pH, pOH, $[H^+]$, $[OH^-]$ problems

Jan 21st

1. a) $HCl \rightarrow H^+ + Cl^-$
1.0M → 1.0M

$\therefore [H^+] = 1.0M$ ✓

$pH = -\log_{10}[H^+]$
$= -\log_{10}[1.0M]$
$\therefore pH = 0$ ✓

$[OH^-] = \frac{kw}{[H^+]}$
$= \frac{1.0\times10^{-14}}{1M}$
$\therefore [OH^-] = 1.0\times10^{-14}\ M$ ✓

$pOH = 14 - pH$
$= 14 - 0$
$\therefore pOH = 14$ ✓

b) $HNO_3 \rightarrow H^+ + NO_3^{1-}$
0.50M → 0.50M

$\therefore [H^+] = 0.50M$ ✓

$pH = -\log_{10}[H^+]$
$= -\log_{10}[0.50M]$
$\therefore pH = 0.301$ ✓

$[OH^-] = \frac{kw}{[H^+]}$
$= \frac{1.0\times10^{-14}}{[0.50M]}$
$\therefore [OH^-] = 2\times10^{-14}\ M$ ✓

$pOH = 14 - pH$
$= 14 - 0.301$
$\therefore pOH = 13.699$ ✓

c) $HClO_4 \rightarrow H^+ + ClO_4^{1-}$
0.0020M → 0.0020M

$\therefore [H^+] = 0.0020M$ ✓

$pH = -\log_{10}[H^+]$
$= -\log_{10}[0.0020]$
$\therefore pH = 2.699$

$[OH^-] = \frac{kw}{[H^+]}$
$= \frac{1.0\times10^{-14}}{0.0020}$
$\therefore [OH^-] = 5.0\times10^{-12}\ M$

$pOH = 14 - pH$
$= 14 - 2.699$
$\therefore pOH = 11.301$

d) $KOH \rightarrow K^+ + OH^-$
$1.5\times10^{-4}M$ → $1.5\times10^{-4}M$

$\therefore [OH^-] = 1.5\times10^{-4}\ M$ ✓

$pOH = -\log_{10}[OH^-]$
$= -\log_{10}[1.5\times10^{-4}]$
$\therefore pOH = 3.824$ ✓

$[H^+] = \frac{kw}{[OH^-]}$
$= \frac{1.0\times10^{-14}}{[1.5\times10^{-4}]}$
$\therefore [H^+] = 6.66\times10^{-11}$ ✓

$pH = 14 - pOH$
$= 14 - 3.824$
$\therefore pH = 10.176$ ✓

f) $C_1V_1 = C_2V_2$

$C_2 = \frac{(0.001L)(0.20M)}{5.0L}$

$\boxed{C_2 = 4.0\times10^{-5}\ M}$ ✓

$HCl \rightarrow H^+ + Cl^-$
$\therefore [H^+] = 4.0\times10^{-5}M$

$pH = -\log_{10}[H^+]$
$= -\log_{10}[4.0\times10^{-5}]$
$\therefore pH = 4.398$

$[OH^-] = \frac{kw}{[H^+]}$
$= \frac{1.0\times10^{-14}}{4.0\times10^{-5}M}$
$\therefore [OH^-] = 2.5\times10^{-10}M$

$pOH = 14 - pH$
$= 14 - 4.398$
$\therefore pOH = 9.602$

e) $C = \frac{n}{V}$
$= \frac{(0.040g \times \frac{1mol}{40.01g})}{2.0L}$
$C = 1.999\times10^{-4}\ M$

$NaOH \rightarrow Na^+ + OH^-$
$\therefore [OH^-] = 5.0\times10^{-4}M$ ✓

$pOH = -\log_{10}[OH^-]$
$= -\log_{10}[5.0\times10^{-4}]$
$\therefore pOH = 3.30$

$[H^+] = \frac{kw}{[OH^-]}$
$= \frac{1.0\times10^{-14}}{(5.0\times10^{-4})}$
$\therefore [H^+] = 2.0\times10^{-11}\ M$

$pH = 14 - pOH$
$= 14 - 3.30$
$\therefore pH = 10.7$

* g) $\frac{0.10\ mol\ Na_2O}{1.0L} \times \frac{2\ mol\ NaOH}{1\ mol\ Na_2O} \times \frac{1\ mol\ OH^-}{1\ mol\ NaOH}$
$= 0.20\ mol\ OH^-/L$
$\therefore [OH^-] = 0.20\ M$ ✓

$Na_2O_{(s)} + H_2O \rightarrow 2NaOH$

$pOH = -\log_{10}[OH^-]$
$= -\log_{10}[0.20M]$
$\therefore pOH = 0.699$

$[H^+] = \frac{kw}{[OH^-]}$
$= \frac{1.0\times10^{-14}}{[0.20M]}$
$\therefore [H^+] = 5\times10^{-14}\ M$

$pH = 14 - pOH$
$= 14 - 0.699$
$\therefore pH = 13.301$

Jan 22

Problems 2-6

* cannot solve stoichometrically

2. a) $HCN \rightleftharpoons H^+ + CN^-$ $K_A = 4.0 \times 10^{-10}$

$[CN^-] = [H^+]$

$[HCN] = C^\circ_A - [H^+]$

$= 1.0M - [H^+]$

$K_A = \frac{[H^+][CN^-]}{[HCN]}$

$4.0 \times 10^{-10} = \frac{[H^+]^2}{1.0 - [H^+]}$

$[H^+] = \sqrt{4.0 \times 10^{-10}(1.0 - [H^+])}$ (0.05)

1.949×10^{-5}

1.999×10^{-5}

$[H^+] = 1.999 \times 10^{-5}$

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

$= -\log_{10}[0.00001999\ M]$

$pH = 4.699$ ✓

% dissociation $= \frac{[H^+]}{C^\circ_A} \times 100\%$

$= \frac{0.00001999M}{1.0} \times 100\%$

% dissociation $= 0.001999\%$ ✓

[b), c), d), e)]

f) $H_3BO_3 \rightleftharpoons H^+ + H_2BO_3^-$ $K_A = 5.9 \times 10^{-10}$

$[H_2BO_3^-] = [H^+]$

$[H_3BO_3] = C^\circ_A - [H^+]$

$= 0.5M - [H^+]$

$K_A = \frac{[H^+][H_2BO_3^-]}{[H_3BO_3]}$

$5.9 \times 10^{-10} = \frac{[H^+]^2}{0.5 - [H^+]}$

$[H^+] = \sqrt{5.9 \times 10^{-10}(0.5 - [H^+])}$ (0.05)

1.629×10^{-5}

1.718×10^{-5}

$[H^+] = 1.718 \times 10^{-5}$

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

$= -\log_{10}[0.00001718M]$

$pH = 4.77$ ✓

% diss $= \frac{[H^+]}{C^\circ_A} \times 100\%$

$= \frac{0.00001718M}{0.5M} \times 100\%$

% diss $= 0.003436\%$ ✓

3. $HF \rightleftharpoons H^+ + F^-$

$[F^-] = [H^+]$

$[HF] = C_A^\circ - [H^+]$

$C_A^\circ = \frac{n}{V}$

$= \frac{2.0g\left(\frac{1mol}{20g}\right)}{1.0L}$

$C_A^\circ = 0.1M$

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

$= 10^{-2.2}$

$[H^+] = 6.31 \times 10^{-3}M$

$K_A = \frac{[H^+][F^-]}{[HF]}$

$= \frac{[H^+]^2}{C_A^\circ - [H^+]}$

$= \frac{(6.31 \times 10^{-3})^2}{0.1M - 6.31 \times 10^{-3}}$

$K_A = 4.25 \times 10^{-4}$ ✓

* not actually HF?

4. $HX \rightarrow H^+ + X^-$

$[X^-] = [H^+]$

$[HX] = 0.100 - [H^+]$

% diss $= \frac{[H^+]}{C^\circ_A} \times 100$

$[H^+] = \frac{(6.0\%)(0.100M)}{100\%}$

$[H^+] = 0.006M$

$K_A = \frac{[H^+][X^-]}{[HX]}$

$= \frac{[H^+]^2}{0.100 - [H^+]}$

$= \frac{(0.006)^2}{0.100 - 0.006}$

$K_A = 3.83 \times 10^{-4}$ ✓

5. $HX \rightleftharpoons H^+ + X^-$

$C^\circ_A = 1.0 \times 10^{-3}\ M$

$[H^+] = 0.2 \times 1.0 \times 10^{-3}$

$= 2.0 \times 10^{-4}\ M$

$[HX] = C^\circ_A - [H^+]$

a) $pH = -\log_{10}[H^+]$

$= -\log_{10}[0.2 \times 10^{-4}]$

$pH = 3.70$

b) $[X^-] = [H^+]$

$[Y^-] = 2.0 \times 10^{-4}\ M$

c) $k_A = \dfrac{[H^+][X^-]}{[HX]}$

$= \dfrac{[H^+]^2}{C^\circ_A - [H^+]}$

$= \dfrac{(2.0 \times 10^{-4})^2}{1.0 \times 10^{-3} - 2.0 \times 10^{-4}}$

$k_A = 5.0 \times 10^{-5}$ ✓

6. $HBrO \rightarrow H^+ + BrO^-$ $\quad k_A = 2.0 \times 10^{-9}$, $pH = 4.8$, $C^\circ_A = ?$

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

$= 10^{-4.8}$

$[H^+] = 1.58 \times 10^{-5}\ M$

$[BrO^-] = [H^+]$

$[HBrO] = C^\circ_A - [H^+]$

$k_A = \dfrac{[H^+][BrO^-]}{[HBrO]}$

$2.0 \times 10^{-9} = \dfrac{[H^+]^2}{C^\circ_A - [H^+]}$

$C^\circ_A = \dfrac{(1.58 \times 10^{-5})^2}{2.0 \times 10^{-9}} + 1.58 \times 10^{-5}$

$C^\circ_A = 0.1248\ M$ ✓

Questions

Acid Base Equilibrium. Review

1. a) Cl^{1-} ✓ b) CH_3^{1-} ✓ c) SO_3^{2-} ✓ d) HSO_4^{1-} ✓ e) NH_2^{1-} ✓ f) ClO_4^{1-} ✓

eoq 2. a) $HCl + H_2O \rightleftharpoons H_3O^{1+} + Cl^{1-}$ (a1, b2, a2, b1) - lies right - acidic

c) $H_2SO_4 + H_2O \rightleftharpoons H_3O^{1+} + HSO_4^{1-}$ (a1, b2, a2, b1) - lies right - acidic

e) $H_2S + H_2O \rightleftharpoons H_3O^{1+} + HS^{1-}$ (a1, b2, a2, b1) - lies left - acidic

6. $HB + X^{1-} \rightleftharpoons HX + B^{1-}$ - lies right

a) X^{1-} and B^{1-} b) X^{1-} is stronger c) HX is weaker.

d) $K_A = \frac{[HX][B^{1-}]}{[HB][X^{1-}]}$, K_A is large e) S: ↑$[B^{1-}]$ R: ↓$[B^{1-}]$ H: use B^{1-} D: Shift left

eoq 8. a) $Na_2CO_3 \rightarrow 2Na^+ + CO_3^{2-}$

$CO_3^{2-} + H_2O \rightleftharpoons OH^- + HCO_3^-$ (b1, a2, b2, a1) - lies left - basic

c) $FeCl_3 \rightarrow Fe^{3+} + 3Cl^{1-}$

$Fe^{3+} + 3H_2O \rightleftharpoons Fe(OH)_3 + 3H^+$ - acidic (H^+)

$Fe^{3+} + 6H_2O \rightleftharpoons Fe(OH)_3 + 3H_3O^+$ (H_3O^+)

e) $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$

$Al^{3+} + 3H_2O \rightleftharpoons Al(OH)_3 + 3H^+$ - acidic (H^+)

g) $KHCO_3 \rightarrow K^+ + HCO_3^{1-}$

acid $HCO_3^{1-} + H_2O \rightleftharpoons H_3O^{1+} + CO_3^{2-}$ (a1, b2, a2, b1) - lies more left - acidic

base $HCO_3^{1-} + H_2O \rightleftharpoons H_2CO_3 + OH^{1-}$ (b1, a2, a1, b2) - lies left - basic

$[H_3O^{1+}] < [OH^{1-}]$ ∴ BASIC