1)** *Mark consequential on structure given for Compound A in (a).*	C_3H_7 OR $C_2H_5CH_2$ for $CH_3CH_2CH_2$ CH=N NO_2 groups in wrong position for remainder of molecule mark	Lack of circle in benzene ring for second mark	**(2 marks)**
	(c) (i) triiodomethane **(1)** CHI_3 or  **(1)**	Iodoform Or "triodomethane"	CH_3I	**(2 marks)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(ii) butan(-)2(-)ol *IGNORE punctuation* $CH_3CH(OH)C_2H_5$ or  *Only penalise if bond is clearly shown pointing to H ie* O H | is OK OH | is wrong	2(-)butanol Or iso-butanol Or butane-2-ol	But-2-ol 2-hydroxybutane	**(1)** **(1)**
				(2 marks)
(d)	(i) (It is not) superimposable on its mirror image OWTTE *Or* Does not have a plane of symmetry Or does not have a centre of symmetry **(1)**		Just "four different groups on the same molecule" OR Just " (has an) asymmetric C atom"	**(1 mark)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(ii) **Rotate** (the) plane (of plane) **polarised** (monochromatic) light (equally) in **opposite directions (1)** *OR* pass polarised light through sample OR use a polarimeter **rotates** the plane (equally) in **opposite directions (1)**			**(1 mark)**
(e)	 and  1 mark for each 2nd isomer cq if first isomer is carboxylic acid	90 ° formula e.g.  cis and trans acid scores **(1)** consequentially		**(1)** **(2 marks)**
				Total 12 marks

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
4 (a) (i)	½Br_2 → Br **(1)** state symbols **(1)** ½ Br_2(g) → Br(g) scores only one e.g. ½Br_2(l)→ Br(g) **(2)** Br_2(l)→ 2Br(g) **(1)** ie for state symbols Br_2→ Br **(0)**		Wrong halogen or use of "X" **(0)**	**(2 marks)**
(ii)	Energy change when **1 mol (1)** of a solid/crystal/lattice **(1)** is formed from its (isolated) gaseous ions **(1)** IGNORE standard states	Heat or enthalpy for energy; energy released instead of energy change Just balanced equation e.g. Na^+(g) + Cl^-(g) → NaCl(s) can score only last two marks	"energy required"	**(3 marks)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK

	(b)	(i)	$\Delta H_f = \Delta H_a[Mg] + IE_1[Mg] + IE_2[Mg] + 2\Delta H_a$ [chlorine]+ 2EA[Cl] + LE[$MgCl_2$] Or this in words Or 2EA = –(2× +122) –(+1450) –(+736) – (+150) + (–642) – (–2526) **(1)** $= -696(kJ \quad mol^{-1})$ **(1)** cq on first mark $EA = \frac{-696}{2}$ $= -348(kJ \quad mol^{-1})$ **(1)** must ÷2 [some likely outcomes – but working must be shown] -348 **scores (3)** -696 or -287 or (+) 348 **scores (2)** -574 or (+) 696 or (+) 287 **scores (1)** (+) 574 **scores (0)**			**(3 marks)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(ii) $MgCl_2$ has (a degree of) covalent character **(1)** due to polarisation of the anion **(1)** (by Mg^{2+} cation)		Mention of "atoms" or "molecules" scores **(0)** for all of (b)(ii) Just "Mg^{2+} (strongly) polarising"	**(2 marks)**
(c)	As group descended, radius of M^{2+} (ion) increases OR cation increases **(1)** Charge on ions remains the same/2+ **(1)** (down group) weaker forces of **attraction** between **ions (1)**	Reverse arguments "size" instead of "radius" Correct formulae of cation**s** for charge mark "charge density decreases" scores one of the first two marks	Mention **specifically** of atoms (e.g. Mg atoms) or molecules ($MgCl_2$ molecules) scores **(0)** for all of part (c) "weaker bonds" OR "weaker bonding"	**(3 marks)**
				Total 13 marks

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
5 (a)	<table><tr><td>Na</td><td>Mg</td><td>Al</td><td>Si</td><td>P</td></tr><tr><td>NaCl</td><td>$MgCl_2$</td><td>$AlCl_3$ *OR* Al_2Cl_6</td><td></td><td>PCl_3 *OR* PCl_5</td></tr></table> All 4 → **(2)** 3 → **(1)** None, one or two correct **(0)**	PCl_4^+, PCl_6^-		**(2 marks)**
(b) (i)	$NaCl(s) + aq \rightarrow Na^+(aq) + Cl^-(aq)$ Or $NaCl(s) + H_2O(l) \rightarrow Na^+(aq) + Cl^-(aq)$ **(1)** $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ *OR* $PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$ *OR* $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ **(1)**		$NaCl(s) + H_2O(l) \rightarrow$ $NaOH(aq) + HCl\ (aq)$	**(2 marks)**
(ii)	**NaCl: Ionic** (so) dissolves (in water) **(1) –** *both needed* **PCl_x: Covalent** (so) reacts (in water) OR hydrolyses (in water) **(1) –** *both needed*			**(2 marks)**

Notes:

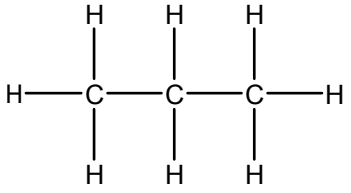
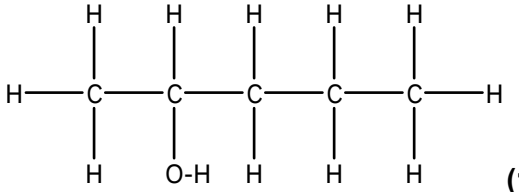
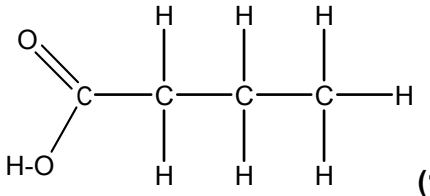
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(c)	$SiCl_4$ reacts/hydrolyses, CCl_4 does not **(1)** [This must be clearly stated and not just implied] (lone) pair of electrons (from the oxygen atom) in a water molecule **(1)** cannot form a bond with/be donated to the C atom Or cannot be accepted by C atom **(1)** because C has no available orbital *OR* no **2d** orbitals in C *OR* C is a small atom surrounded by Cl atoms *OR* Cl atoms are large and surround C atom (so attack is sterically hindered) **(1)** Si has (available) **3*d*** orbital(s) **(1)**			"lone pair" for "(lone) pair of electrons" reverse argument for Si atom	CCl_4 has no d orbitals [see below] Or "CCl_4 has no 2d orbital(s)" Just "C has no d-orbital(s)" $SiCl_4$ has available 3d orbitals (but penalise this only once)	**(5 marks)**
	(d)	(i)	$PbO_2 + 4HCl \rightarrow PbCl_2 + 2H_2O + Cl_2$ Species **and** balancing **(1)**	Multiples		**(1 mark)**
		(ii)	+2 (oxidation state) becomes more stable down the group relative to +4 *MUST have comparison of +2 and +4 oxidation states*	Relative stabilities of Pb and Si oxidation states		**(1 mark)**
						Total 13 marks

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK

6	(a)	(i)	Eth<u>a</u>nenitrile OR Methyl cyanide OR ethanitrile OR ethanonitrile IGNORE any formula	phonetic spelling e.g. ethanenitrille	Eth<u>e</u>nenitrile	**(1 mark)**
		(ii)	(Acid) hydrolysis IGNORE word “acid” before hydrolysis	phonetic spelling e.g. hydrolisis		**(1 mark)**
		(iii)	Step 1: any named mineral acid (eg. hydrochloric acid) or formula Step 2: PCl_5 / $SOCl_2$	Using a named alkali or formula , <u>then</u> acidify Just “HCl” or “H_2SO_4” PCl_3	**Conc** H_2SO_4 Cl_2	**(2 marks)**
		(iv)	$CH_3COCl + CH_3NH_2 \rightarrow CH_3CONHCH_3 + HCl$ *OR* $CH_3COCl + 2CH_3NH_2 \rightarrow CH_3CONHCH_3 + CH_3NH_3Cl$ **(1)**			**(1 mark)**

Notes:

	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(b) **L**:  **(1)**			
	M:  **(1)** Only penalise if bond is clearly shown pointing to H atom	Allow OH		
	N:  **(1)** Penalise omissions of H atoms once only If $-CH_3$, $-CH_2$ are used **max (2)**	Allow OH	– COOH Or $-CO_2H$	**(3 marks)**
				Total 8 marks

Notes: