AQA

A-level CHEMISTRY (7405/2)

Paper 2: Organic and Physical Chemistry

Mark scheme

Specimen paper

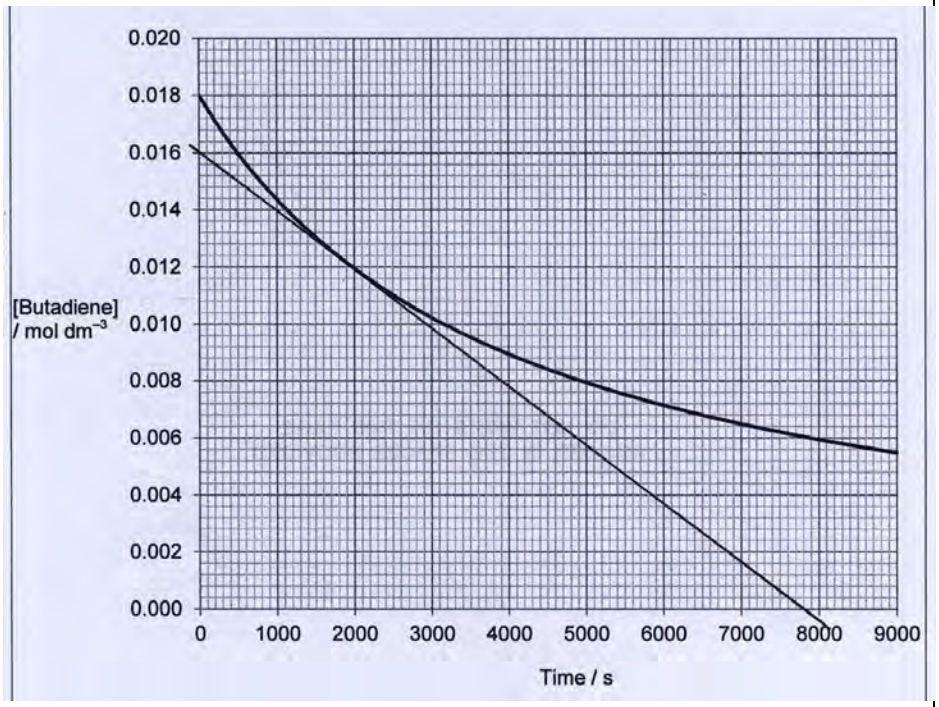
Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

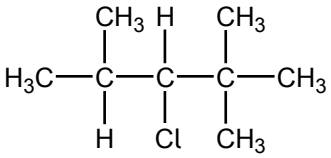
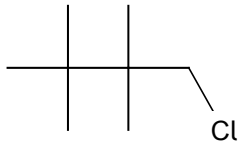
Further copies of this mark scheme are available from aqa.org.uk

Question	Marking guidance	Mark	AO	Comments
01.1	Consider experiments 1 and 2: [B constant] [A] increases × 3: rate increases by 3^2 therefore 2nd order with respect to A	1	AO3 1a	
	Consider experiments 2 and 3: [A] increases × 2: rate should increase × 2^2 but only increases × 2 Therefore, halving [B] halves rate and so 1st order with respect to B	1	AO3 1a	
	Rate equation: rate = $k[A]^2[B]$	1	AO3 1b	
01.2	rate = k $[C]^2[D]$ therefore k = rate / $[C]^2[D]$	1	AO2h	
	$k = \frac{7.2 \times 10^{-4}}{(1.9 \times 10^{-2})^2 \times (3.5 \times 10^{-2})} = 57.0$	1	AO2h	Allow consequential marking on incorrect transcription
	$mol^{-2}\,dm^{+6}\,s^{-1}$	1	AO2h	Any order
01.3	rate = $57.0 \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2} = 3.99 \times 10^{-3}$ $(mol\ dm^{-3}\ s^{-1})$ **OR** Their $k \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2}$	1	AO2h	

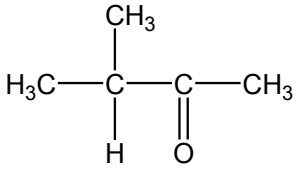
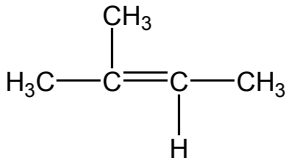
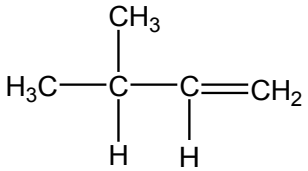
01.4	Reaction occurs when molecules have $E \geq E_a$ Raising T by 10 °C causes <u>many</u> more molecules to have this E Whereas doubling [**E**] only doubles the number with this E	1 1 1	AO1a AO1a AO1a	
01.5	$E_a = RT(\ln A - \ln k)/1000$ $E_a = 8.31 \times 300\ (23.97 - (-5.03))/1000 = 72.3$ (kJ mol^{-1})	1 1	AO1b AO1b	Mark is for rearrangement of equation and factor of 1000 used correctly to convert J into kJ

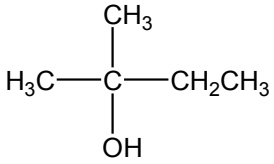
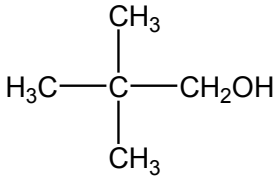
Question	Marking guidance	Mark	AO	Comments
02.1	Gradient drawn on graph  	1	AO3 1a	Line must touch the curve at 0.012 but must not cross the curve.

02.2	Stage 1: Rate of reaction when concentration = 0.0120 mol dm^{-3} From the tangent Change in [butadiene] = –0.0160 – 0 and change in time = 7800 – 0 Gradient = –(0.0160 – 0)/(7800 – 0) = $–2.05 \times 10^{-6}$ Rate = 2.05×10^{-6} (mol dm^{-3} s^{-1}) Stage 2: Comparison of rates and concentrations Initial rate/rate at 0.0120 = $(4.57 \times 10^{-6})/(2.05 \times 10^{-6}) = 2.23$ Inital concentration/concentration at point where tangent drawn = 0.018/0.012 = 1.5 Stage 3: Deduction of order If order is 2, rate should increase by factor of $(1.5)^2 = 2.25$ this is approximately equal to 2.23 therefore order is 2nd with respect to butadiene	1 1 1 1 1	AO3 1a AO3 1a AO3 1a AO3 1a AO3 1b	Extended response Marking points in stage 2 can be in either order

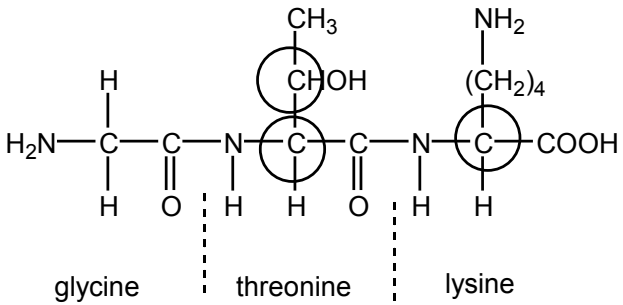
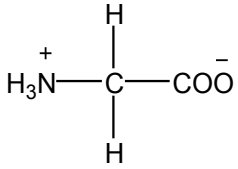
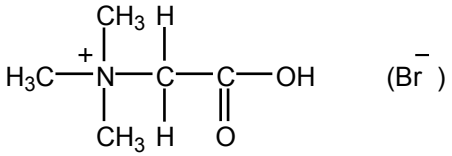
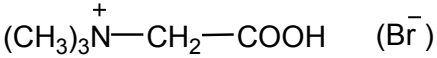
Question	Marking guidance	Mark	AO	Comments
03.1	2,2,4-trimethylpentane	1	AO1a	
03.2	5	1	AO2b	
03.3	$C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$	1	AO2b	
03.4	Mainly alkenes formed	1	AO1b	
03.5	4 (monochloro isomers) 	1 1	AO2b AO2a	
03.6		1	AO2a	

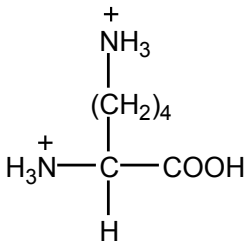
03.7	$C_8H_{17}{}^{35}Cl$ = 96.0 + 17.0 + 35.0 = 148.0 and $C_8H_{17}{}^{37}Cl$ = 96.0 + 17.0 + 37.0 = 150.0 M_r of this $C_8H_{17}Cl$ $\left(\frac{1.5}{2.5} \times 148.0\right) + \left(\frac{1.0}{2.5} \times 150.0\right)$ = 148.8	1 1	AO1b AO1b	Both required
03.8	$\frac{24.6}{12}$ $\frac{2.56}{1}$ $\frac{72.8}{35.5}$ = 2.05 : 2.56 : 2.05 Simplest ratio = $\frac{2.05}{2.05}$: $\frac{2.56}{2.05}$: $\frac{2.05}{2.05}$ = 1 : 1.25 : 1 Whole number ratio (× 4) = 4 : 5 : 4 MF = $C_8H_{10}Cl_8$	 1 1 1	 AO2b AO2b AO2b	

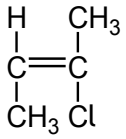
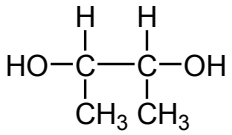
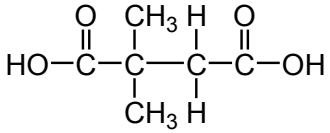
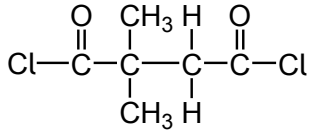
Question	Marking guidance	Mark	AO	Comments
04.1	3-methylbutan-2-ol	1	AO1a	
04.2		1	AO2g	Allow $(CH_3)_2CHCOCH_3$
04.3	Elimination	1	AO1a	
04.4		1	AO2g	Allow $(CH_3)_2C=CHCH_3$
		1	AO2g	Allow $(CH_3)_2CHCH=CH_2$

04.5	Position	1	AO1a	
04.6	C B A	1	AO3 1b	
04.7		1	AO2g	Allow $(CH_3)_2C(OH)CH_2CH_3$
04.8		1	AO2e	Allow $(CH_3)_3CCH_2OH$

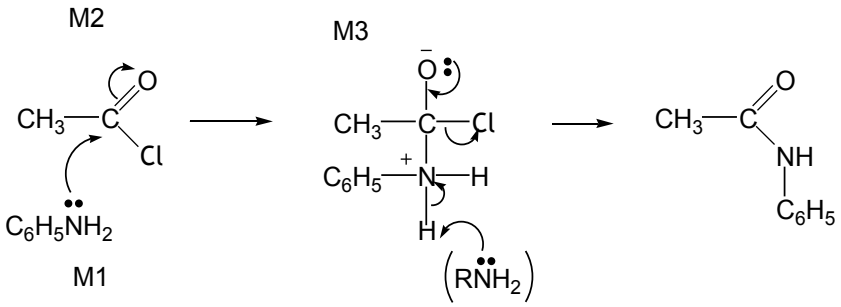
Question	Marking guidance	Mark	AO	Comments
05.1	Secondary	1	AO1a	
05.2	Nitrogen and oxygen are very electronegative Therefore, C=O and N–H are polar Which results in the formation of a hydrogen bond between O and H In which a lone pair of electrons on an oxygen atom is strongly attracted to the δ+H	1 1 1 1	AO1a AO1a AO1a AO1a	

Question	Marking guidance	Mark	AO	Comments
06.1		1	AO2a	
06.2		1	AO2a	
06.3		1	AO2a	Allow 
06.4	2-amino-3-hydroxybutanoic acid	1	AO2a	

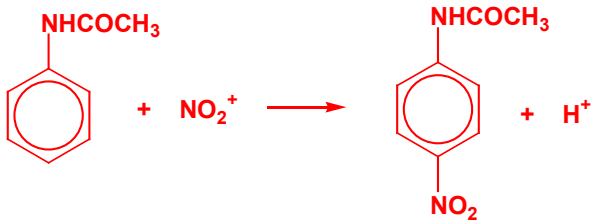
06.5		1	AO2a	

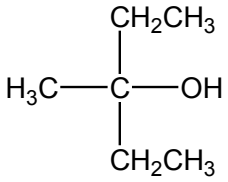
Question	Marking guidance	Mark	AO	Comments
07.1		1	AO1a	
	Addition	1	AO1a	
07.2		1	AO2e	
	 OR 	1	AO2e	
07.3	**Q** is biodegradable	1	AO2g	
	Polar C=O group or δ+ C in **Q** (but not in **P**)	1	AO2c	
	Therefore, can be attacked by nucleophiles (leading to breakdown)	1	AO2c	

Question	Marking guidance	Mark	AO	Comments
08.1	2-deoxyribose	1	AO1a	
08.2	Base A Top N–H forms hydrogen bonds to lone pair on O of guanine The lone pair of electrons on N bonds to H–N of guanine A lone pair of electrons on O bonds to lower H–N of guanine	1 1 1 1	AO3 1b AO2a AO2a AO2a	If Base B stated, allow 1 mark only for response including hydrogen bonding Allow all 4 marks for a correct diagram showing the hydrogen bonding Students could also answer this question using labels on the diagram
08.3	Allow either of the nitrogen atoms with a lone pair NOT involved in bonding to cytosine	1	AO2a	
08.4	Use in very small amounts / target the application to the tumour	1	AO2e	

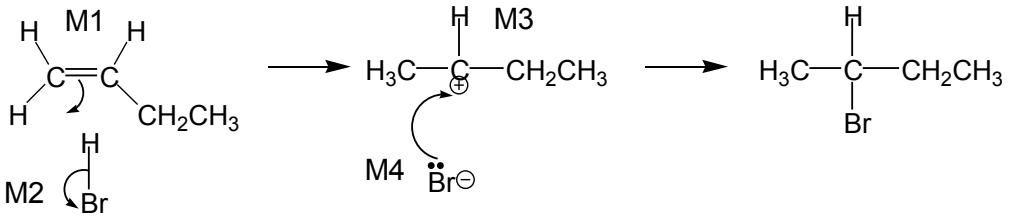
Question	Marking guidance	Mark	AO	Comments
09.1	(nucleophilic) addition-elimination	1	AO1a	Not electrophilic addition-elimination
	 M4 for 3 arrows and lp	4	AO2a	Allow C_6H_5 or benzene ring Allow attack by :$NH_2C_6H_5$ M2 not allowed independent of M1, but allow M1 for correct attack on C+ M3 for correct structure <u>with charges</u> but lone pair on O is part of M4 M4 (for three arrows and lone pair) can be shown in more than one structure

09.2	**The minimum quantity of hot water was used:**			
	To ensure the hot solution would be saturated / crystals would form on cooling	1	AO1b	
	The flask was left to cool before crystals were filtered off:			
	Yield lower if warm / solubility higher if warm	1	AO1b	
	The crystals were compressed in the funnel:			
	Air passes through the sample not just round it	1	AO1b	Allow better drying but not water squeezed out
	A little cold water was poured through the crystals:			
	To wash away soluble impurities	1	AO1b	
09.3	Water	1	AO3 1b	Do not allow unreacted reagents
	Press the sample of crystals between filter papers	1	AO3 2b	Allow give the sample time to dry in air
09.4	M_r product = 135.0	1	AO2h	
	Expected mass = $5.05 \times \frac{135.0}{93.0}$ = 7.33 g	1	AO2h	
	Percentage yield = $\frac{4.82}{7.33} \times 100 = 65.75 = 65.8(\%)$	1	AO1b	Answer must be given to this precision

09.5	 OR $C_6H_5NHCOCH_3 + NO_2^+ \rightarrow C_6H_4(NHCOCH_3)NO_2 + H^+$	1	AO2c	
09.6	Electrophilic substitution	1	AO1a	
09.7	Hydrolysis	1	AO3 1a	
09.8	Sn/HCl	1	AO1b	Ignore acid concentration; allow Fe/HCl

Question	Marking guidance	Mark	AO	Comments
10	**IR**			Extended response
	M1 Absorption at 3360 cm^{-1} shows OH alcohol present	1	AO3 1a	Deduction of correct structure without explanation scores maximum of 4 marks as this does not show a clear, coherent line of reasoning.
	NMR			
	M2 There are 4 peaks which indicates 4 different environments of hydrogen	1	AO3 1a	Maximum of 6 marks if no structure given OR if coherent logic not displayed in the explanations of how two of OH, CH_3 and CH_2CH_3 are identified.
	M3 The integration ratio = 1.6 : 0.4 : 1.2 : 2.4 The simplest whole number ratio is 4 : 1 : 3 : 6	1	AO3 1a	
	M4 The singlet (integ 1) must be caused by H in OH alcohol	1	AO3 1a	
	M5 The singlet (integ 3) must be due to a CH_3 group with no adjacent H	1	AO3 1b	
	M6 Quartet + triplet suggest CH_2CH_3 group	1	AO3 1b	
	M7 Integration 4 and integration 6 indicates two equivalent CH_2CH_3 groups	1	AO3 1b	
	M8 	1	AO3 1b	

Question	Marking guidance		Mark	AO	Comments
11.1	$CH_3CH_2COCH_3 + 2[H] \longrightarrow CH_3CH_2CH(OH)CH_3$		1	AO1b	
11.2	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.		6	1 AO1a 5 AO2a	**Indicative Chemistry content** **Stage 1:** Formation of product • Nucleophilic attack • Planar carbonyl group • H^- attacks from either side (stated or drawn) **Stage 2:** Nature of product • Product of step 1 shown • This exists in two chiral forms (stated or drawn) • Equal amounts of each enantiomer/racemic mixture formed **Stage 3:** Optical activity • Optical isomers/enantiomers rotate the plane of polarised light equally in opposite directions • With a racemic/equal mixture the effects cancel
	Level 3 5–6 marks	All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.			
	Level 2 3–4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete. Answer is mainly coherent and shows progression from stage 1 to stage 3.			
	Level 1 1–2 marks	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.			
	Level 0 0 marks	Insufficient correct chemistry to gain a mark.			

Question	Marking guidance	Mark	AO	Comments
12.1	HBr **OR** HCl **OR** H_2SO_4	1	AO1b	Allow HI or HY
12.2	Electrophilic addition  	1 4	AO1a AO2a	 Allow consequential marking on acid in 12.1 and allow use of HY
12.3	The major product exists as a pair of enantiomers The third isomer is 1-bromobutane (minor product) Because it is obtained via primary carbocation	1 1 1	AO2a AO2a AO2a	