



ASSESSMENT and  
QUALIFICATIONS  
ALLIANCE

## General Certificate of Education

# Chemistry 6421

*CHM4 Further Physical and Organic Chemistry*

## Mark Scheme

*2006 examination – January series*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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.

# CHM4

## SECTION A

### Question 1

(a)	exp 2	$4.0 \times 10^{-3}$	1
	exp 3	$0.45 \times 10^{-5}$	1
	exp 4	$9.0 \times 10^{-3}$	1
(b)		$\frac{1.8 \times 10^{-5}}{(3.0 \times 10^{-3})^2(1.0 \times 10^{-3})}$	1
		2000	1
		$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$	1

**Total 6**

### Question 2

(a)	(i)	$[\text{H}^+][\text{OH}^-]$	1
		$-\log [\text{H}^+]$	1
	(ii)	$[\text{H}^+] = [\text{OH}^-]$	1
	(iii)	$(2.0 \times 10^{-3}) \times 0.5 = 1.0 \times 10^{-3}$	1
	(iv)	$[\text{H}^+] = \frac{4.02 \times 10^{-14}}{1.0 \times 10^{-3}} \quad (= 4.02 \times 10^{-11})$	1
		$\text{pH} = 10.40$	1
(b)	(i)	$K_a = \frac{[\text{H}^+][\text{CH}_3\text{CH}_2\text{COO}^-]}{[\text{CH}_3\text{CH}_2\text{COOH}]}$	1
		$= \frac{[\text{H}^+]}{[\text{CH}_3\text{CH}_2\text{COOH}]}$	1
		$[\text{H}^+] = \sqrt{(1.35 \times 10^{-5}) \times 0.125} \quad (= 1.30 \times 10^{-3})$	1
		$\text{pH} = 2.89$	1

- (c) (i)  $(50.0 \times 10^{-3}) \times 0.125 = 6.25 \times 10^{-3}$  1
- (ii)  $(6.25 \times 10^{-3}) - (1.0 \times 10^{-3}) = 5.25 \times 10^{-3}$  1
- (iii) mol salt formed =  $1.0 \times 10^{-3}$  1
- $$(\text{H}^+) = K_a \times \frac{[\text{CH}_3\text{CH}_2\text{COOH}]}{[\text{CH}_3\text{CH}_2\text{COO}^-]}$$
- $$= (1.35 \times 10^{-5}) \times \frac{(5.25 \times 10^{-3}) / V}{(1.0 \times 10^{-3}) / V} \quad (= 7.088 \times 10^{-5})$$
- pH = 4.15 1

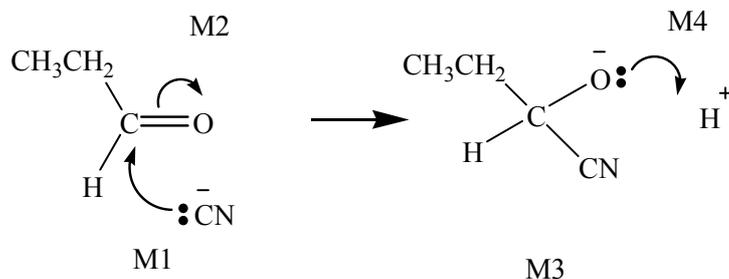
**Total 16****Question 3**

- (a) (i)  $\text{C} + 3\text{D} \longrightarrow 2\text{A} + \text{B}$  1
- (ii) mol dm<sup>-3</sup> 1
- (iii) (forward reaction is) exothermic or more products formed 1
- (b) (i) for N<sub>2</sub>O<sub>4</sub> Mr = 92.0 1
- $$\text{Mol} = \frac{36.8}{92.0} = 0.400$$
- (ii) mol N<sub>2</sub>O<sub>4</sub> reacted =  $0.400 - 0.180 = 0.220$  1
- mol NO<sub>2</sub> formed = 0.440 1
- (iii)  $K_c = \frac{(\text{NO}_2)^2}{(\text{N}_2\text{O}_4)}$  1
- $$= \frac{(0.44/16)^2}{(0.18/16)}$$
- $$= 0.067$$
- (iv) move to NO<sub>2</sub>/ to right / forwards 1
- none 1

**Total 12**

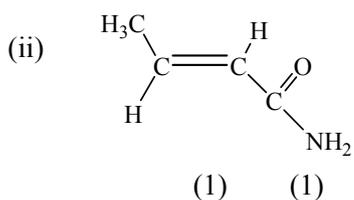
**Question 4**

- (a) nucleophilic addition 1



4

- (b) (i) 2-hydroxybutanenitrile 1



*(allow 1 for amide even if not C<sub>4</sub>H<sub>7</sub>NO, i.e. RCONH<sub>2</sub>)*  
*(if not amide, allow one for any isomer of C<sub>4</sub>H<sub>7</sub>NO which shows geometric isomerism)* 2

- (c) (i)
- 
- $$\begin{array}{c}
 \text{H} \\
 | \\
 \text{CH}_3\text{CH}_2-\text{C}-\text{OH} \\
 | \\
 \text{COOCH}_3
 \end{array}$$
1

- (ii)
- 
- $$\begin{array}{c}
 \text{O} \\
 || \\
 \text{CH}_3\text{CH}_2-\text{C}-\text{COOH}
 \end{array}$$
1

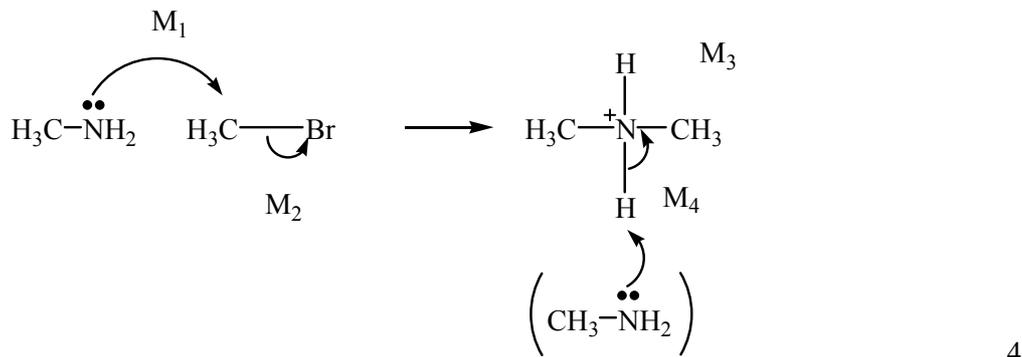
- (iii) CH<sub>3</sub>CH=CHCOOH 1

**Total 11**

**Question 5**

(a) dimethylamine 1

(b) nucleophilic substitution 1



(c) quaternary ammonium salt 1

(cationic) surfactant / bactericide / detergent / fabric softener or conditioner/  
hair conditioner 1**Total 10****Question 6**(a) polyamide or nylon (2,4) 1  
(allow nylon without numbers but if numbers are present they must be correct)

condensation 1



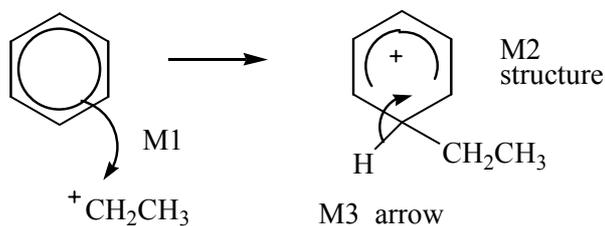
(c) ionic bonding in aminoethanoic acid (can only score if includes that aminoethanoic is ionic) 1

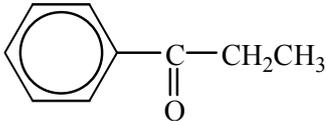
stronger attractions than Hydrogen bonding in hydroxyethanoic (e.g. stronger Hydrogen bonding in aminoethanoic acid scores 0) 1  
mention of electrostatic forces between molecules scores 0)**Total 5**

**SECTION B**

**Question 7**

- (a) ethyl benzene 1
- chloroethane or bromoethane (*or ethene and hydrogen chloride/bromide*) 1
- aluminium chloride/bromide or iron(III) chloride /bromide or iron + chlorine/bromine 1
- $\text{CH}_3\text{CH}_2\text{Cl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CH}_2^+ + \text{AlCl}_4^-$  1
- electrophilic substitution 1



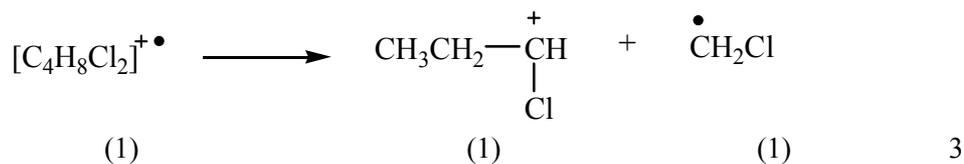
- (b)  1
- $\text{CH}_3\text{CH}_2\text{COCl}$  / propanoyl chloride or  $(\text{CH}_3\text{CH}_2\text{CO})_2\text{O}$  / propanoic anhydride 1
- $\text{NaBH}_4$  or  $\text{LiAlH}_4$  or  $\underline{\text{H}_2/\text{Ni}}$  (*not Sn/Fe with HCl*) 1

**Total 11**

**Question 8**

- (a) (i) 3 peaks or shown in a list 1
- $m/z = 126, 128$  and  $130$  ( $56 + 70/72/74$ ) (*all 3 scores 2*) 2  
 (*if 56 wrong allow  $(x + 70/72/74)$  for 1 ( $x$  cannot be zero)*)  
 (*any two scores 1*)

(ii)



allow wrong structure

for structure

dot can be anywhere

(b)	(i)	optical	1
		<u>equal</u> mixture of enantiomers	1
		(optically) inactive or effects cancel	1
		plane polarised light	use <u>stereospecific</u> reagent (QoL)
		<u>rotated</u> in opposite/different	1
		directions (QoL)	reacts with one isomer only
	(ii)	carbocation	1
		planar - ( <i>must refer to carbocation or intermediate</i> )	1
		attack from either side equally likely – ( <i>must refer to carbocation /intermediate</i> )	1
			7 max
(c)	(i)	2 peaks ( <i>if 4 peaks allow splitting only</i> )	1
		ratio 6:2 or 3:1	1
		doublet (6 or 3)	1
		quartet (2 or 1)	1
	(ii)	<b>S</b>	
		$\begin{array}{c} \text{Cl} \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2\text{CH}_3 \\   \\ \text{Cl} \end{array}$	1
		<b>T</b>	
		$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2\text{Cl} \\   \\ \text{Cl} \end{array}$	1

**Total 19**