



RECOGNISING ACHIEVEMENT

UNIFYING CONCEPTS  
IN CHEMISTRY

Mark Scheme 2816/01

January 2003



1. (a) Forward and reverse reactions at same rate ✓

Achievable from either direction ✓, requires closed system ✓

concentrations of reactants and products are constant ✓

max: [2]

(b) (i)  $K_c = \frac{[\text{CH}_3\text{OH}(\text{g})]}{[\text{CO}(\text{g})][\text{H}_2(\text{g})]^2}$  ✓✓ 1 mark for top; 1 mark for bottom

[2]

(ii)  $K_c = \frac{(2.6 \times 10^{-5})}{(3.1 \times 10^{-3})(2.4 \times 10^{-2})^2}$  ✓ = 14.6 ✓ ( $\text{dm}^6 \text{mol}^{-2}$ )

[2]

- (c) (i) Why did the equilibrium move to the right

fewer molecules on right ✓

reaction relieves increase in pressure ✓

[2]

- (ii) What is the effect, if any, on  $K_c$

$K_c$  stays same ✓

[1]

- (iii) Rate changes

Rate increases ✓

Increased collisions/more concentrated ✓

Rates initially forward faster than reverse ✓

At equilibrium, rates same ✓

[4]

- (d) (i)  $K_c$  decreases so products decrease/reactants increase ✓

Therefore equilibrium moves to the left/to endothermic side ✓

2nd mark dependent on first.

[2]

- (ii)  $\Delta H$  is negative because of equilibrium change in (i) ✓

Mark consequential on (i)

[1]

- (iii) Partial pressure decreases because less  $\text{CH}_3\text{OH}$  is now present ✓

[1]

[Total: 17]

2. (a) (i)  $m(\text{NH}_4\text{NO}_3) = 80$  ✓  
 moles  $\text{N}_2\text{O} = \text{moles } \text{NH}_4\text{NO}_3 = 100/80 = 1.25$  mol ✓  
 mass  $\text{N}_2\text{O} = 1.25 \times (28 + 16) = 55$  g ✓  
 [3]
- (ii) nitrogen in  $\text{NH}_4^+$ :  $-3 \longrightarrow +1$  / increases by 4 ✓  
 nitrogen in  $\text{NO}_3^-$ :  $+5 \longrightarrow +1$  / decreases by 4 ✓  
 [2]
- (b) (i) 1st order has a constant half life ✓  
 Evidence from graph, either drawn or stated below with 2 half lives ✓  
 half life approx 52 s ✓  
 [3]
- (ii) rate =  $k[\text{N}_2\text{O}(\text{g})]$  ✓  
 [1]
- (iii) evidence of tangent on graph ✓  
 rate =  $0.00524$  ✓  $\text{mol dm}^{-3} \text{s}^{-1}$   
 (allow  $\pm 0.005$  : i.e. values in range  $0.00475 - 0.00575$   $\text{mol dm}^{-3} \text{s}^{-1}$ )  
 [2]
- (iv)  $0.00524$  (ans to (ii)) =  $k \times 0.400$   
 $k = 0.0131$  ✓  $\text{s}^{-1}$  ✓  
 [2]
- (v) rate determining step involves 1 molecule of  $\text{N}_2\text{O}$  ✓  
 equation shows 2 mol  $\text{N}_2\text{O}$  reacting ✓  
 [2]
- (c) Increases the pressure/rate increases ✓  
 Gives out heat ✓  
 Forms oxygen  $\longrightarrow$  more efficient combustion ✓  
 moles of products > moles of reactants ✓

[2 max]

[Total: 17]

3. (a)

Acid is a proton/ $H^+$  donor ✓Base is a proton/ $H^+$  acceptor ✓Conjugate acid has  $H^+$  more than conjugate base ✓

Equation showing acid-base pairs ✓

2 acid-base pairs labelled correctly ✓

Dilute acid has small number of moles dissolved per volume ✓

Weak acid has partial dissociation ✓

[7]

**Quality of Written Communication**

At least **two** complete sentences that are legible and where the spelling, punctuation and grammar allow the meaning to be clear. At least one equation shown. ✓

[1]

(b) (i)

$$K_a = \frac{[H^+(aq)][CN^-(aq)]}{[HCN(aq)]} \quad \checkmark$$

[1]

(ii)

$$K_a = \frac{[H^+(aq)]^2}{[HCN(aq)]} \quad \therefore 4.9 \times 10^{-10} = \frac{[H^+(aq)]^2}{0.010} \quad \checkmark$$

$$[H^+(aq)] = \sqrt{\{(4.9 \times 10^{-10}) \times (0.010)\}} = 2.2 \times 10^{-6} \text{ mol dm}^{-3} \quad \checkmark$$

$$\text{pH} = -\log[H^+(aq)] = -\log 2.2 \times 10^{-6} = 5.65/5.66/5.7 \quad \checkmark$$

(accept calculator value)

[3]

[Total: 12]

4. (a) (i)

$$\begin{array}{rcccc}
 & \text{C} & : & \text{H} & : & \text{O} \\
 = & 66.7/12 & : & 11.1/1 & : & 22.2/16 \quad \checkmark \\
 = & 5.56 & : & 11.1 & : & 1.39 \\
 = & 4 & : & 8 & : & 1
 \end{array}$$

empirical formula =  $\text{C}_4\text{H}_8\text{O}$  ✓ $48 + 8 + 16 = 72$  which is half of  $M_r$ Therefore molecular formula =  $\text{C}_8\text{H}_{16}\text{O}_2$  ✓Structural formula =  $\text{CH}_3(\text{CH}_2)_6\text{COOH}$  ✓

[4]

- (ii) caprylic acid is a longer molecule/contains more electrons ✓  
 caprylic acid has more van der Waals forces between molecules ✓  
 caprylic acid has a higher boiling point / is less volatile ✓

[2 max]

(b)

$$[\text{H}^+(\text{aq})] = K_w / [\text{OH}^-(\text{aq})] \quad \checkmark = 1.00 \times 10^{-14} / 0.500 = 2.00 \times 10^{-14} \text{ mol dm}^{-3} \quad \checkmark$$

$$\text{pH} = -\log[\text{H}^+(\text{aq})] = -\log 2 \times 10^{-14} = 13.699 / 13.7 \quad \checkmark \quad (\text{calculator value: } 13.69897)$$

[3]

$$\text{moles NaOH in } 25.00 \text{ cm}^3 = \text{moles NaOH} = 0.0125 \text{ mol} \quad \checkmark$$

$$\text{moles A in } 21.40 \text{ cm}^3 = \text{moles NaOH} = 0.0125 \text{ mol} \quad \checkmark$$

$$\text{moles A in } 250 \text{ cm}^3 = 0.0125 \times 250/21.40 = 0.146 \text{ mol} / [\text{A}] = 0.584 \text{ mol dm}^{-3} \quad \checkmark$$

0.146 mol A has a mass of 10.8 g

$$\text{molar mass of A} = 10.8/0.146 = 74 \text{ g mol}^{-1} \quad \checkmark$$

Therefore A is propanoic acid /  $\text{CH}_3\text{CH}_2\text{COOH}$  ✓

[5]

[Total: 14]