Mark Scheme 2816/01
June 2006

UNIFYING CONCEPTS IN CHEMISTRY

Abbreviations, annotations and conventions used in the Mark Scheme		
	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument	

Question	Expected Answers	Marks
1 (a)	The contribution of a gas to the total pressure in a gas mixture / pressure exerted by the gas alone / mole fraction x total pressure / x P ✓	[1]
(b)	Mole fraction of Cl (g) 3.0/88.0 or 0.034 ✓ (calc. 0.034090909)	[1]
(c) (i)	$K_p = \frac{p\,Cl(g)^2}{p\,Cl_2(g)}$ ✓ state symbols not required	[1]
(ii)	$K_p = \frac{3^2}{85}$ = 0.11 / 0.106 ✓ kPa ✓ (calc: 0.1058823529) *Could be ecf from incorrect K_p expression.* pCl_2 / pCl^2, gives 9.4 kPa^{-1}. 2 pCl / pCl_2, gives 0.0706 / 0.071 no units. pCl / pCl_2, gives 0.0353 / 0.035 no units. no units must be specified.	[2]
(d)	Equilibrium moves to the side with fewer molecules which is → left/more Cl_2 / less Cl ✓ relieves the increased pressure/ minimises change/minimises this effect ✓ (*i.e.* attempts to explain in terms of le Chatelier)	[2]
(e)	K_p decreases so equilibrium goes to the left/more Cl_2 / less Cl ✓	[1]
(f)	Amount Cl_2 produced = 1.6 x 10^{12}/71 or 2.25 x 10^{10} mol ✓ Amount NaCl required = 2 x 2.25 x 10^{10} or 4.5 x 10^{10} mol ✓ ecf moles 2 x Cl_2 Volume brine = 4.5 x 10^{10}/4 = 1.125 x 10^{10} dm^3 ✓ ecf moles Cl_2/4 *i.e.* 1.12 – 1.13 x 10^{10} dm^3	[3]
		Total: 11

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Question	Expected Answers	Marks
2 (a)	(change in) concentration/mass/volume with time	[1]
(b) (i)	O_2: Exp 2 has 4 x $[O_2]$ as Exp. 1: rate increases by 4 ✓, so order = 1 with respect to O_2 ✓ NO: Exp 3 has 3 x [NO] as Exp. 3: rate has increases by 9✓, so order = 2 with respect to NO ✓	[4]
(ii)	rate = $k[O_2]\,[NO]^2$ ✓	[1]
(iii)	$k = \frac{\text{rate}}{[O_2]\,[NO]^2} = \frac{7.10}{0.0010 \times 0.0010^2} = 7.10 \times 10^9$ ✓ units: $dm^6\ mol^{-2}\ s^{-1}$ ✓	[2]
(c) (i)	The slowest step ✓	[1]
(ii)	$2NO_2 \rightarrow NO + NO_3$ ✓ $NO_3 + CO \rightarrow NO_2 + CO_2$ ✓ *(or similar stage involving intermediates)*	[2]
(d)	$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ ✓ N from +4 to +5 O from 0 to −2 ✓ Could be below equation	[2]
		Total: 13

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Question	Expected Answers	Marks
3 (a)	strength of acid/extent of dissociation/ionisation ✓	[1]
(b) (i)	$H_2SO_3(aq) + CH_3COOH(aq) \rightleftharpoons HSO_3^-(aq) + CH_3COOH_2^+(aq)$ acid 1 base 2 ✓ base 1 acid 2 ✓ *1 mark for labels on each side of equation*	[2]
(ii)	*CH_3COOH is the stronger acid/* K_a CH_3COOH is greater/ CH_3COOH is more acidic ORA ✓ $C_6H_5OH(aq) + CH_3COOH(aq) \rightleftharpoons C_6H_5OH_2^+(aq) + CH_3COO^-(aq)$ ✓	[2]
(c)	For HCl, pH = $-\log[H^+]$ ✓ (or with values). Could be awarded below = −log 0.045 = 1.35 ✓ (accept 1.3) For CH_3COOH, $[H^+] = \sqrt{(K_a \times [CH_3COOH])}$ / $\sqrt{(1.70 \times 10^{-5} \times 0.045)}$ ✓ *$[H^+] = 8.75 \times 10^{-4}\ mol\ dm^{-3}$* ✓ pH = $-\log 8.75 \times 10^{-4}$ = 3.058/3.06 ✓ (accept 3.1)	[5]
(d)	HCl and CH_3COOH have same number of moles/ release same number of moles H^+ / 1 mole of each acid produce ½ mol of H_2 ✓ $[H^+]$ in CH_3COOH < $[H^+]$ in HCl/ CH_3COOH is a weaker acid than HCl (ora) ✓ $Mg + 2HCl \rightarrow MgCl_2 + H_2$ ✓ $Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$ ✓ or $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ✓✓	[4]
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Question	Expected Answers	Marks

4	Buffer
	A buffer minimises changes in pH ✓
	
	Role of NH_4Cl
	NH_4Cl provides NH_4^+ /
	$NH_4Cl \rightarrow NH_4^+ + Cl^-$ ✓
	
	equilibrium:
	1 $NH_4^+ \rightleftharpoons NH_3 + H^+$ /
	2 $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ ✓
	
	How alkali is removed: ✓
	NH_4^+ removes added alkali / OH^-
	OR
	if equilibrium 1 has been used:
	H^+ removes added alkali / OH^- ✓
	Could be from an equation
	
	How acid is removed: ✓
	NH_3 *removes* added acid or H^+ /
	OR
	if equilibrium 2 has been used:
	OH^- *removes* added acid / H^+ ✓
	Could be from an equation
	
	A correct equilibrium statement:
	Any of the following ✓
	on addition of alkali,
	$NH_4^+ \rightleftharpoons NH_3 + H^+$ *moves to right*
	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ moves to left
	on addition of acid,
	$NH_4^+ \rightleftharpoons NH_3 + H^+$ moves to left
	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ moves to right
	
	QWC A correct equation **and** a correct chemistry sentence related to buffers ✓
		[6]
		
		[1]

		Total: 7

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Question			Expected Answers	Marks
5	(a)	(i)	*mass sucrose* = 0.47 x 43 g or 20.21 g ✓ M_r of sucrose = 342 ✓ moles sucrose = 0.47 x 43/342 or 0.059 mol ✓ (calc: 0.0590935672) no of sucrose molecules = .059 x 6.02 x 10^{23} = 3.6 x 10^{22} ✓	[4]
		(ii)	$C_{12}H_{22}O_{11}(s) + 12\ O_2(g) \rightarrow 12\ CO_2(g) + 11\ H_2O(l)$ ✓ Ignore state symbols Energy = .059 x 5640 = 332.76 kJ ✓ = 332.76/4.18 = 79.6 Calories ✓ (i.e. mol sucrose from (a) x 5640/4.18) If 0.059 is missed, 5640/4.18 = 1349 Calories would score 1 mark	[3]
	(b)		Empirical formula N : O = 63.64/14 : 36.36/16 ✓ = 4.56 : 2.27 = 2 : 1. Empirical formula = N_2O ✓ Molecular formula M_r of gas = 1.833 x 24 = 44 ✓ (calc 43.992) With these two pieces of evidence, assume that molecular formula = N_2O	[3]
	(c)		amount of NaOH in titration = 0.175 x 22.05/1000 or 3.86 x 10^{-3} ✓ (calc: 3.85875 x 10^{-3}) amount of **A** in 25.0 cm^3 = 0.5 x mol NaOH or 1.93 x 10^{-3} ✓ (calc: 1.929375 x 10^{-3}) amount of **A** in 250 cm^3 = 10 x 1.93 x 10^{-3} or 1.93 x 10^{-2} ✓ *1.93 x 10^{-2} mol* **A** *has a mass of 2.82 g* molar mass of **A** = 2.82/1.93 x 10^{-2} = 146 g mol^{-1} ✓ (or M_r of **A** is 146) Therefore **A** is adipic acid / $HOOC(CH_2)_4COOH$ ✓	[5]
				Total: 15