

**CAMBRIDGE**  
INTERNATIONAL EXAMINATIONS

**November 2003**

**GCE A AND AS LEVEL**

**MARK SCHEME**

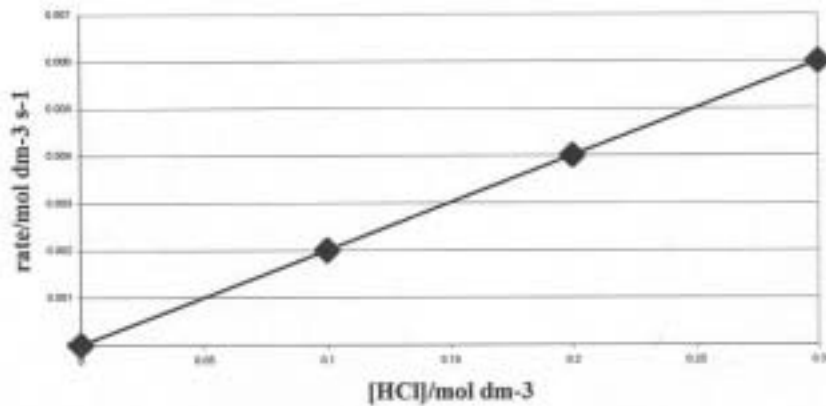
**MAXIMUM MARK: 60**

**SYLLABUS/COMPONENT: 9701/04**

**CHEMISTRY**  
**Theory 2 (Structured Questions)**



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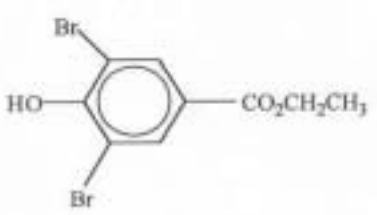
- 1 (a) The power to which the **concentration** (of reagent) is raised (in the rate equation)  
 or: the value of  $a$  in the expression  $\text{rate} = k[A]^a$  (1) [1]
- (b)  $\text{rate} = k[\text{CH}_3\text{COCH}_3][\text{H}^+]$  (1) [1]
- (c) (i) A (1)
- (ii) B (1) [2]
- (d)
- 
- line (through zero) (1)  
 clear points (1) [2]
- (e) mechanism B (1)  
 because the rate is determined by the slow step,  
 which involves propanone +  $\text{H}^+$ ,  
 but not  $\text{I}_2$  any two points (2) [3]
- (f) (i) titration with thiosulphate *or* colorimetry (1)
- (ii)  $k = \text{rate}/[\text{propanone}][\text{H}^+] = 3.3 \times 10^{-6}/(0.2 \times 0.5) = 3.3 \times 10^{-5}$  (1)
- (iii) units are  $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$  (1) [3]
- Total: 12**

- 2 (a) (i)  $K_a = [\text{HCO}_2^-][\text{H}^+]/\text{HCO}_2\text{H}$  (1)
- (ii)  $\sqrt{K_a[\text{HCO}_2\text{H}]} = \sqrt{1.77 \times 10^{-4} \times 0.05} = 2.97 \times 10^{-3}$   
 (3.0 x 10<sup>-3</sup>) (1)
- (iii)  $100 \times 2.97 \times 10^{-3} / 0.05 = 5.94\%$  (6%) (1)
- (iv)  $\text{pH} = -\log_{10}(2.97 \times 10^{-3}) = 2.5(2)$  (1) [4]
- (b)  $\text{pH} = -\log_{10}(0.05) = 1.30$  (1) [1]

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- (c) (i)  $2\text{HCO}_2\text{H} + \text{Mg} \rightarrow (\text{HCO}_2)_2\text{Mg} + \text{H}_2$  (1)  
 (or  $2\text{H}^+ + \text{Mg} \rightarrow \text{Mg}^{2+} + \text{H}_2$ )
- (ii) moles of  $\text{H}^+$  =  $0.05 \times 20/1000$  =  $1 \times 10^{-3}$  (1)  
 moles of  $\text{H}_2$  =  $1 \times 10^{-3}/2$  =  $0.5 \times 10^{-3}$   
 volume of  $\text{H}_2$  =  $0.5 \times 10^{-3} \times 24,000$  = **12 cm<sup>3</sup>** (1)  
 (or =  $0.5 \times 10^{-3} \times 22400$  = **12 cm<sup>3</sup>**)
- (iii) (rate  $\propto [\text{H}^+]$ ) lower  $[\text{H}^+]$  in methanoic acid or  $\text{HCO}_2\text{H}$  dissociates slowly/partially (1)
- (iv) the equilibrium ( $\text{HCO}_2\text{H} \rightleftharpoons \text{HCO}_2^- + \text{H}^+$ ) continually shifts to the right as  $\text{H}^+$  is used up (1) [5]  
**Total: 10**

- 3 (a) (i)  $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$  (1) + (1)  
 [or  $\text{MnO}_4^- + 4\text{H}^+ + 3\text{Fe}^{2+} \rightarrow \text{MnO}_2 + 3\text{Fe}^{3+} + 2\text{H}_2\text{O}$ ]  
 (reactants + products) + balancing
- (ii)  $\text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ + 3\text{SO}_2 \rightarrow 2\text{Cr}^{3+} + 3\text{SO}_4^{2-} + \text{H}_2\text{O}$  (1) + (1) [4]  
 (or molecular equations including the counter ions  $\text{K}^+$  and  $\text{SO}_4^{2-}$ )
- (b) (i) purple (1)
- (ii) the first (permanent) pink colour (from a colourless solution) (1)  
 $n(\text{MnO}_4^-) = 0.01 \times 14/1000 = 1.4 \times 10^{-4}$  (1)  
 $n(\text{Fe}^{2+}) = 5 \times 1.4 \times 10^{-4} = 7 \times 10^{-4}$   
 $\text{FeSO}_4 = 55.8 + 32.1 + 64 = 151.9$  (1)  
 so mass =  $151.9 \times 7 \times 10^{-4} = \mathbf{0.106 \text{ g}}$  (1) [5]
- (c) (i) to carry  $\text{O}_2$  from lungs to muscles/tissues  
 the  $\text{O}_2$  molecule is a ligand attached to the Fe atom/ $\text{Fe}^{2+}$  ion in haemoglobin (1)
- (ii) CO exchanges with  $\text{O}_2$  and forms a **stronger ligand bond.** [1] [3]  
**Total: 12 max 11**

- 4 (a) phenol, ester, arene/benzene ring any two (1) + (1) [2]
- (b) (i)  $\text{Na}^+ \text{O}-\text{C}_6\text{H}_4-\text{CO}_2\text{C}_2\text{H}_5$  (1)
- (ii)  $\text{Na}^+ \text{O}-\text{C}_6\text{H}_4-\text{CO}_2^- \text{Na}^+$  ✓  $\text{C}_2\text{H}_5\text{OH}$  ✓ (2)
- (iii)  (1) [4]

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- (c) (i) acidity:  $G > E > F$  (1)
- (ii) only G reacts/gives off  $\text{CO}_2$  with  $\text{Na}_2\text{CO}_3$  (1)
- E and G both dissolve in  $\text{NaOH}(\text{aq})$  (1) [3]
- Total: 9**

- 5 (a) reagents:  $\text{NaOH} + \text{I}_2$  (1)
- observations: yellow solid/ppt. with H and nothing with L. (1) [2]

- (b) J is more acidic than propanoic acid (1)
- chlorine is electroegative/electron-withdrawing (1) [2]

- (c)
- $$\text{NH}_2\text{CH}(\text{CH}_3)\text{CO}_2\text{H} + (\text{Na}^+)\text{OH}^- \longrightarrow \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ | \quad | \quad || \\ \text{N} - \text{C} - \text{C} - \text{O}^- (\text{Na}^+) \\ | \quad | \\ \text{H} \quad \text{CH}_3 \end{array} + \text{H}_2\text{O}$$
- balancing* (1)
- displayed formula* (1) [2]

- (d)  $+\text{NH}_3\text{CH}(\text{CH}_3)\text{CO}_2^-$  (1) [1]

- (e) (i) peptide *or* amide (1)

- (ii)
- $$\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \quad \text{H} \quad \text{H} \quad \text{O} \\ | \quad | \quad || \quad | \quad | \quad || \\ \text{N} - \text{C} - \text{C} - \text{N} - \text{C} - \text{C} - \text{OH} \\ | \quad | \quad \quad | \\ \text{H} \quad \text{CH}_3 \quad \quad \text{CH}_3 \end{array}$$
- (1) [2]

- (f) (i)  $\text{C}_6\text{H}_5\text{COCl}$  (1)

- (ii)  $\text{HCl}$  *or*  $\text{H}_2\text{SO}_4$  *or*  $\text{NaOH}$  (1)

- (aq) + heat/reflux (1) [3]
- Total: 12**

- 6 (a) (i)  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$  (1)

- (ii)  $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$  (1) [2]

- (b) to reduce acidity/raise the pH of soil/neutralize acid soils (1) [1]

- (c) more stable down the group (1)

- (due to) larger cations (1)

- (hence) less polarization/distortion of  $\text{CO}_3^{2-}$  (1) [3]
- Total: 6**