



**General Certificate of Education**

**Chemistry (6421)**

**CHM4 Further Physical and Organic  
Chemistry**

**Mark Scheme**

*2008 examination - January series*

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**Question 1**

- (a) (i)  $K_w = [H^+][OH^-]$  if wrong only score in (ii) and (iii) except if  $[H_2O] = 1$  \* 1
- (ii)  $2.34 \times 10^{-7}$  penalise  $2.3 \times 10^{-7}$  i.e. 2 sfs once in the question 1
- (iii)  $2.34 \times 10^{-7}$  conseq = (ii) 1
- (iv)  $5.48$  to  $5.50 \times 10^{-14}$  conseq = (ii)  $\times$  (iii) 1  
\*if  $[H_2O] = 1$  can score for correct answer here
- (b)  $[H^+] = \frac{10^{-14}}{0.136}$  (1) =  $7.35 \times 10^{-14}$  OR  $pOH = 0.87$  1
- $pH = 13.13$  1

**Total 6****Question 2**

- (a) M1  $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$  if wrong, score max 1 for M3 from their  $[H^+]$  1  
penalise round brackets once in the qu
- M2  $[H^+] = \sqrt{(1.35 \times 10^{-5} \times 0.169)}$  (1) =  $1.51 \times 10^{-3}$  1  
If  $\sqrt{\quad}$  visible can score 2 for 5.64
- M3  $pH = 2.82$  allow 1 for correct pH from their  $[H^+]$  1
- (b) (i)  $CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$  penalise 1  
OR  $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$  covalent Na
- (ii) mol propanoic acid =  $0.250 - 0.015 = 0.235$  penalise rounding to 1  
mol propanoate ions =  $0.190 + 0.015 = 0.205$  2sfs once 1
- (iii) M1  $[H^+] = \frac{K_a \times [CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$  correct rearrangement, 1  
as here or with their numbers even if x
- M2 =  $\frac{(1.35 \times 10^{-5})(0.235)}{0.205}$  allow  $\frac{K_a \times [HA]}{[A^-]}$  1  
insertion of correct numbers here or in  $K_a$  expression  
(=  $1.548 \times 10^{-5}$ )
- M3 4.81 allow 1 for correct pH from their  $[H^+]$  1

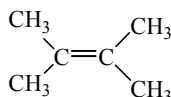
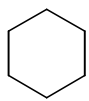
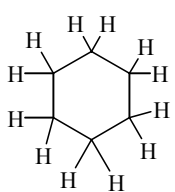
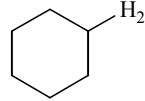
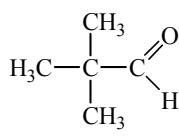
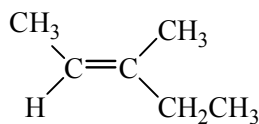
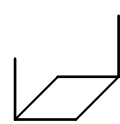
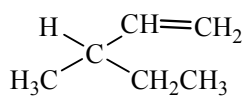
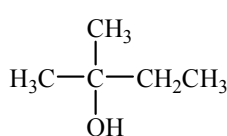
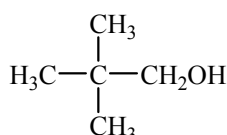
**Total 9**

**Question 3**

- (a)  $K_c = \frac{[H_2]^3[C_2H_2]}{[CH_4]^2}$  if round brackets, penalise here but mark on 1  
if  $K_c$  wrong can score only M1 and conseq units
- (b) M1 dividing by volume throughout shown if moles used instead of conc can score only M3\* (+ units M4); can score this in M2 1
- M2  $K_c = \frac{\left(\frac{0.28}{0.25}\right)^3 \left(\frac{0.12}{0.25}\right)}{\left(\frac{0.44}{0.25}\right)^2}$  1
- (=  $\frac{(1.12)^3(0.48)}{(1.76)^2}$ )
- M3 = 0.218 or 0.22 \* 1.36 × 10<sup>-2</sup> if vol not used 1  
allow 0.217 – 0.22
- M4 mol<sup>2</sup> dm<sup>-6</sup> 1
- (c) to right or to product(s) or forwards 1  
Increase 1
- (d) to left or to reagent or backwards 1  
no effect 1
- (e) total no moles = 0.84 if CE, no second mark 1
- $\frac{0.12}{0.84} = 0.14(3)$  allow  $\frac{1}{7}$  1
- (f)  $0.143 \times 2.78 \times 10^4 = 3.97 \times 10^3$  (allow 3.89– 4.00 × 10<sup>3</sup> & 2 sfs i.e. 3.9 – 4.0) 1  
conseq on (e) : penalise wrong units
- (g) mol H<sub>2</sub> = 2.1 mark independently 1  
mol C<sub>2</sub>H<sub>2</sub> = 0.7 1

**Total 14**

## Question 4

- (a) (i) A  must show C=C 1
- B  allow  but NOT  etc 1
- (ii) C  or (CH<sub>3</sub>)<sub>3</sub>CCHO NOT (CH<sub>3</sub>)<sub>3</sub>CCOH 1
- D  $\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2\text{CH}_3$  allow C<sub>2</sub>H<sub>5</sub> and C<sub>2</sub>H<sub>5</sub>COC<sub>2</sub>H<sub>5</sub> 1
- (iii) E CH<sub>3</sub>CH<sub>2</sub>COOH or C<sub>2</sub>H<sub>5</sub>CO<sub>2</sub>H 1
- F HCOOCH<sub>2</sub>CH<sub>3</sub> or HCO<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> 1
- (iv) G CH<sub>3</sub>CH=CHCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> CH<sub>3</sub>CH=CHCH(CH<sub>3</sub>)<sub>2</sub>  
 CH<sub>3</sub>CH=CHC<sub>3</sub>H<sub>7</sub> CH<sub>3</sub>CH<sub>2</sub>CH=CHCH<sub>2</sub>CH<sub>3</sub> 1
-   must show C=C in alkenes
- H  allow C<sub>2</sub>H<sub>3</sub> or CHCH<sub>2</sub> 1
- (v) I  or (CH<sub>3</sub>)<sub>2</sub>C(OH)C<sub>2</sub>H<sub>5</sub> 1
- J  or (CH<sub>3</sub>)<sub>3</sub>CCH<sub>2</sub>OH 1

(b)	(i)	5		1
	(ii)	a	singlet QWC	1
		b	triplet QWC	1

**Total 13****Question 5**

(a)	(i)	$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{N}^+ - \text{C} - \text{COO}^- \\   \\ \text{H} \end{array}$		1
	(ii)	H <sub>2</sub> N-CH <sub>2</sub> CH <sub>2</sub> -COOH	not H <sub>2</sub> N-C <sub>2</sub> H <sub>4</sub> -COOH	1
	(iii)	ethan(e)-1,2-diamine	allow ethylene diamine or 1,2-diaminoethane but penalise wrong numbers	1
		butan(e)-(-1,4-)dioic acid	NOT dibutanoic acid	1
(b)	(i)	addition	not additional	1
	(ii)	3-methylpent-2-ene		1
(c)	(i)	HOCH <sub>2</sub> CH <sub>2</sub> OH		1
		HOOCCH <sub>2</sub> CH <sub>2</sub> COOH	or ClOCCH <sub>2</sub> CH <sub>2</sub> COCl	1
	(ii)	HOCH <sub>2</sub> CH <sub>2</sub> COO <sup>-</sup>	allow -COONa but not covalently bonded Na	1
(d)	(i)	van der Waals	allow vdW or London forces or dispersion forces	1
	(ii)	dipole- dipole	QWC Not temporary dipole- induced dipole	1

**Total 11****Question 6 all answers to 3 sfs penalise fewer once**

(a)	(i)	Expt 2	$2.68 \times 10^{-4}$	1
		Expt 3	$10.7(2) \times 10^{-4}$	1
		Expt 4	$2.08 \times 10^{-3}$	1
	(ii)	k	$= \frac{\text{rate}}{[\text{X}]^2}$ or $\frac{2.68 \times 10^{-4}}{(1.20 \times 10^{-3})^2}$	1
			= 186	1
		mol <sup>-1</sup> dm <sup>3</sup> s <sup>-1</sup>	allow mol <sup>-1</sup> dm <sup>3</sup> for misprint	1

(b) increases (exponentially) allow straight line but not  1

**Total 7**

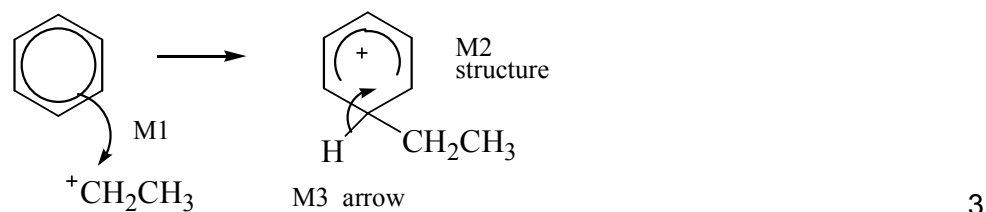
**Question 7**

(a)  $\text{AlCl}_3$  or  $\text{AlBr}_3$   $\text{FeCl}_3$   $\text{FeBr}_3$  1

$\text{CH}_3\text{CH}_2\text{Cl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CH}_2^+ + \text{AlCl}_4^-$  ignore arrows unless  
wrong e.g. from lp on Al 1

$\text{H}^+ + \text{AlCl}_4^- \rightarrow \text{AlCl}_3 + \text{HCl}$  allow words if all reagents and  
products described correctly 1

electrophilic substitution 1



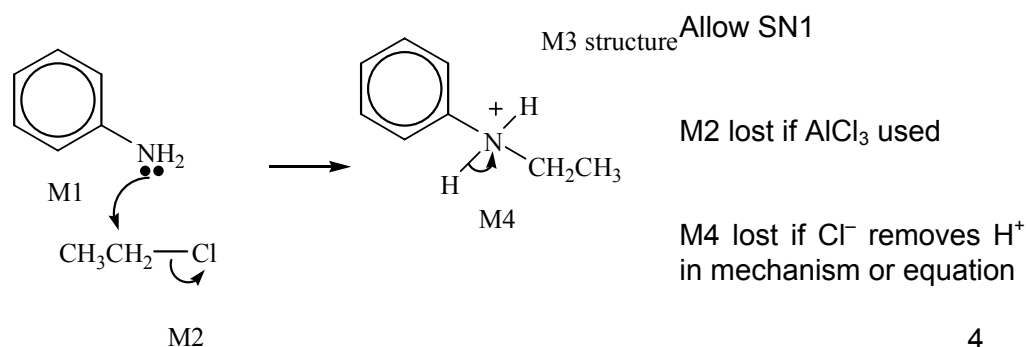
ethylbenzene ignore numbers allow phenylethane 1

phenylethene or poly(phenylethene) or styrene or poly(styrene) 1

or formula or repeating unit

**9 marks**

(b) nucleophilic substitution 1



N-ethylphenylamine or 1

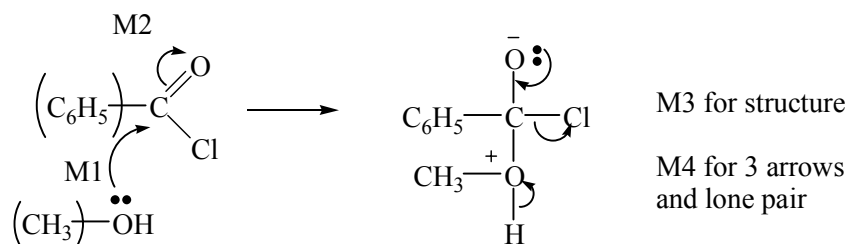
N-phenylethylamine

**6 marks**

**Total 15**

## Question 8

- (a) (nucleophilic) addition-elimination 1



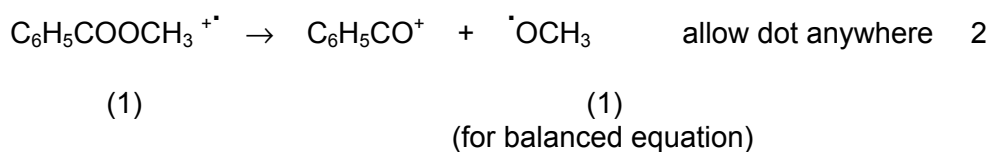
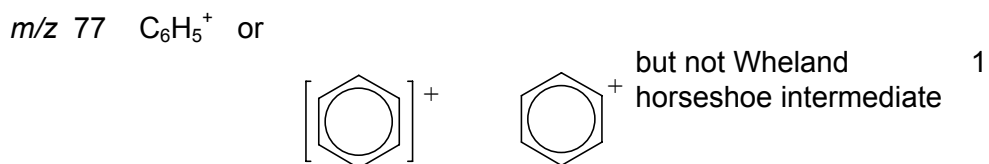
**NB** Different from Qu 7b → do not penalise M4 if Cl<sup>-</sup> removes H<sup>+</sup> 4

5 marks

**NB** There are four fragment ions in parts (b) and (c).

If these are written with a negative charge or with a radical dot they are all wrong, but if they are written with no charge at all, penalise the first two without + then allow the rest .

- (b)  $m/z$  105  $\text{C}_6\text{H}_5\text{CO}^+$  or  $\text{C}_6\text{H}_5\text{CO}^+$  1



4 marks

- (c)  $m/z$  43  $\text{CH}_3\text{CO}^+$  1  
**V** is  $\text{CH}_3\text{COOC}_6\text{H}_5$  1
- $m/z$  91  $\text{C}_6\text{H}_5\text{CH}_2^+$  or 1
- W** is  $\text{HCOOCH}_2\text{C}_6\text{H}_5$   $\text{HCOOC}_6\text{H}_4\text{CH}_3$  1

4 marks



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(d)	(i)	OH or acid or (absorption at) 2500-3000 $\text{cm}^{-1}$ (present in acid not in ester)	1
	(ii)	use of fingerprint region or (exact match with) known spectrum	1

*2 marks*

**Total 15**