A Special Equilibrium !!!!

Jan 21st

alternate

$H_2O \rightleftharpoons H^{1+} + OH^{1-}$

$2H_2O \rightleftharpoons H_3O^{1+} + OH^{1-}$

$k_w = [H^{1+}][OH^{1-}]$

↖ water

$kw = [H_3O^{1+}][OH^{1-}]$

$kw = 1 \times 10^{-14}$ @ 25°C

Provided:

1. $pH = -\log_{10}[H^{1+}]$
2. $pOH = -\log_{10}[OH^{1-}]$
3. $[H^{1+}] = 10^{-pH}$
4. $[OH^{1-}] = 10^{-pOH}$
5. $kw = [H^{1+}][OH^{1-}]$

$1 \times 10^{-14} = [H^{1+}][OH^{1-}]$

$\log 1 \times 10^{-14} = \log [H^{1+}][OH^{1-}]$

$-14 = \log[H^{1+}] + \log[OH^{1-}]$

$14 = -\log[H^{1+}] + (-\log[OH^{1-}])$ * $-\log[H^{1+}] = pH$, $-\log[OH^{1-}] = pOH$

6. $14 = pH + pOH$

ex - strong acid or base calculation (gr.11)

$HCl \longrightarrow H^{1+} + Cl^{1-}$ find $[H^{1+}]$ $[OH^{1-}]$, pH, pOH

12.1 M → 12.1 M

∴ $[H^{1+}] = 12.1$ M

↓

$pH = -\log_{10}[H^{1+}]$

$= -\log_{10}[12.1\ M]$

∴ $pH = -1.08279$

$k_w = [H^{1+}][OH^{1-}]$

$[OH^{1-}] = \frac{1 \times 10^{-14}}{[12.1\ M]}$

∴ $[OH^{1-}] = 8.26 \times 10^{-16}$ M

$pOH = -\log_{10}[OH^{1-}]$

$= -\log_{10}[8.26 \times 10^{-16}]$

∴ $pOH = 15.08279$

ex - $KOH \rightarrow K^{1+} + OH^{1-}$

6.0M → 6.0M

- must do one of the starting points stoichiometrically.

$\therefore [OH^{1-}] = 6.0M$

$[H^{1+}] = \frac{Kw}{[OH^{1-}]}$

$= \frac{1 \times 10^{-14}}{[6.0]}$

$\therefore [H^{1+}] = 1.66 \times 10^{-15} M$

$pH = -\log_{10}[H^{1+}]$

$= -\log_{10}[1.66 \times 10^{-15}]$

$\therefore pH = 14.778$

$pOH = 14 - pH$

$= 14 - 14.778$

$\therefore pOH = -0.778$

* once you know one, you're off to the races!

Do @ Problem #1

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

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

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

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

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

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