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Mark Scheme (Results)
Summer 2007

GCE

GCE Chemistry (6244) Paper 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.

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

Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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.

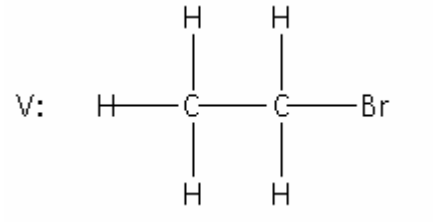
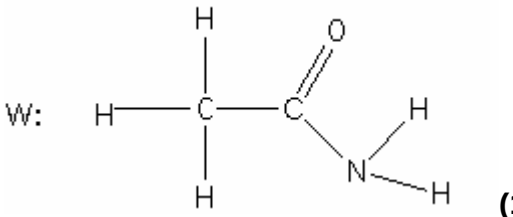
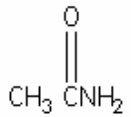
1 / means that the responses are alternatives and either answer should receive full credit.
2 ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
3 [ ] words inside square brackets are instructions or guidance for examiners.
4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
5 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.

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
1.	(a)	(i)	$Mg^{2+}(g)$ (+) $O^{2-}(g)$		if state symbols missing If $2e^-$ included in box	**(1)**
		(ii)	ΔH_1 (Enthalpy of) formation (of MgO) **(1)** ΔH_2 (Enthalpy of) atomisation (of Mg) **(1)** ΔH_3 1st plus 2nd electron affinity (of O) OR 1st and 2nd electron affinity (of O) **(1)**	Recognisable abbreviation such as "EA" for electron affinity.		**(3)**
		(iii)	$\Delta H_f = -602 = (+150) + (+2186) + (+249) + (+657) + LE$ OR (LE =) -(+657)-(+249)-(+2186)-(+150)+(-602)**(1)** (LE =) -3844 (kJ mol^{-1}) **(1)** Correct answer only with no working **(1 max)**		Doubling electron affinity and/or atomisation values scores **(0)** any incorrect sign in algebraic expression **(0)**	**(2)**

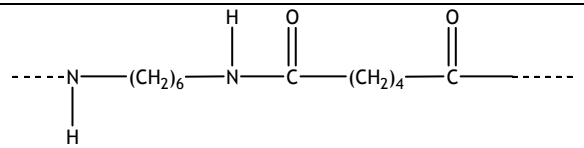
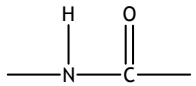
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(b)	(i)	The electrons around the iodide ion are drawn towards the magnesium ion	(Mg^{2+}) polarises (I^- ion) "distortion" if clearly linked to the iodide ion "Mg **ion**" "I **ion**" OR "iodine **ion**"	Any reference to atoms or molecules e.g. "Mg polarises….." "iodine/I/I_2 is polarised" Wrong polarisation e.g. "magnesium ion is polarised" "I^- polarises Mg^{2+}"	**(1)**
		(ii)	Radius/size (of ions) **(1)** charge (on ions) **(1)**	Distance between ions OR Sum of (ionic) radii OR Type of crystal structure OR Madelung constant "Charge density"	"**atomic** radius"	**(2)**
		(iii)	Less (exothermic) **(1)** covalent character (strengthens lattice) **(1)** Mark each aspect independently	Smaller OR more endothermic OR Less negative OR Lower Theoretical value based on purely/100 % ionic model	Higher/greater Any implication of magnesium iodide being **totally** covalent	**(2)**

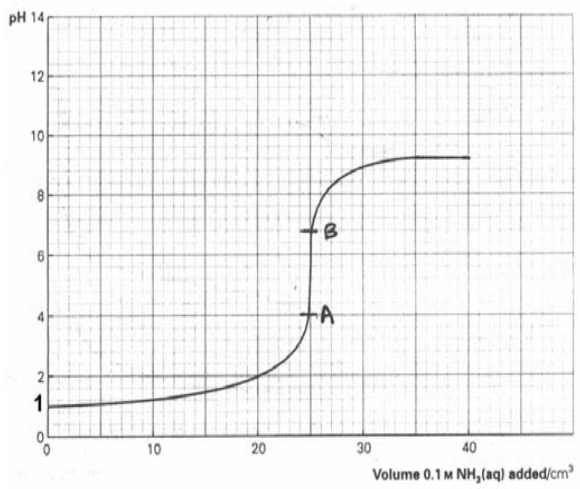
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(c)	(i)	Enthalpy change when 1 mol of gaseous ions **(1)** is dissolved such that further dilution causes no further heat change **(1)** IGNORE "standard conditions" **Mark each aspect independently**	Energy or heat "Added to water"/"reacts with water" instead of "dissolved" Is dissolved to form an infinitely dilute solution OR Is dissolved in a large/excess/infinite amount of water	Any implication of an endothermic process e.g. energy required "….1 mol of gaseous **atoms**" Just "hydrated" Just "completely hydrated"	**(2)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
		(ii)	**EITHER** $\Delta H_{SOLN} = (-\Delta H_{LE} + \Delta H_{HYD})$ **(1)** Expression quoted or correctly used in at least one of the calculations below $\Delta H_{SOLN}\ MgSO_4 = -(-2874) + (-1920)$ $= +954 (kJ\ mol^{-1})$ **(1)** $\Delta H_{SOLN}\ BaSO_4 = -(-2374) + (-1360)$ $= +1014 (kJ\ mol^{-1})$ **(1)** Enthalpy of solution of $MgSO_4$ less endothermic/more exothermic/more negative than for $BaSO_4$, so $MgSO_4$ more soluble than $BaSO_4$ (or reverse argument) **(1)** **OR** (both) lattice energies **and** hydration enthalpies decrease from $MgSO_4$ to $BaSO_4$ (or down group) **(1)** (but) lattice energies change less **(1)** $\Delta H_{SOLN} = (-\Delta H_{LE} + \Delta H_{HYD})$ **(1)** stated in words or symbols so ΔH_{soln} less exothermic/more endothermic/more positive for $BaSO_4$ so less soluble OR so ΔH_{soln} more exothermic/more negative/less endothermic for $MgSO_4$ so $MgSO_4$ more soluble **(1)**	Answer only with no working **(1)** Answer only with no working **(1)** "The hydration energies decrease faster….."	**Just** "solubility/ΔH_{soln} depends on a balance between lattice and hydration energies" (-)500 and (-)560 stated without further explanation **Just** "solubility/$\Delta H_{solution}$ depends on a balance between lattice and hydration energies"	**(4)**
						(Total 17 marks)

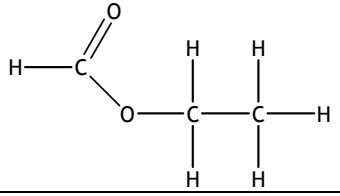
	EXPECTED ANSWER	ACCEPT	REJECT	MARK
2.	(a) V:  **(1)**		Any compressed formulae e.g. C_2H_5Br OR CH_3CH_2Br	**(2)**
	W:  **(1)**		Any compressed formulae e.g. CH_3CONH_2 OR 	

	EXPECTED ANSWER		ACCEPT	REJECT	MARK
	(b)	**Accept names or formulae, but ignore correct or incorrect conditions** **Step A**: NH_3 **(1)** Ignore state or dilution or solvent for ammonia **Step B**: $K_2Cr_2O_7$ **(1)** and H_2SO_4 **(1)** N.B. only award the acid/H_2SO_4 mark if a correct (or a near-miss) oxidising agent given **Step C**: PCl_5 OR $SOCl_2$ OR PCl_3 **(1)** **Step D**: P_2O_5 OR P_4O_{10} **(1)** **Step E**: $LiAlH_4$ **(1)**	"Hydrochloric acid"/"HCl" instead of "H_2SO_4" $Cr_2O_7^{2-}$ and H^+ **(2)** OR CrO_4^{2-} and H^+ **(2)** OR Acidified dichromate **ions (2)** OR Acidified $K_2Cr_2O_7$ **(2)** OR acidified dichromate((VI)) **(1)** OR $KMnO_4$ **(1)** and **H_2SO_4 (1)** OR alkaline $KMnO_4$ **(1)** **then** acidify (accept any acid) **(1)** C_2H_5OH **and** Na OR H_2 and Ni /Pt/Pd (catalyst) OR Lithal	Incorrect oxidation number for dichromate**(VI)** CrO_4^{2-} alone **(0)** Hydrochloric acid/HCl with $KMnO_4$ **(0)** Incorrect oxidation number for manganate**(VII)** $NaBH_4$ **(0)**	**(6)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(c)	(i)	(substituted) amide OR (N-substituted) amide OR secondary amide OR 2° amide		Polyamide amine	**(1)**
		(ii)	 peptide link  **(1)** Rest of molecule and continuation bonds **(1)** 2nd mark is CQ on a polyamide being drawn		$-CONH$	**(2)**
	(d)	**Loss of smell:** $CH_3CH_2NH_2 + H^+ \rightarrow CH_3CH_2NH_3^+$ **(1)** **Return of smell:** $CH_3CH_2NH_3^+ + OH^- \rightarrow CH_3CH_2NH_2 + H_2O$ OR $CH_3CH_2NH_3Cl + NaOH \rightarrow CH_3CH_2NH_2 + H_2O + NaCl$ **(1)**		HCl as a reactant and $CH_3CH_2NH_3^+Cl^-$ as product (charges are not required). $CH_3CH_2NH_3^+ + NaOH \rightarrow$ $CH_3CH_2NH_2 + H_2O + Na^+$ **(1)**		**(2)**
						(Total 13 marks)

	EXPECTED ANSWER		ACCEPT	REJECT	MARK
3.	(a)	 Do not worry about general shape of the curve, the scoring points are: • Starting pH ~ 1 **and** finishing pH between 9 and 11 **(1)** • Vertical at 25 cm^3 **(1)** • Vertical range: at least three pH units in the range 3 to 8 e.g. pH range 3 to 6 OR 3 to 7 OR 3 to 8 OR 4 to 7 OR 4 to 8 OR 5 to 8 **(1)** (do not need to start/finish on whole numbers) • Middle of vertical pH range between 4 and 6 **(1)**		pH range 3 to 5	**(4)**

	EXPECTED ANSWER		ACCEPT	REJECT	MARK
	(b)	Bromocresol green Indicator(s) CQ on graph [check table on question paper]	More than one indicator for extended vertical regions		**(1)**
	(c)	pH change around equivalence point too small OR pH changes over too big a volume **(1)**	Too small a vertical (region) OR no vertical (region) OR no point of inflexion OR no sudden change in pH OR no straight section		
		for a sharp colour change of indicator **(1)** [If say ammonia is a strong base or ethanoic acid is a strong acid, or both, **(0 out of 2)**]	No sharp/clear/precise end point OR very small range over which indicator changes colour	No suitable indicator OR No "easy" colour change	**(2)**
					(Total 7 marks)

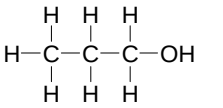
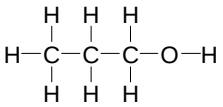
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
4.	(a)					**(1)**
	(b)	ester				**(1)**
	(c)	(i)	Moles: C_2H_5OH: 3.75 **(1)** Moles: $HCOOC_2H_5$: 2.50 and moles H_2O : 2.50 **(1) for both**			**(2)**
		(ii)	$K_c = \frac{[HCOOC_2H_5][H_2O]}{[HCOOH][C_2H_5OH]}$		Obviously round brackets **"( )"**	**(1)**
		(iii)	$K_c = \frac{2.50/0.485 \times 2.50/0.485}{0.50/0.485 \times 3.75/0.485}$ **(1)** Must have clearly divided moles of each component by 0.485 for 1st mark e.g. $[HCOOC_2H_5] = [H_2O] = 5.16$ (mol dm^{-3}) and $[HCOOH] = 1.03$ (mol dm^{-3}) and $[C_2H_5OH] = 7.73$ (mol dm^{-3}) = 3.33 **(1) stand alone mark** IGNORE sig.figs.	$K_c = \frac{(2.50)^2}{0.50 \times 3.75} = 3.33$ only scores **(2)** if it is stated that V cancels either here or in (iv) If $[H_2O]$ omitted in (ii), then answer $K_c = 0.647$ $mol^{-1}dm^3$ **(2)** but this will give $K_c = 1.33$ $mol^{-1}dm^3$ with V omitted from calculation **(1)**	1st mark if 485 used as V in expression	**(2)**
		(iv)	No, (as) equal numbers of moles on both sides OR volumes cancel OR mol dm^{-3} cancel OR units cancel OR crossing out units to show they cancel	"equal powers/moles on both sides" OR " powers cancel" Mark CQ on K_c expression in (ii)	"concentrations cancel"	**(1)**

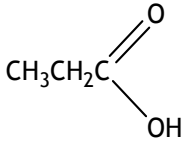
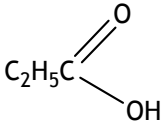
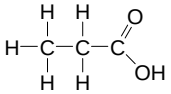
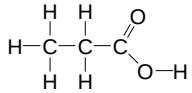
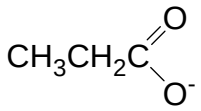
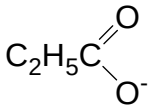
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(d)	(i)	(as reaction) endothermic **(1)** K_c decreases **(1)** numerator in quotient (has to) decrease OR denominator in quotient (has to) increase OR fraction (has to) decrease **(1)** yield of $HCOOC_2H_5$ decreases **(1)**	Exothermic in backward direction (or words to that effect) If state exothermic in forward direction, **1 mark only (out of 4)** for CQ "increase in K_c"		**(4)**
		(ii)	no effect as catalysts do not affect (the value of) K OR no effect as catalysts do not affect the position of equilibrium OR no effect as catalysts do not affect the yield OR No effect as catalysts increase the rate of the forward and backward reactions equally/to the same extent OR no effect as catalysts **only** increase the rate OR no effect as catalysts **only** alter the rate "no effect" can be stated or implied IGNORE any references to activation energy		Just "catalysts increase rate"	**(1)**
						(Total 13 marks)

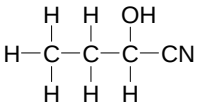
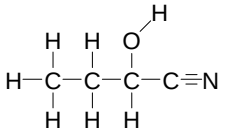
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
5.	IGNORE state symbols throughout this question.					
	(a)	(i)	$Na_2O + H_2O \rightarrow 2NaOH$	$.. \rightarrow 2Na^+OH^-$ OR $.. \rightarrow 2Na^+ + 2OH^-$ Multiples e.g. $2Na_2O + 2H_2O \rightarrow 4NaOH$		**(1)**
		(ii)	ionic	Giant ionic OR electrovalent		**(1)**
	(b)	(i)	$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ OR $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$	Multiples		**(1)**
		(ii)	covalent	'molecular covalent' 'simple covalent'	'co**n**valent' OR 'giant covalent' OR dative covalent	**(1)**
	(c)	**basic** (oxides) to **acidic** (oxides) **(1) both words needed** IGNORE references to Al_2O_3 IGNORE references to amphoteric character of Al_2O_3 metallic character (of the elements) decreases **(1)** IGNORE "across group" if used instead of "across period"		 metal to non-metal	The **elements** change from basic to acidic	**(2)**

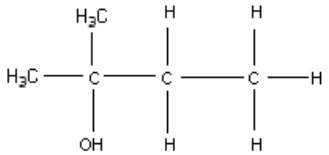
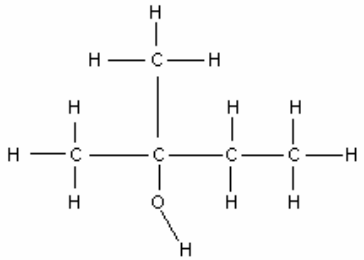
	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(d)	(i)	$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$ OR $CO_2 + 2H_2O \rightleftharpoons H_3O^+ + HCO_3^-$	$CO_2 + H_2O \rightleftharpoons 2H^+ + CO_3^{2-}$ OR $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ OR $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$ "$\rightarrow$" instead of "$\rightleftharpoons$"	JUST $CO_2 + H_2O \rightleftharpoons H_2CO_3$	**(1)**
		(ii)	$PbO + 2H^+ \rightarrow Pb^{2+} + H_2O$ OR $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$ **(1)** $PbO + 2OH^- + H_2O \rightarrow Pb(OH)_4^{2-}$ OR $PbO + 2NaOH + H_2O \rightarrow Na_2Pb(OH)_4$ OR $PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$ **(1)**	formation of $Pb(OH)_6^{4-}$ OR $Na_4Pb(OH)_6$	PbO with other acids Any equations with PbO_2	**(2)**

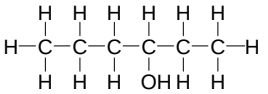
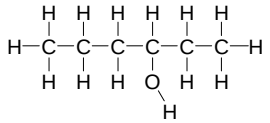
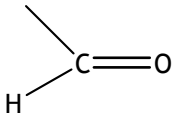
	EXPECTED ANSWER	ACCEPT	REJECT	MARK
	(e) Increases as **EITHER** **oxides** acidic at the top of the group **(1)** amphoteric at bottom of group **(1)** [amphoteric must be stated for the 2nd mark] **OR** **atoms** become larger **(1)** (so) more easily lose electrons OR have lower ionisation energies OR more easily form positive ions (in compounds) **(1)** [allow 2nd mark even if no specific reference has been made to atoms] [N.B. Marking cannot allow points taken from **both** the EITHER and OR arguments together]	Oxides more basic down group **1 (out of 2)** OR oxides less acidic down group **1 (out of 2)** **atoms** have more shielding/shells/energy levels OR "(outer) electrons further from nucleus" [no need to refer to atoms in **this** case]	Just "increases" on its own **(0)** OR "increases" followed by incorrect justification **(0)** Just "more electrons" OR "the elements become larger"	**(2)**
				(Total 11 marks)

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
6.	(a)	(i)	$CH_3CH_2CH_2OH$ **(1)** Reduction OR nucleophilic addition **(1)** IGNORE heterolytic	$C_2H_5CH_2OH$ OR full structural formula e.g.  OR  Redox "Nucleophilic reduction"	C_3H_7OH	**(2)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
		(ii)	 **(1)** oxidation OR redox **(1)**	 OR CH_3CH_2COOH OR $CH_3CH_2CO_2H$ OR C_2H_5COOH OR $C_2H_5CO_2H$ C_2H_5 instead of CH_3CH_2 OR full structural formula e.g.  OR  "oxidisation"	 OR 	**(2)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
		(iii)	$CH_3CH_2CH(OH)C \equiv N$ **(1)** nucleophilic addition **(1) both words needed** IGNORE "heterolytic"	$C_2H_5CH(OH)CN$ OR $CH_3CH_2CH(OH)CN$ OR full structural formula e.g.  OR 		**(2)**
	(b)	(i)	$Mg + C_2H_5Br \rightarrow C_2H_5MgBr$ IGNORE charges		C_2H_5BrMg C_2H_5MgI	**(1)**
		(ii)	Dry ethoxyethane OR dry ether IGNORE references to I_2 OR heat			**(1)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
	(c)	(i)	**<u>With propanone:</u>** **Structure**: $(CH_3)_2C(OH)CH_2CH_3$ **(1)** **Name:** 2-methylbutan-2-ol OR 2-hydroxy-2-methylbutane **(1)** IGNORE punctuation	C_2H_5 in lieu of CH_2CH_3 OR the full structural formula e.g.  OR  CQ structure provided it is a tertiary alcohol CQ name provided that it is a tertiary alcohol	$C_5H_{11}OH$	**(2)**

	EXPECTED ANSWER			ACCEPT	REJECT	MARK
			<u>With butanal:</u> **Structure**: $CH_3CH_2CH_2CH(OH)CH_2CH_3$ **(1)** **Name:** hexan-3-ol **(1)**	the full structural formula e.g.  OR  CQ structure provided it is a secondary alcohol hexane-3-ol CQ name provided that it is a secondary alcohol	$C_6H_{13}OH$	**(2)**
		(ii)	 (group in butanal) is planar **(1)** attacked (with equal probability) from two directions **(1)** **Mark each aspect independently unless reference made to carbocations etc**		Butanal/the molecule/it is planar OR Butanal/the molecule/it is linear References to carbocations OR carbonium ions OR Planar intermediates OR S_N1 mechanisms scores **(0 out of 2)**	**(2)**
						(Total 14 marks)