OCR

RECOGNISING ACHIEVEMENT

A2

UNIFYING CONCEPTS IN CHEMISTRY

Mark Scheme 2816/01
June 2004

Question			Expected Answers	Marks
1	(a)	(i)	rate at start (of reaction)/ t=0 ✓	[1]
		(ii)	0.048 (mol dm^{-3} s^{-1}) ✓	[1]
	(b)	(i)	$C_{12}H_{22}O_{11}$(aq): Exp 2 has twice [$C_{12}H_{22}O_{11}$ (aq)] as Exp 1 and rate x 2 ✓, so order = 1 with respect to $C_{12}H_{22}O_{11}$✓ HCl(aq): Exp 3 has 1.5 x [HCl] as Exp 1 and rate increases by 1.5 ✓, so order = 1 with respect to HCl(aq) ✓ *ORDER HAS TO BE CORRECT TO GET REASON MARK*	[4]
		(ii)	2/second order ✓ This will be dependent on answer to (i)	[1]
		(iii)	rate = k[$C_{12}H_{22}O_{11}$] [HCl] ✓✓ OR rate = 2.4 [$C_{12}H_{22}O_{11}$] [HCl] ✓✓ *rate* = k [$C_{12}H_{22}O_{11}$] [H_2O] scores 1 mark) *rate* = [$C_{12}H_{22}O_{11}$] [HCl] scores 1 mark) k [$C_{12}H_{22}O_{11}$] [HCl] scores 1 mark) k = [$C_{12}H_{22}O_{11}$] [HCl] scores zero Check for ecf from (i)	[2]
	(c)		increases ✓	[1]
	(d)	(i)	time for concentration (of a reactant) to fall to half the original value ✓	[1]
		(ii)	$C_{12}H_{22}O_{11}$: 0.05 mol dm^{-3} ✓ In one half life, [$C_{12}H_{22}O_{11}$], concentration halves 0.1/2 ✓ HCl: 0.1 mol dm^{-3} ✓ *Assume* mol dm^{-3} unless told otherwise *Assume* 'mol dm^3 means mol dm^{-3} but Penalise wrong unit once only	[3]
				Total: 14

Question	Expected Answers	Marks
2 (a) (i)	$K_c = \frac{[NO]^2}{[N_2]\,[O_2]}$ ✓✓ *award 1 mark if upside down* *K_p expression worth 1 mark*	[2]
(ii)	Equil ⟶ left because K_c is very small	[1]
(iii)	$[O_2(g)] = \frac{[NO]^2}{[N_2] \times K_c} = \frac{(4.0 \times 10^{-16})^2}{1.1 \times 4.8 \times 10^{-31}}$ ✓ = 0.30 mol dm^{-3}✓ (calculator: 0.303030303) answer given to 2 sig figs✓ 3.3 ✓✓ (upside down) calc: 3.3 7.6×10^{14} ✓✓ (missing out ^{2}) calc: 7.5757….. 0.37 ✓✓ (1.1 on top) calc: 0.366666.. 5.2×10^{-46} ✓✓ ('4' values swapped) calc: $5.236363. \times 10^{-46}$	[3]
(b) (i)	ΔH is +ve ✓	
(ii)	equilibrium moves to the right to compensate for increase in temperature/to lower the temperature / to minimise the change ✓ increase in proportion of NO ✓ because K_c increases *Can be linked to either increased proportion of NO or enthalpy change* ✓	[4]
(iii)	$2NO + O_2 \longrightarrow 2NO_2$ ✓✓ *species correct for 1st mark* *'simplest' balanced equation for 2nd mark* $NO + {}^1/_2O_2 \longrightarrow NO_2$ also gets both marks *N_2O_4 is fine* *NO_2 for 1st mark*	[2]

(c)	Optimum Pressure low pressure ✓ fewer gaseous moles on left ✓ Optimum Temperature optimum: low temperature ✓ forward reaction is exothermic ✓ Reason mark can only be awarded if the condition mark is correct. Condition mark is independent 1000°C used to increase rate with more energetic collisions *OR* so that a greater proportion of molecules exceed activation energy ✓	
	10 atm used to increase rate by increasing concentration *OR* increasing collisons ✓ Catalyst used to increase rate by lowering the activation energy/providing a lower energy route ✓ *NOT increase equilibrium yield* Quality of written communication: Recognition of a compromise between rate and equilibrium amount ✓	[7] [1]
		Total: 20

Question			Expected Answers	Marks
3	(a)	(i)	$pH = -\log[H^+(aq)]$ ✓ *state symbols not needed*	[1]
		(ii)	HBr is stronger than CH_3COOH because pH is lower ✓ HBr dissociates more/more H^+ ions..... for the same concentration ✓	[2]
		(iii)	*diluting by a factor of 10/ 10-fold dilution* ✓ pH = 3 ✓ Credit a calculated pH for ecf from a wrong dilution with working shown	[2]
	(b)	(i)	$K_w = [H^+(aq)]\,[OH^-(aq)]$ ✓ *state symbols not needed*	[1]
		(ii)	$[H^+(aq) = \frac{K_w}{[OH^-(aq)]} = \frac{1.0 \times 10^{-14}}{0.0200} = 5 \times 10^{-13}$ mol dm^{-3} ✓ $pH = -\log(5 \times 10^{-13}) = 12.30$ ✓ (accept calc value: 12.30103) ecf is possible for pH mark providing that the $[H^+]$ value has been derived from $K_w/[OH^-]$ If pOH method is used, pOH = 1.7 would get 1st mark, pH = 14 – 1.7 = 12.3 gets 2nd mark.	[2]
	(c)	(i)	start at pH=3.4 (approx half way up 0-7 rise) ✓ sharp rise at 20 cm^3 (must have a vertical part) ✓ finish higher above pH 7 than starting pH .....with line continued to 50 cm^3 .....but finish pH is less than 14 ✓ NOTE that lines should not loop	[3]
		(ii)	Indicator that has a pH range coinciding with steepest part of titration curve in (i). Likely to be thymol blue OR brilliant yellow✓ pH range coincides with .....pH change during sharp rise /equivalence point ✓	[2]
				Total: 13

Question	Expected Answers	Marks
4 (a)	P : O = 43.7/31 : 56.3/16 / 1.41 : 3.52 ✓ Ratio P:O = 2 : 5 / Empirical formula = P_2O_5 ✓ Molecular formula = P_4O_{10} (from M_r value) ✓ $Ca_3(PO_4)_2$ ✓ Equations: $P_4 + 5O_2 \longrightarrow P_4O_{10}$ ✓ (or $P_4 + 5O_2 \longrightarrow 2P_2O_5$) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ ✓ (or $P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$) $Ca_3(PO_4)_2 + 3H_2SO_4 \longrightarrow 2H_3PO_4 + 3CaSO_4$ ✓ A candidate who writes an equation forming P_4O_8 or P_2O_3 can score the equation mark for oxidation of P_4.	[3] [1] [3]
(b) (i)	$H_3PO_4 > H_2PO_4^- > HPO_4^{2-}$ Increased strengths with increasing K_a values✓	[1]
(ii)	Molar mass of Na_2HPO_4 = 142 g mol^{-1} ✓ amount of Na_2HPO_4 = 4.26/142 = 0.03 mol ✓ *e.c.f. mass/molar mass* volume of H_3PO_4 needed = 0.03 x 1000 / 0.5 = 60 cm^3 ✓ *e.c.f. moles Na_2HPO_4 x 1000/0.5* amount of NaOH = 2 x 0.03 = 0.06 mol ✓ *e.c.f. 2 x moles Na_2HPO_4* volume of NaOH needed = 0.06 x 1000 / 0.5 = 120 cm^3 ✓ *e.c.f. moles NaOH x 1000/0.5* Penalise units once.	[5]
		Total: 13