Chemical Principles Coursework

Please submit via Blackboard with answers for Monday 27th March 2017 to the questions provided. Please provide all workings for required questions and include units where appropriate.

1. Identify each reactant and product in the following reactions as acid, base or neither. Arrange the species in each reaction as conjugate acid/base pairs.

   a) $NH_3 + HI \rightleftharpoons NH_4^+ + I^-$

   b) $CH_3COOH + NO_2^- \rightleftharpoons HNO_2 + CH_3COO^-$

(20 marks)

$NH_3 + HI \rightleftharpoons NH_4^+ + I^-$

B.L. BASE 2½ | B.L ACID 2½ | CONJ ACID 2½ | CONJ BASE 2½

$CH_3COOH + NO_2^- \rightleftharpoons HNO_2 + CH_3COO^-$

B.L. ACID 2½ | B.L. BASE 2½ | CONJ ACID 2½ | CONJ BASE 2½

2. Classify the following samples from most acidic to most basic.

   a) Blood (pH 7.4)
   b) A 1 M solution of hydrochloric acid 0
   c) Tomatoes (pH 4.5)
   d) Milk (pH 6.5)
   e) A solution of sodium hydroxide at 0.100 mol.dm^{-3} 13
   f) A solution B that has $[H_3O^+] = 8.2 \times 10^{-2}$ mol.dm^{-3} =1.08
   g) A neutral solution of water =7

ACIDIC B, F, C, O, G, A, E BASIC

(1) for each in order

(20 marks)

2b) $pH = -\log_{10}[H^+_{(aq)}]$ (1) $\Rightarrow pH = -\log_{10}[1.0]$ (1) $\Rightarrow pH = 0$ (1)

e) $[NaOH] = 0.1\ mol\,dm^{-3}$

$\therefore [OH^-_{(aq)}] = 0.1\ mol\,dm^{-3}$ (1)

$\therefore [H^+_{(aq)}] = \frac{K_w}{[OH^-]}$ (1) $= \frac{10^{-14}\ mol^2\,dm^{-6}}{0.1\ mol\,dm^{-3}}$ (1) (1)

$\therefore [H^+_{(aq)}] = 10^{-13}\ mol\,dm^{-3}$ (1)

$\therefore pH = -\log[10^{-13}] = 13$ (1)

F) $[H^+_{(aq)}] = 8.2 \times 10^{-2}\ mol\,dm^{-3}$ $\therefore pH = -\log[8.2 \times 10^{-2}] = 1.08$ (1) (1)

$\therefore pH = 1.08$

g) $pH = 7$ (1)

3. Complete the following table:

$[H_3O^+]$ mol.dm^{-3}	3.6×10^{-3}	2.77×10^{-12} (2)	3.98×10^{-11} (2)	1.54×10^{-10} (2)	10^{-7} (2)
$[HO^-]$ mol.dm^{-3}	2.77×10^{-12} (2)	3.6×10^{-3}	2.51×10^{-4} (2)	6.3×10^{-5}	10^{-7} (2)
pH	~~1.55~~ 2.44 (2)	11.55 (2)	10.4	9.81 (2)	7.0

(20 marks)

$[OH^-] = \frac{10^{-14}\ mol^2dm^{-6}}{3.6\times10^{-3}\ mol\,dm^{-3}} = 2.77\times10^{-12}\ mol\,dm^{-3}$

pH = ~~1.55~~ 2.44

$[H^+] = \frac{10^{-14}\ mol^2dm^{-6}}{3.6\times10^{-3}\ mol\,dm^{-3}}$

$[H^+] = 2.77\times10^{-12}\ mol\,dm^{-3}$

pH = 11.55

$[H^+_{(aq)}] = 10^{-pH} = 10^{-10.4}$

$[H^+_{(aq)}] = 3.98\times10^{-11}\ mol\,dm^{-3}$

$so\ [OH^-] = \frac{10^{-14}\ mol^2dm^{-3}}{3.98\times10^{-11}\ mol\,dm^{-3}}$

$= 2.51\times10^{-4}\ mol\,dm^{-3}$

$[H^+] = \frac{10^{-14}}{6.5\times10^{-5}}$

$= 1.54\times10^{-10}$

So pH = 9.81

$[H^+] = 10^{-pH}$

$= 10^{-7}\ mol\,dm^{-3}$

$so\ [OH^-] = \frac{10^{-14}\ mol^2dm^{-6}}{10^{-7}\ mol\,dm^{-3}}$

4. Consider an aqueous solution of sodium hydroxide NaOH. What is the concentration [NaOH] in mol.dm^{-3} if the pH of the solution is 8.6 ?

ANS = 3.98×10^{-6} mol.dm^{-3}

(20 marks)

Step1 Find $[H^+]$

$pH = -\log_{10}[H^+_{(aq)}]$ so $[H^+_{(aq)}] = 10^{-pH}$ (2) so $[H^+_{(aq)}] = 10^{-8.6}$ (2)

so $[H^+_{(aq)}] = 2.51\times10^{-9}\ mol\,dm^{-3}$ (1)

Step2 : Find $[OH^-]$ using k_w

$[OH^-_{(aq)}] = \frac{k_w}{[H^+_{(aq)}]}$ (6) so $[OH^-_{(aq)}] = \frac{10^{-14}\ mol^2dm^{-6}}{[2.51\times10^{-9}]\ mol\,dm^{-3}}$ (2)

so $[OH^-_{(aq)}] = 3.98\times10^{-6}\ mol\,dm^{-3}$ (2)

Step3: Consider stoichometry

So $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

$\therefore$ so $[NaOH] = 3.98\times10^{-6}\ mol\,dm^{-3}$ (2) $3.98\times10^{-6}\ mol\,dm^{-3}$

5. Calculate the pH of a solution of acetic acid where $[CH_3COOH]$ = 0.05 mol.dm^{-3}. (pK_a CH_3COOH/CH_3COO^- = 4.74)

ANS = 3.02

(20 marks)

Step1 write equation for dissociation and ka $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

Step2 From Pka, find ka

$K_a = 10^{-pK_a}$ (1)

$K_a = 10^{-4.74}$ (1)

$K_a = 1.81\times10^{-5}$ (1)

Step3 re-arrange step1 ka to find $[H^+]$

$\sqrt{K_a \times [CH_3COOH]} = [H^+]$ (1)

$\therefore \sqrt{(1.81\times10^{-5}) \times 0.05} = [H^+]$ (1)

$9.54\times10^{-4} = [H^+]$ (1)

$pH = -\log[9.5\times10^{-4}] \Rightarrow pH = 3.02$ (2)

$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ (1)

let $[CH_3COO^-] \equiv [H^+]$

$K_a = \frac{[H^+]^2}{[CH_3COOH]}$ (1)