SCH 4U1 - a

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Knowledge /15	Thinking /14	Communication /8

Chapter 8 Test - Acid-Base Equilibrium

THINKING (14 MARKS)

1. If the K_a for hydrofluoric acid, HF(aq), is 6.6×10^{-4}, calculate the pH of a 2.55 mol/L solution of hydrofluoric acid. (6 marks)

① $HF_{(aq)} + H_2O_{(l)} \Leftrightarrow F^-_{(aq)} + H_3O^+_{(aq)}$

	$HF_{(aq)}$	+ $H_2O_{(l)}$	$\Leftrightarrow$ $F^-_{(aq)}$	+ $H_3O^+_{(aq)}$
I	2.55	–	0	0
C	$-x$	–	$+x$	$+x$
E	$2.55-x$	–	x	x

② $K_a = \dfrac{[F^-][H_3O^+]}{[HF]}$

$6.6\times10^{-4} = \dfrac{x^2}{2.55}$ ← 100 rule applies

$4.10\times10^{-2} = x$

$\therefore [H_3O^+_{(aq)}] = 4.10\times10^{-2}$

③ $pH = -\log[H_3O^+]$

$= -\log(4.10\times10^{-2})$

$= 1.387$

$\therefore$ pH of HF = 1.387

2. Determine whether a solution of ammonium nitrite is acidic, basic, or neutral. Show all of your work! (4 marks)

$NH_4NO_{2(aq)} \rightarrow NH_4^+_{(aq)} + NO_2^-_{(aq)}$

– both are weak acid-bases

① $NH_4^+_{(aq)} + H_2O_{(l)} \Leftrightarrow NH_{3(aq)} + H_3O^+_{(aq)}$ acidic

② $NO_2^-_{(aq)} + H_2O_{(l)} \Leftrightarrow HNO_{2(aq)} + OH^-_{(aq)}$ basic

$\therefore$ compare K_a and K_b

① $K_a = 5.8\times10^{-10}$

② $K_b = \dfrac{K_w}{K_a}$

$= 2.2\times10^{-11}$

③ $K_a > K_b$ $\therefore$ the solution will be acidic

3. What is the pH of a solution when 12.5 mL of 3.00 mol/L HI is titrated with 15 mL of 2.50 mol/L KOH? (4 marks)

① $n = C \times V$

$HI \Rightarrow H^+ + I^-$ $[H^+_{(aq)}] = 3\,mol/L \times 12.5\,mL$
1:1 ratio $= 37.5\,mmol$

$KOH \rightarrow K^+ + OH^-$ $[OH^-_{(aq)}] = 2.5\,mol/L \times 15\,mL$
1:1 ratio $= 37.5\,mmol$

② $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

37.5mmol	37.5mmol
0mmol	0mmol

∴ as both HI and KOH are used up completely, only water is produced. therefor the solution will have a pH of 7.00 due to no H^+ and OH^- remaining

COMMUNICATION (8 MARKS)

1. Show, using equations for each, how according to the Bronsted-Lowry theory, the hydrogen phosphate ion, $H_2PO_4^-$ (aq) is amphiprotic, whereas the fluoride ion, F^-, is not. Label in your equations for $H_2PO_4^-$ what are the acid (A), base (B), conjugate acid (CA), and conjugate base (CB). (4 marks)

① $H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow H_3PO_{4(aq)} + OH^-_{(aq)}$
B A CA CB

② $H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow HPO_4^{2-}{}_{(aq)} + H_3O^+_{(aq)}$
A B CB CA

③ $F^-_{(aq)} + H_2O_{(l)} \leftrightarrow HF_{(aq)} + OH^-_{(aq)}$

∴ in ①, $H_2PO_4^-$ acts as a base as it accepts a hydrogen atom (proton)
in ②, $H_2PO_4^-$ acts as an acid as it donates a proton
in ③, F^- can only accept protons and therefore is not amphiprotic and only acidic

2. You are given a solution of NH_3 (aq) that has a concentration of 0.10 M. The solution was titrated with 0.10 M HCl (aq). Sketch a titration curve below, showing the following: (4 marks)

a) The stoichiometric (equivalence) point (approximate pH
b) The region corresponding to the buffering action of the weak base
c) The endpoint of the titration.

$NH_{3(aq)} + HCl_{(aq)} \leftrightarrow NH_4^+{}_{(aq)} + Cl^-_{(aq)}$ Titration of Weak Base with Strong Acid

NH_3 weak base
HCl strong acid