3. solubility: a measure of how much of a substance dissolves in water; in the process breaking intermolecular forces

$C_6H_{12}O_6\ (s) \rightleftharpoons C_6H_{12}O_6\ (aq)$

ionization: process where a dissolved particle will break an intramolecular bond to form two ions

4a) $HCO_3^-\ (aq) + S^{2-}\ (aq) \rightleftharpoons HS^-\ (aq) + CO_3^{2-}\ (aq)$

acid — base — conjugate acid — conjugate base

b) $H_2CO_3\ (aq) + OH^-\ (aq) \rightleftharpoons HCO_3^-\ (aq) + H_2O\ (l)$

Acid — base — conjugate base — conjugate acid

c) $HSO_4^-\ (aq) + HPO_4^{2-}\ (aq) \rightleftharpoons SO_4^{2-}\ (aq) + H_2PO_4^-\ (aq)$

acid — base — conjugate base — conjugate acid

d) $H_2O\ (l) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + OH^-\ (aq)$

acid — base — conjugate acid — conjugate base

5. $HNO_3\ (aq) \rightarrow H^+\ (aq) + NO_3^-\ (aq)$

a) 0.30 mol/L — 0.30 mol/L — 0.30 mol/L

b) $K_w = [H^+][OH^-]$

$1 \times 10^{-14} = (0.3)[OH^-]$

$[OH^-] = 3.3 \times 10^{-13}$

6. $[HCl] = \frac{n}{MV}$

$= 0.37\,g\ HCl \times \frac{1\ mol\ HCl}{36.46\,g\ HCl} \times \frac{1}{0.25\,L}$

$= 0.041\ \frac{mol\ HCl}{L}$

$m = 0.37\,g$ HCl
$M = 36.46\,g/mol$
$V = 0.25\,L$

$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

$0.041 \qquad 0.041\ \frac{mol}{L}$ strong acid

$K_w = [H^+][OH^-]$

$1 \times 10^{-14} = (0.041)[OH^-]$

$[OH^-] = 2.5 \times 10^{-13}\ \frac{mol}{L}$

7. a) $HI_{(aq)} \rightarrow H^+_{(aq)} + I^-_{(aq)}$

$0.006\ \frac{mol}{L} \qquad 0.006\ \frac{mol}{L} \quad 0.006\ \frac{mol}{L}$ strong acid

$pH = -\log [H^+]$
$= -\log (0.006)$
$pH = 2.2$

$pOH = 14 - pOH$
$= 14 - 2.2$
$pOH = 11.8$

$[OH^-] = 10^{-pOH}$
$= 10^{-11.8}$
$= 1.7 \times 10^{-12}\ \frac{mol}{L}$

b) $HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$

$0.025\ \frac{mol}{L} \qquad 0.025\ \frac{mol}{L} \quad 0.025\ \frac{mol}{L}$ strong acid

$pH = -\log [H^+]$
$= -\log (0.025)$
$pH = 1.60$

$pOH = 14 - pH$
$= 14 - 1.6$
$pOH = 12.40$

$[OH^-] = K_w / [H^+]$
$= 1 \times 10^{-14} / 0.025$
$= 4 \times 10^{-13}\ \frac{mol}{L}$

8. $[NaOH] = \frac{n}{MV}$

$m = 26\,g$

$M = 40.01\,g/mol$

$V = 0.150\,L$

$= 26\,g \times \frac{1\,mol\,NaOH}{40.01\,g\,NaOH} \times \frac{1}{0.150\,L}$

$= 4.3\,\frac{mol}{L}$

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

$4.3\,\frac{mol}{L}$ $\qquad$ $4.3\,\frac{mol}{L}$

$pOH = -\log[OH^-]$

$= -\log(4.3)$

$= -0.64$

$pH = 14 - pOH$

$= 14 - (-0.64)$

$pH = 14.64$

9. $2\,HClO_{4\,(aq)} + Ca(OH)_{2\,(aq)} \rightarrow 2\,H_2O_{(l)} + Ca(ClO_4)_{2\,(aq)}$

$0.0155\,\frac{mol}{L}$ $\qquad$ $2.34\,mol/L$

$0.2561\,L$ $\qquad$ $0.001\,L$

$n_{H^+} = [HClO_4] \times V \times$ mol ratio

$= 0.2561\,L \times 0.0155\,\frac{mol\,HClO_4}{L} \times \frac{1\,mol\,H^+}{1\,mol\,HClO_4} = 3.97 \times 10^{-3}\,mol\,H^+$

$n_{OH^-} = [Ca(OH)_2] \times V \times$ mol ratio

$= 2.34\,\frac{mol\,Ca(OH)_2}{L} \times 0.001\,L \times \frac{2\,mol\,OH^-}{1\,mol\,Ca(OH)_2}$

$= 4.68 \times 10^{-3}\,mol\,OH^-$

$pOH = -\log[OH^-]$

$= -\log(0.0028$

$= 2.559$

$pH = 14 - pOH$

$= 14 - 2.559$

$pH = 11.441$

$n_{OH^-} > n_{H^+}$

$H^+ + OH^- \rightarrow H_2O$

$n_{OH^-\,remain} = n_{OH^-\,have} - n_{OH^-\,req}$

$= 4.68 \times 10^{-3}\,mol\,OH^- - \left(3.97 \times 10^{-3}\,mol\,H^+ \times \frac{1\,mol\,OH^-}{1\,mol\,H^+}\right)$

$= 7.1 \times 10^{-4}\,mol\,OH^-$

$[OH^-] = \frac{n}{V} = \frac{7.1 \times 10^{-4}\,mol\,OH^-}{(0.2572\,L)} = 0.00276\,mol/L$

10. $HCl_{(aq)}$ + $NaOH_{(aq)}$ → $H_2O_{(l)}$ + $NaCl_{(aq)}$

15.12 mL — 34.51 mL

$3.4514 \times 10^{-3} \frac{mol}{L}$ — $1.212 \times 10^{-3} \frac{mol}{L}$

$n_{H^+} = [HCl] \times V \times \text{mol ratio} = 3.4514 \times 10^{-3} \frac{mol\ HCl}{L} \times 0.01512\,L \times \frac{1\ mol\ H^+}{1\ mol\ HCl}$

$= 5.218 \times 10^{-5}\ mol\ H^+$

$n_{OH^-} = [NaOH] \times V \times \text{mol ratio} = 1.212 \times 10^{-3} \frac{mol\ NaOH}{L} \times 0.03451\,L \times \frac{1\ mol\ OH^-}{1\ mol\ NaOH}$

$= 4.183 \times 10^{-5}\ mol\ OH^-$

$mol(H^+) > mol(OH^-)$

$n_{H^+ \text{ remain}} = n_{H^+ \text{ have}} - n_{H^+ \text{ neutral}}$

$= 5.218 \times 10^{-5}\ mol\ H^+ - \left(4.183 \times 10^{-5}\ mol\ OH^- \times \frac{1\ mol\ H^+}{1\ mol\ OH^-}\right)$

$= 1.035 \times 10^{-5}\ mol\ H^+$

15.12
0.3451
49.63

$[H^+] = \frac{n_{H^+}}{V}$

$= \frac{(1.035 \times 10^{-5}\ mol(H^+))}{(0.01512 + 0.03451)\,L}$

$[H^+] = 0.0002086 \frac{mol\ H^+}{L}$

$pH = -\log[H^+]$

$= -\log(0.0002086)$

$= 3.6806$