SCOTTISH QUALIFICATIONS AUTHORITY

2004 Chemistry

Advanced Higher

Finalised Marking Instructions

Advanced Higher Chemistry

General information for markers

The general comments given below should be considered during all marking.

1 Marks should **not** be deducted for incorrect spelling or loose language as long as the meaning of the word(s) is conveyed.

Example: Answers like 'distiling' (for 'distillation') and 'it gets hotter' (for 'the temperature rises') should be accepted.

2 A right answer followed by a wrong answer should be treated as a cancelling error and no marks should be given.

Example: What is the colour of universal indicator in acid solution?

The answer 'red, blue' gains no marks.

3 If a right answer is followed by additional information which does not conflict, the additional information should be ignored, whether correct or not.

Example: Why can the tube not be made of copper?

If the correct answer is related to a low melting point, and the candidate's answer is 'It has a low melting point and is coloured grey' this would **not** be treated as a cancelling error.

4 Full marks should be awarded for the correct answer to a calculation on its own whether or not the various steps are shown **unless the question is structured or working is specifically asked for.**

5 A mark should be deducted in a calculation for each arithmetic slip **unless stated otherwise in the marking scheme.** No marks should be deducted for incorrect or missing units at intermediate stages in a calculation.

6 A mark should be deducted for incorrect or missing units **unless stated otherwise in the marking scheme**. Please note, for example, that KJ mol^{-1} is not acceptable for kJ mol^{-1} and a mark should be deducted.

7 Where a wrong numerical answer (already penalised) is carried forward to another step, no further penalty is incurred provided the result is used correctly.

8 No mark is given for the solution of an equation which is based on a wrong principle.

Example: Use the information in the table to calculate the standard entropy change for the reaction:

$$C_2H_2 + 2HCl \longrightarrow CH_2ClCH_2Cl$$

Compound	**S^o/J K^{-1} mol^{-1}**
C_2H_2	201
HCl	187
CH_2ClCH_2Cl	208

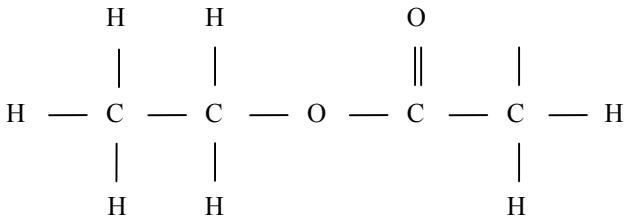
Using $\Delta S^o = S^o_{\text{reactions}} - S^o_{\text{products}}$ would gain zero marks.

9 No marks are given for the description of the wrong experiment.

10 Full marks should be given for correct information conveyed by a sketch or diagram in place of a written description or explanation.

11 In a structural formula, if one hydrogen atom is missing but the bond is shown, no marks are deducted.

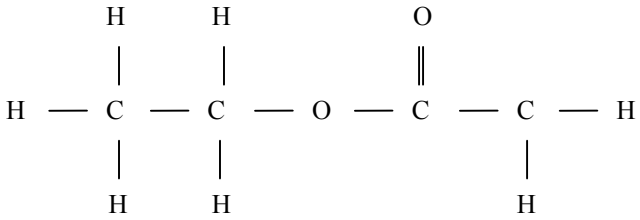
Examples:



Would not be penalised as the structural formula for ethyl ethanoate.

If the bond is also missing, then zero marks should be awarded.

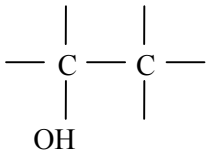
Example:



12 If a structural formula is asked for, CH_3– and CH_3CH_2– are acceptable as methyl and ethyl groups respectively.

13 With structures involving an –OH or an $–NH_2$ group, no mark should be awarded if the 'O' or 'N' are not bonded to a carbon, i.e. $OH–CH_2$ and $NH_2–CH_2$.

14 When drawing structural formulae, no mark should be awarded if the bond points to the 'wrong' atom, eg



15 A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the marking scheme**.

16 When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these has been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

17 If an answer comes directly from the text of the question, no marks should be given.

Example: A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy.

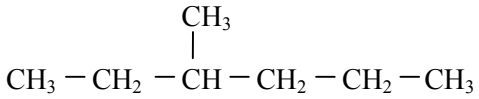
$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

Name the kind of enthalpy change which the student measured.

No marks should be given for 'burning' since the word 'burned' appears in the text.

18 A guiding principle in marking is to give credit for (partially) correct chemistry rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon.

Although not completely correct, the answer, '3, methyl-hexane' would gain the full mark ie wrong use of commas and dashes.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	**pH**
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

How is the strength of the acids related to the number of chlorine atoms in the molecule?

Again, although not completely correct, an answer like 'the more Cl_2, the stronger the acid' should gain the full mark.

Example 3: Why does the (catalytic) converter have a honeycomb structure?

A response like 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

2004 Chemistry Advanced Higher

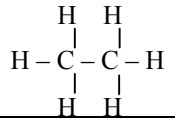
Marking scheme

Section A

1.	D	21.	C
2.	C	22.	A
3.	B	23.	C
4.	D	24.	A
5.	D	25.	A
6.	B	26.	B
7.	C	27.	B
8.	B	28.	A
9.	D	29.	B
10.	C	30.	D
11.	B	31.	A
12.	D	32.	A
13.	A	33.	C
14.	C	34.	D
15.	B	35.	D
16.	B	36.	A
17.	B	37.	D
18.	C	38.	A
19.	A	39.	C
20.	C	40.	D

Section B

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
1 (a) (i)	Increasing nuclear charge/more protons/greater attraction from nucleus or Decreasing atomic radius or Atoms getting smaller	1	More electrons More protons and more electrons Atoms getting more stable	use of word 'molecules' instead of 'atoms'
(ii)	Nitrogen has a half filled p sub-shell or set of p-orbitals or Oxygen has two electrons paired in a p-orbital → electron/electron repulsion makes it easier to remove one of these electrons	1	Orbital instead of p subshell Orbital box notation given without any further explanation Because of Hund's Rule	
(b)	2nd ionisation of Lithium involves removal of electron from 1s **orbital** which is **closer to nucleus** Lowest shell or full shell or lower energy level or stable or full 1s orbital or breaking into new shell or Li^+ has noble gas arrangement	1	full orbital	stable octet

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
2 (a)	bonds broken: $H-C\equiv C-H + H-H + H-H$ bonds made:  $2 \times H-H$ 432 x 2 $C\equiv C$ 835 $2 \times C-H$ 414 x 2 $C-C$ – 346 $6 \times C-H$ – 414 x 6 $\Delta H =$ 2527 – 2830 = -303kJ mol^{-1} Identifying correct bonds Correct energies of bonds broken/formed Arithmetic and units + 303kJ = 2 out of 3	**1** **1** **1**	C = C - deduct 1 mark -536kJ - 2 out of 3 43kJ - 2 out of 3	
(b)	$C\equiv C$, C–C and C–H are mean (average) bond energies or Enthalpies of combustion can be measured directly (bond energies are calculated)	**1**	Experimental errors associated with ΔH combustion experiments Neglecting intermolecular forces Not standard states Heat losses to surroundings	

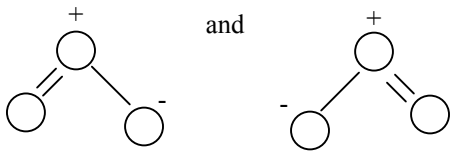
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
3 (a)	$\Delta H_f^o = \Delta H_f^o\ Na_2CO_3 + \Delta H_f^o\ CO_2 + \Delta H_f^o\ H_2O - 2 \times \Delta H_f^o\ NaHCO_3$ $\Delta H^o = -1131 - 394 - 242 + 1896$ $\Delta H^o = +129\ kJ\ mol^{-1}$ + 129 … 1 mark – units not required Either 1 mark or zero	1	-129 kJ mol^{-1} 129000 kJ or 129000 J	
(b)	$\Delta G^o = \Delta H^o - T\Delta S^o$ $0 = \Delta H^o - T\Delta S^o$ or equivalent expression $T = \frac{\Delta H^\circ}{\Delta S^\circ}$ $T = \frac{+129000}{335}$ Any of these 3 lines for 1 mark $T = 385{\cdot}1$ K or 385 K (or $111{\cdot}9^\circ C$ or $112^\circ C$) 1 mark Follow through from wrong answer in (a) is acceptable to get 2 marks in (b)	2	Lose 1 mark for ° K No units, lose 1 mark $T = \frac{-\Delta H^\circ}{\Delta S^\circ}$ deduct 1 mark	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
3 (c)	Value in range 378 – 380 K (or 105 - 107˚C)	1		No units or º K unless already deducted in part (b)
(d)	Oil bath heated too quickly Impure/wet sample Sº values valid @ 25ºC rather than at room temp Oil bath not stirred Leaks Sticky gas syringe Not carried out under standard conditions Unequal distribution of temperature in the powder	1	Experimental error Inaccuracy in reading thermometer Human error Heat lost to surroundings Inaccuracy in thermometer	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
4 (a)	(more) stronger van der Waals for 2-phenylpropane 2-phenylpropane more polar so stronger (or greater) intermolecular forces 2-phenylpropane is more polar so has dipole-dipole attractions bigger molecules so stronger intermolecular forces	**1**	Molecules more polar (by itself) Bigger molecules (by itself) More bonds/greater intermolecular forces	
(b)	Benzoic acid has hydrogen bonding or correct diagram showing H-bonding	**1**	Stronger intermolecular forces	
(c)	Any 2-halopropane Ignore anything else such as Fe Cl_3 or $AlCl_3$ Accept correct carbocation from 2-halopropane	**1**		
5 (a)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$ or $[Ne]\ 3s^2\ 3p^6\ 3d^7$ Correct answer including $4s^o$	**1**	$[Ar]\ 3d^7$ (doesn't show s and p)	
(b)	Hexaamminecobalt (II) Hexamminecobalt (II)	**1**	Use of amino/amine/ammino Presence of commas/hyphens	
(c)	Oxidising agent/oxidating agent Oxidises the Co^{2+} to Co^{3+}	**1**		cancelling error if wrong species being oxidised
(d)	Change in d → d splitting Different CFSE Different ligand field strength	**1**	Changing d orbital configuration Must state d orbitals not just orbitals	Ligands absorbing different colours

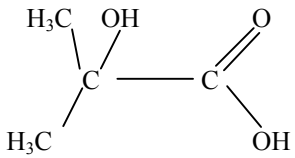
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
5 (e)	$E = \frac{Lhc}{\lambda}$ $= \frac{6 \cdot 02 \times 10^{23} \times 6 \cdot 63 \times 10^{-34} \times 3 \times 10^{8} \times 10^{-3}}{5 \cdot 5 \times 10^{-7}}$ $= 217 \cdot 7$ or 218 kJ mol^{-1} (units not required)	**1** **1** **1**	217705 then lose 1 mark no L get $3 \cdot 616 \times 10^{-22}$ (2/3) or $3 \cdot 616 \times 10^{-19}$ J (1/3)	E = Lh λ wrong principle
6 (a)	$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(1)$ Ignore state symbols	**1**		$\bar{e}$ on both sides
(b) (i)	Number of moles of Fe^{2+} in 30·1 cm^3 of 0·002 mol 1^{-1} $= 6 \cdot 02 \times 10^{-5}$ Number of moles of $MnO_4^-(aq)$ = 1/5 × number of moles of $Fe^{2+}(aq)$ $= 1 \cdot 204 \times 10^{-5}$ Can also use other methods of doing this calculation Follow on from wrong equation (a)	**1** **1**		

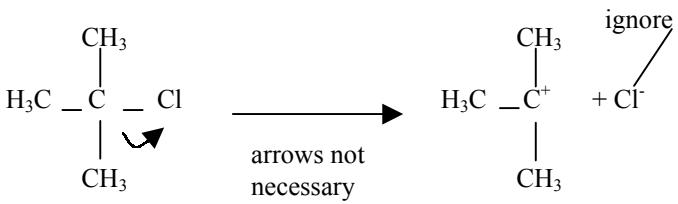
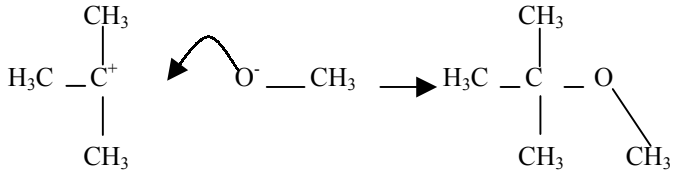
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
6 (b) (ii)	Number of moles of MnO_4^-(aq) and hence Mn^{2+}(aq) in 100 cm^3 flask $= 4 \times 1 \cdot 204 \times 10^{-5} = 4 \cdot 816 \times 10^{-5}$ Mass of manganese = $54 \cdot 9 \times 4 \cdot 816 \times 10^{-5} = 2 \cdot 64 \times 10^{-3}$ g $\%Mn = \frac{2 \cdot 64 \times 10^{-3}}{1 \cdot 11} \times 100\%$ $= 0 \cdot 238\%$ or $0 \cdot 24\%$ $0 \cdot 2\%$ Do not deduct marks for rounding errors Various alternative answers following on from wrong answers in part (b) (i) and part (a)	**1** **1**	Deduct 1 mark for not multiplying by 4. Deduct 1 mark if use a value for RAM other than $54 \cdot 9$	
(c)	Spectrophotometer/colorimeter/intensity of absorption AAS/AES	**1**	Calorimeter Mass spectrometer/spectrometer EDTA Gravimetric analysis Prepare derivative Calibration graph on its own	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
7 (a)	Two diagrams required for mark  Correct diagrams without charges Correct combination of dots or dots and crosses 2 correct plus conjugated version Ignore bond lengths and angles	**1**	Wrong number of lone pairs 2 correct and 1 wrong Wrong charges One resonance structure and one composite/conjugated structure	
(b) (i)	$O_3(g) + O(g) \longrightarrow 2O_2(g)$ States can be omitted	**1**	NO on both sides	
(ii)	Catalyst	**1**		

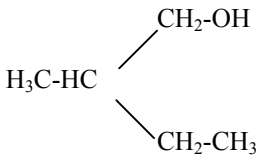
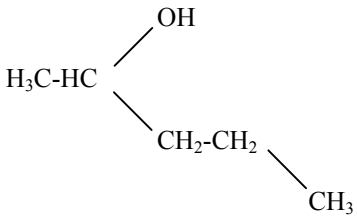
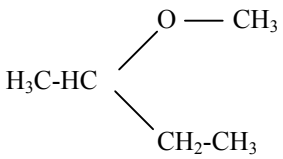
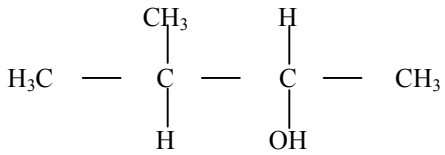
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
7 (c) (i)	Second order or 2	1		
(ii)	$\text{Rate} = k[O]\,[NO_2]$ $k = \dfrac{\text{Rate}}{[O][NO_2]}$ 1 Do not deduct for K (capital K) as not part of final answer	1		
	$= \dfrac{6 \cdot 10 \times 10^{-17}}{9 \cdot 20 \times 10^{-15} \times 1 \cdot 11 \times 10^{-12}}$ 1 for correct substitution and arithmetic	1		
	$= 5 \cdot 97 \times 10^{9}$ $mol^{-1}\,l\,s^{-1}$ (1 for correct units) $5 \cdot 9 \times 10^{9}$ $6 \cdot 0 \times 10^{9}$ 6×10^{9}	1		
	Follow through in (ii) from wrong answer in (i)			

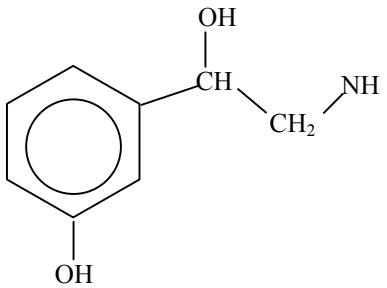
Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
8 (a)	pH remains/stays the same/doesn't change/reasonably constant if small volumes of H^+ or OH^- added (of acid or of alkali instead of H^+ or OH^-) Amphoteric	**1**	If small volumes of acid and alkali or equivalent are omitted	
(b)	$pH = pKa - \log \frac{[acid]}{[salt]}$ or $[H^+] = K_a \times \frac{[acid]}{[salt]}$ or $pH = pKa + \log \frac{[salt]}{[acid]}$ no of moles of $C_3H_5O_2K = \frac{2 \cdot 24}{112 \cdot 1}$ GFM $C_3H_5O_2K = 112 \cdot 1$ no of moles of $C_3H_5O_2K = 0 \cdot 0200$ $c = \frac{n}{v} = \frac{0 \cdot 0200}{0 \cdot 250}$ c = $\underline{0 \cdot 0800}$ mol 1^{-1} for getting concentration value (no units required) $pH = 4 \cdot 9 - \log \frac{0 \cdot 200}{0 \cdot 08}$ or $[H^+] = 1 \cdot 3 \times 10^{-5} \times \frac{0 \cdot 200}{0 \cdot 08}$ $pH = 4 \cdot 9 - 0 \cdot 398$ or $[H^+] = 3 \cdot 25 \times 10^{-5}$ $pH = 4 \cdot 5$ (or $4 \cdot 502$) or $pH = -\log(3 \cdot 25 \times 10^{-5}) = 4 \cdot 5$ $(4 \cdot 49)$ For pH value of $4 \cdot 5$ or $4 \cdot 49$ or $4 \cdot 502$	**1** **1** **1**	If use C $= 2 \cdot 24$ then 0 marks out of 2 for calculation. [So 1 out of 3 if correct equation given]	Look for cancelling errors giving correct answer

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
9 (a) (i)	Reagent X = aluminium oxide Al_2O_3 or alumina or (concentrated) sulphuric acid H_2SO_4 or orthophosphoric acid or H_3PO_4 or phosphoric acid	1	Dilute sulphuric or phosphoric acids	
(ii)	Reagent Y = hydrogen cyanide or HCN Acidified KCN	1	CN^- KCN/cyanide HCN^-	
(b)	 full or shortened structural formula	1	Molecular formula	
(c)	Reduction	1	Addition Hydrogenation – but not as a cancelling error	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (a)	Ethers or alkoxyalkanes	**1**		
(b)	Add sodium metal/alkali metal/group 1 metal or $2Na + 2CH_3OH \rightarrow 2CH_3ONa + H_2$ (or word equation)	**1**		
(c) (i)	First step – show the heterolytic fission of the C-Cl bond to form the carbocation  Second step – show the nucleophilic attack of the methoxide ion  Must show 2 steps Correct text acceptable for 2 marks	**2**	If wrong carbocation – may still get 2nd mark. Shown as 1 step = 0 marks No carbocation at all = 0 marks Any suggestion of S_N2 = 0 marks	S_N2 mechanism

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (c) (ii)	Can give one of two reasons, students wording may vary but should mention one of two concepts either the carbocation formed has three methyl (alkyl) groups attached which can feed in electron density stabilising the positive charge thus making an S_N1 mechanism more favourable. Tertiary (carbo)cation stable or the tertiary haloalkane has three methyl groups attached which offer steric hindrance w.r.t. the formation of the five co-ordinate transition state seen as part of the S_N2 mechanism bulky groups/too crowded/steric hindrance	**1** **1**	Tertiary on own without explanation Not possible to invert as it would be with S_N2	

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
10 (d)	    any one	**1**		Drawn as  0 marks

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
11 (a)	An agonist will produce a response like the body's natural active compound Enhances body's natural response Binds to receptor to produce response Stimulates receptors/triggers natural response Mimics active molecule Binds with receptor and causes the same reaction as the natural molecule	**1**		
(b)		**1**		
(c)	Secondary amine	**1**		

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
12 (a) (i)	C=O bond/C=O/carbonyl/ester	**1**	aldehyde C = O ketone C = O	
(ii)	ester	**1**		
(b) (i)	Mass of carbon $= 0 \cdot 478\text{g} \times \frac{12}{44} = 0 \cdot 1304\text{g}$ or $0 \cdot 130\text{g}$ Mass of hydrogen $= 0 \cdot 196\text{g} \times \frac{2}{18} = 0 \cdot 0218\text{g}$ or $0 \cdot 022\text{g}$ ← for two masses (for 1 mark) Mass of oxygen $= 0 \cdot 210 - 0 \cdot 130 - 0 \cdot 0218 = 0 \cdot 058\text{g}$ May still get 2nd mark if an error in first part.	**2**		

Question	Acceptable Answer	Mark	Unacceptable Answer	Negates
12 (b) (ii)	C : H : O $\frac{0 \cdot 130}{12}$: $\frac{0 \cdot 0218}{1}$: $\frac{0 \cdot 058}{16}$ $0 \cdot 01083$: $0 \cdot 0218$: $3 \cdot 625 \times 10^{-3}$ 3 : 6 : 1 Empirical formula C_3H_6O Follow through from incorrect answer to (i)	**1**	Any error	
(c) (i)	RMM = 116 115 – 117 116 amu	**1**	116 g	
(ii)	$C_6H_{12}O_2$ No other acceptable answers	**1**		
(d)	Ethyl butanoate	**1**		

[END OF MARKING INSTRUCTIONS]