Phone: +442081445350

www.chemistryonlinetuition.com

Email:asherrana@chemistryonlinetuition.com

CHEMISTRY

PHYSICAL CHEMISTRY

Level & Board	CIE (A-LEVEL)
TOPIC:	EQUILIBRIA
PAPER TYPE:	SOLUTION - 1
TOTAL QUESTIONS	10
TOTAL MARKS	75

Equilibria - 1

1)

(a) A weak acid dissociates incompletely in water to give H^+

$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$

$CH_3CO_2H(aq) \rightleftharpoons H+(aq) + H+(aq) + CH_3CO_2^-(aq)$

(b) (i) C_i /mold m^{-3} 0.100 - -

C_{eqm} /mold m^{-3} 0.100 – x X X

$$k_C \frac{[H^+][CH_3CO_2^-]}{[CH_3CO_2H]}$$

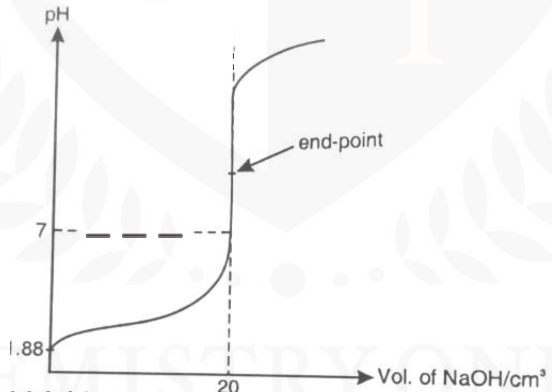
$$1.74 \times 10^{-5} = \frac{x^2}{0.100 - x}$$

Assume x << 0.100 since CH_3CO_2H is a weak acid.

$$1.74 \times 10^{-5} = \frac{x^2}{0.100}$$

x = 1.319×10^{-2} mol dm^{-3}

pH = -lg[H^+] = 1.88



Indicator : phenolphthalein

(c) $n_{HCl} 0.200 \times \frac{14}{1000} = 2.8 \times 10^{-3} mol$

n_N = 2.8×10^{-3} mol

m_N = $2.8 \times 10^{-3} \times 14 = 3.92 \times 10^{-2}$g

% N = $\frac{3.92 \times 10^{-2}}{0.100} \times 100$ = 39.2%

2)

(a) A buffer is usually a mixture of a weak acid and its salt or a weak base and its salt, and it is able to resist pH changes when a little acid or base is added to it.

(b) $OH^- + H^+ \longrightarrow H_2O$

When OH- it is removed by reading with the H+ in the system.
Hence, the pH does not increase.

(c) $K_a \frac{[H^+][HCO_3^-]}{[CO_2]}$

$7.90 \times 10^{-7} = [H^+].\frac{20}{1}$

$[H^+] = 3.95 \times 10^{-8}$ mol dm^{-3}

$\therefore$ pH = - lg[H$^+$] = 7.40

(d) (i) $CO_2 + Ba(OH)_2 \longrightarrow BaCO_3 + H_2O$

(ii) Mr of $BaCO_3$ = 137 + 12 + 3 × 16 = 197

$n_{BaCO3} = \frac{0.600}{197} = 3.05 \times 10^{-3}$ mol

Hence, total amount of CO2 + HCO_3^- = 3.05 = 10^{-3} mol.

$\frac{[HCO_2^-]}{[CO_2]} = \frac{20}{1}$

$[HCO_3^-] = 20[CO_2]$

$[HCO_3^-] + [CO_2] = 21[CO_2]$

$\frac{3.05\times10^{-3}}{\frac{100}{100}} = 21[CO_2]$

$[CO_2] = 1.45 \times 10^{-3}$ mol d^{m-3}

3)

(b) (i) $K_{sp} = [Sr^{2+}][IO_3^-]^2$ mol^3 dm^{-9}

(ii) Let $[Sr^{2+}]$ = x.

Then $[IO_3^-]$ = 2x

$X(2x)^2 = 1.1\times10^{-9}$

X = 6.50 × 10-4 mol dm^{-3}

4)

(b) (i) $HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$

$[H^+] = 0.08 \times 0.1$

$= 8 \times 10^{-3}$ mol dm^{-3}

pH = - lg[H^+] = 2.1

(ii) The dissociation of HF involves breaking the H – F bond. This process is highly endothermic as indicated by the high bond energy.

5)

(a) (i) $pK_a = -\lg K_a$

(ii) for a weak acid, $HA \rightleftharpoons H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

(iii) $K_a = 10^{-2.57}$

$= 2.69 \times 10^{-3}$ mol dm^{-3}

(b) (i) FCH_2CO_2H

CH_3CO_2H

(ii) The pressure of electronegative F and Cl withdraws negative charge away from – CO_2^- by inductive effective. This spreads the charge and stabilizes the anion. Hence, the acids FCH_2CO_2H and $ClCH_2H$ are stronger. F is more electronegative than Cl. Hence, the stabilizing effect is greater and FCH_2CO_2H is more acidic than $ClCH_2CO_2H$.

6)

(b) (i) $K_p = -\frac{P_{N_2O_3}^2}{P_{N_2O_3}^2 P_{NO}^2}$

(ii) $K_c = \frac{0.25^2}{0.75 \times 1.5^2}$ = 0.0370 atm^{-1}

(c) (i) According to Le Chateller's principle, when temperature increase, the position of equilibrium shifts to the left whereby the excess heat is removed since the backward reaction is endothermic.

(ii) When pressure is increased, according to Le Chatelier's principle, the position of equilibrium shifts to the right where there is a reduction in the number of gaseous particles. This helps to reduce the increased pressure.

7)

(a) The rate of forward reaction equals the rate of backward reaction.

(b) $K_a = \frac{[CH_3CO_2C_2H_5][H_2O]}{[CH_3CO_{2H}][C_2H_5OH]}$

(c) $CH_3CO_2H + C_2H_5OH \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$

Initial moles

Let x be the number of moles of reactants used and that of products produced

equilibrium moles (0.5 – x) (0.5 – x) (0.1 + x) (0.1 + x)

equilibrium concentration / mole dm^{-3} $\frac{(0.5-x)}{V}$ $\frac{(0.5-x)}{V}$ $\frac{(0.1-x)}{V}$ $\frac{(0.1-x)}{V}$

$$K_c = \frac{\left(\frac{(0.1-x)}{V}\right)\left(\frac{(0.1-x)}{V}\right)}{\frac{(0.5-x)}{V}\frac{(0.5-x)}{V}}$$

$$4 = \frac{(0.1+x)^2}{(0.5+x)^2}$$

$(0.5 - x)^2 4 = (0.1 + x)^2$

$2(0.5 - x) = (0.1 + x)$

$1 - 2x = 0.1 + x$

$x = 0.3$

$\therefore n(CH_3CO_2H) = n(C_2H_5OH) = 0.5 - 0.3 = 0.2$

$n(CH_3CO_2C_2H_5) = n(H2O) = 0.1 + 0.3 = 0.4$

Reagent(s) and conditions \ alcohol	$CH_3CH_2CH_2OH$	$CH_3CH_2CH(OH)CH_3$	$(CH_3)_3COH$
Red phosphorus and iodine heat under reflux		$CH_3CH_2CHCH_3$ (with I attached to the CH)	
Concentrated H_2SO_4 heat			$CH_2{-}C{=}CH_2$ (with CH attached to the C)
$Cr_2O_7^{2-}/H^+$ Heat under reflux	$CH_3CH_2CH_3CO$	$CH_3CH_2COOH_3$	no reaction

8)

(i) $K_a = \frac{[RCO_2^-][H^+]}{[RCO_2H]}$

(i) $pK_a = -\log10\ K_a$

(b) (i) Acid strength increases down the table. As the number of chlorine atoms increase, electron with – drawing effect increases making anjon more stable.

(ii) Chlorine atom is further away from O — H in number 4, so it has less influence upon — OH, making acid to be weaker than in number 2.

(iii) $pH = \frac{1}{2}(pK_a - \log_{10}[Acid])$

$= \frac{1}{2}(4.9 - \log_{10}0.01$

$= \frac{1}{2}(4.9 + 2) = 3.45 \approx 3.5$

9)

(a) $2\ MnO_4^-\ 5\ H_2O_2 + 6\ H^+ \rightarrow 2\ Mn^{2+} + 8\ H^2O + 5\ O_2$

(b) $E^{\ominus}_{cell}$ = 1.52 – 0.68 = + 3 × 0.84 V

(c) (i) Colour changes from purple to colourless

Since $H_2O_2 : MnO_4^- = 5 : 2$

$n(H_2O_2) = \frac{5}{2} \times 3 \times 10^{-4}$ in 25 cm^3

$\therefore [H_2O_2] = 7.5 \times \frac{1000}{25} = 3.0 \times 10^{-2}$ mol dm^{-3}

10)

(a) High temperature and pressure provide enough energy to break $N \equiv N$ bond.

(b) (i) C_1 CO_1 hydrocarbons and SO_2 and H_2S_1 NO_x

(ii) Pt or Pd and Rh

(iii) $2NO + 2CO \rightarrow 2CO_2 + N_2$ or $2NO + C \rightarrow CO_2 + N_2$

(c) (i) $Kc = \frac{[NO]^2[Cl_2]}{[NOCl]^2}$, unit: mol dm^{-3}

(ii) 230 ^{0}C: $Kc = \frac{(1.46\times10^2)^2\times(1.15\times10^{-2})}{(2.33\times10^{-3})^2} = 4.5 \times 10^{-3}\ mol\ dm^{-3}$

465 ^{0}C: $Kc = \frac{(7.63\times10^{-3})^2\times(2.14\times10^{-4})}{(3.68\times10^{-4})^2} = 9.2\ \times 10^{-2}\ mol\ dm^{-3}$

(iii) Endothermic because KC increases with temperature.

(d) (i) Equilibrium moves to R.H.S. because more moles on R.H.S.

(ii) No change to equilibrium position.

DR. ASHAR RANA

M.B.B.S / MS. CHEMISTRY

CHEMISTRY ONLINE TUITION

Phone: +442081445350
www.chemistryonlinetuition.com
Email: asherrana@chemistryonlinetuition.com

- Founder & CEO of Chemistry Online Tuition Ltd.
- Completed Medicine (M.B.B.S) in 2007
- Tutoring students in UK and worldwide since 2008
- CIE & EDEXCEL Examiner since 2015
- Chemistry, Physics, Math's and Biology Tutor

CONTACT INFORMATION FOR **CHEMISTRY ONLINE TUITION**

- UK Contact: 02081445350
- International Phone/WhatsApp: 00442081445350
- Website: www.chemistryonlinetuition.com
- Email: asherrana@chemistryonlinetuition.com

Address: 210-Old Brompton Road, London SW5 OBS, UK