

pH, pOH, [H⁺], [OH⁻] problems

Jan 21st

1. a) $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$
 $1.0\text{M} \rightarrow 1.0\text{M}$
 $[\text{OH}^-] = \frac{K_w}{[\text{H}^+]}$
 $= \frac{1.0 \times 10^{-14}}{1\text{M}}$
 $\therefore [\text{H}^+] = 1.0\text{M} \checkmark$
 $\text{pH} = -\log_{10}[\text{H}^+]$
 $= -\log_{10}[1.0\text{M}]$
 $\therefore \text{pH} = 0 \checkmark$
 $\therefore [\text{OH}^-] = 1.0 \times 10^{-14} \text{M} \checkmark$
 $\text{pOH} = 14 - \text{pH}$
 $= 14 - 0$
 $\therefore \text{pOH} = 14 \checkmark$

b) $\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-$
 $0.50\text{M} \rightarrow 0.50\text{M}$
 $\text{pH} = -\log_{10}[\text{H}^+]$
 $= -\log_{10}[0.50\text{M}]$
 $\therefore [\text{H}^+] = 0.50\text{M} \checkmark$
 $\therefore \text{pH} = 0.301 \checkmark$
 $[\text{OH}^-] = \frac{K_w}{[\text{H}^+]}$
 $= \frac{1.0 \times 10^{-14}}{0.50\text{M}}$
 $\therefore [\text{OH}^-] = 2 \times 10^{-14} \text{M} \checkmark$
 $\text{pOH} = 14 - \text{pH}$
 $= 14 - 0.301$
 $\therefore \text{pOH} = 13.699 \checkmark$

c) $\text{HClO}_4 \rightarrow \text{H}^+ + \text{ClO}_4^-$
 $0.002\text{M} \rightarrow 0.002\text{M}$
 $\text{pH} = -\log_{10}[\text{H}^+]$
 $= -\log_{10}[0.0020]$
 $\therefore [\text{H}^+] = 0.0020\text{M} \checkmark$
 $\therefore \text{pH} = 2.699$
 $[\text{OH}^-] = \frac{K_w}{[\text{H}^+]}$
 $= \frac{1.0 \times 10^{-14}}{0.0020}$
 $\therefore [\text{OH}^-] = 5.0 \times 10^{-12} \text{M}$
 $\text{pOH} = 14 - \text{pH}$
 $= 14 - 2.699$
 $\therefore \text{pOH} = 11.301$

d) $\text{KOH} \rightarrow \text{K}^+ + \text{OH}^-$
 $1.5 \times 10^{-4} \text{M} \rightarrow 1.5 \times 10^{-4} \text{M}$
 $\text{pOH} = -\log_{10}[\text{OH}^-]$
 $= -\log_{10}[1.5 \times 10^{-4}]$
 $\therefore [\text{OH}^-] = 1.5 \times 10^{-4} \text{M} \checkmark$
 $\therefore \text{pOH} = 3.824 \checkmark$
 $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]}$
 $= \frac{1.0 \times 10^{-14}}{1.5 \times 10^{-4}}$
 $\therefore [\text{H}^+] = 6.66 \times 10^{-11} \text{M}$
 $\text{pH} = 14 - \text{pOH}$
 $= 14 - 3.824$
 $\therefore \text{pH} = 10.176 \checkmark$

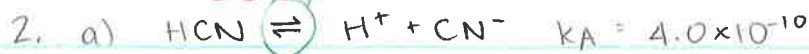
f) $C_1V_1 = C_2V_2$
 $C_2 = \frac{(0.001\text{L})(0.20\text{M})}{5.0\text{L}}$
 $C_2 = 4.0 \times 10^{-5} \text{M} \checkmark$
 $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$
 $\therefore [\text{H}^+] = 4.0 \times 10^{-5} \text{M}$
 $\text{pH} = -\log_{10}[\text{H}^+]$
 $= -\log_{10}[4.0 \times 10^{-5}]$
 $\therefore \text{pH} = 4.398$
 $[\text{OH}^-] = \frac{K_w}{[\text{H}^+]}$
 $= \frac{1.0 \times 10^{-14}}{4.0 \times 10^{-5}}$
 $\therefore [\text{OH}^-] = 2.5 \times 10^{-10} \text{M}$
 $\text{pOH} = 14 - \text{pH}$
 $= 14 - 4.398$
 $\therefore \text{pOH} = 9.602$

e) $C = \frac{n}{V}$
 $= \frac{(0.040\text{g}) \times \frac{1\text{mol}}{40.01\text{g}}}{2.0\text{L}}$
 $C = 4.999 \times 10^{-4} \text{M}$
 $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$
 $\therefore [\text{OH}^-] = 5.0 \times 10^{-4} \text{M}$
 $\text{pOH} = -\log_{10}[\text{OH}^-]$
 $= -\log_{10}[5.0 \times 10^{-4}]$
 $\therefore \text{pOH} = 3.30$
 $\text{pH} = 14 - \text{pOH}$
 $= 14 - 3.30$
 $\therefore \text{pH} = 10.7$
 $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]}$
 $= \frac{1.0 \times 10^{-14}}{(5.0 \times 10^{-4})}$
 $\therefore [\text{H}^+] = 2.0 \times 10^{-11} \text{M}$

* g) $\frac{0.10\text{mol Na}_2\text{O}}{1.0\text{L}} \times \frac{2\text{mol NaOH}}{1\text{mol Na}_2\text{O}} \times \frac{1\text{mol OH}^-}{1\text{mol NaOH}}$
 $= 0.20\text{mol OH}^-/\text{L}$
 $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$
 $\therefore [\text{OH}^-] = 0.20\text{M} \checkmark$
 $\text{pOH} = -\log_{10}[\text{OH}^-]$
 $= -\log_{10}[0.20\text{M}]$
 $\therefore \text{pOH} = 0.699$
 $\text{pH} = 14 - \text{pOH}$
 $= 14 - 0.699$
 $\therefore \text{pH} = 13.301$
 $[\text{H}^+] = \frac{K_w}{[\text{OH}^-]}$
 $= \frac{1.0 \times 10^{-14}}{0.20\text{M}}$
 $\therefore [\text{H}^+] = 5 \times 10^{-14} \text{M}$

Jan 22

Problems 2-6 ** cannot solve stoichiometrically*



$$[\text{CN}^-] = [\text{H}^+]$$

$$[\text{HCN}] = C_A - [\text{H}^+]$$

$$= 1.0\text{M} - [\text{H}^+]$$

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

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

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

$$\left. \begin{array}{l} 1.949 \times 10^{-5} \\ 1.999 \times 10^{-5} \end{array} \right\}$$

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

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

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

$$|\text{pH} = 4.699| \checkmark$$

$$\% \text{ dissociation} = \frac{[\text{H}^+]}{C_A} \times 100\%$$

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

$$|\% \text{ dissociation} = 0.001999\%| \checkmark$$

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



$$[\text{H}_2\text{BO}_3^-] = [\text{H}^+]$$

$$[\text{H}_3\text{BO}_3] = C_A - [\text{H}^+]$$

$$= 0.5\text{M} - [\text{H}^+]$$

$$K_A = \frac{[\text{H}^+][\text{H}_2\text{BO}_3^-]}{[\text{H}_3\text{BO}_3]}$$

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

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

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

$$\left. \begin{array}{l} 1.629 \times 10^{-5} \\ 1.718 \times 10^{-5} \end{array} \right\}$$

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

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

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

$$|\text{pH} = 4.77| \checkmark$$

$$\% \text{ diss} = \frac{[\text{H}^+]}{C_A} \times 100\%$$

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

$$|\% \text{ diss} = 0.003436\%| \checkmark$$



$$[\text{F}^-] = [\text{H}^+]$$

$$[\text{HF}] = C_A - [\text{H}^+]$$

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

$$C_A = 0.1\text{M}$$

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

$$= 10^{-2.2}$$

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

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

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

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

$$|\text{K}_A = 4.25 \times 10^{-4}| \checkmark$$

* not actually HF?



$$[\text{X}^-] = [\text{H}^+]$$

$$[\text{HX}] = 0.100 - [\text{H}^+]$$

$$\% \text{ diss} = \frac{[\text{H}^+]}{C_A} \times 100$$

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

$$[\text{H}^+] = 0.006\text{M}$$

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

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

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

$$|\text{K}_A = 3.83 \times 10^{-4}| \checkmark$$



$C^{\circ}_A = 1.0 \times 10^{-2} \text{ M}$

$[\text{H}^+] = 0.2 \times 1.0 \times 10^{-2}$

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

$[\text{HX}] = C^{\circ}_A - [\text{H}^+]$

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

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

$\text{pH} = 3.70$

b) $[\text{X}^-] = [\text{H}^+]$

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

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

$= \frac{[\text{H}^+]^2}{C^{\circ}_A - [\text{H}^+]}$

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

$K_A = 5.0 \times 10^{-5}$ ✓



$K_A = 2.0 \times 10^{-9}$

$\text{pH} = 4.8$

$C^{\circ}_A = ?$

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

$= 10^{-4.8}$

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

$[\text{B}_2\text{O}^-] = [\text{H}^+]$

$[\text{HB}_2\text{O}] = C^{\circ}_A - [\text{H}^+]$

$K_A = \frac{[\text{H}^+][\text{B}_2\text{O}^-]}{[\text{HB}_2\text{O}]}$

$2.0 \times 10^{-9} = \frac{[\text{H}^+]^2}{C^{\circ}_A - [\text{H}^+]}$

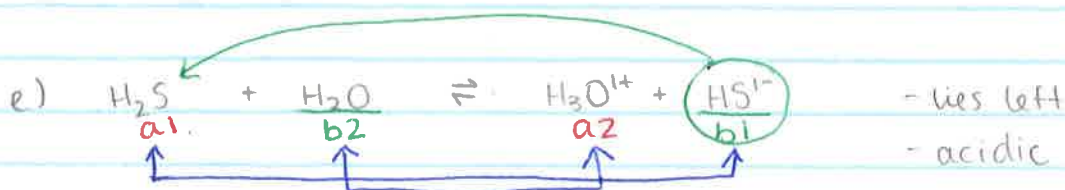
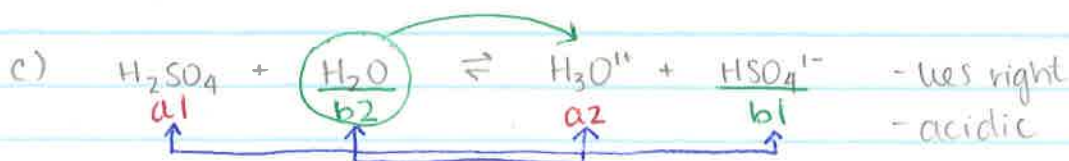
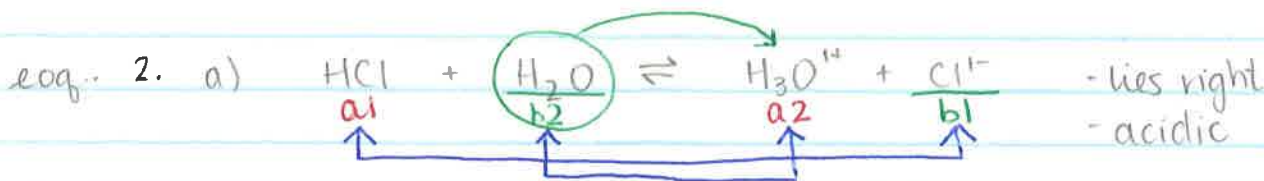
$C^{\circ}_A = \frac{(1.58 \times 10^{-5})^2}{2.0 \times 10^{-9}} + 1.58 \times 10^{-5}$

$C^{\circ}_A = 0.1248 \text{ M}$ ✓

Questions

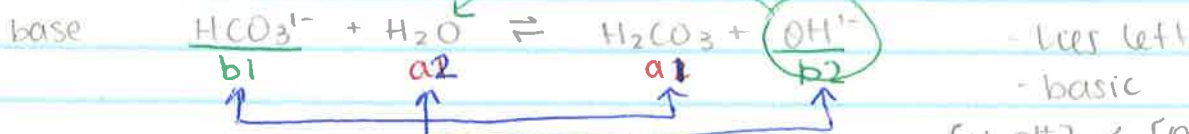
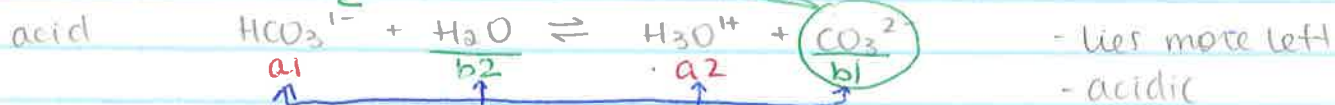
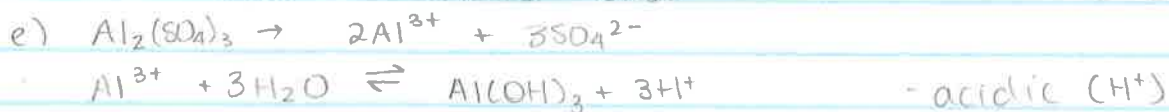
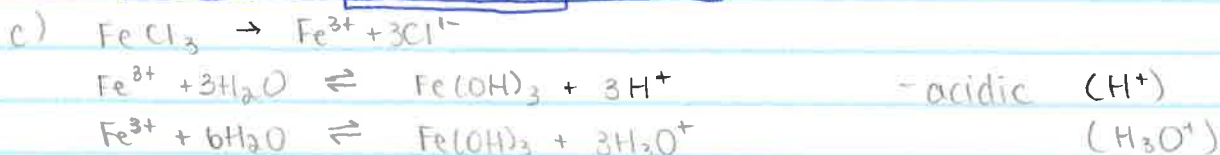
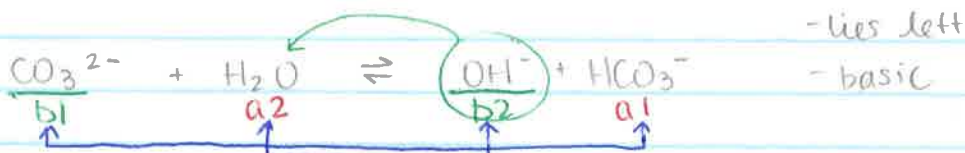
Acid Base Equilibrium. Review

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



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: $\uparrow[B^{1-}]$ R: $\downarrow[B^{1-}]$ H: use B^{1-} D: shift left



$[H_3O^{1+}] < [OH^{1-}] \therefore$ BASIC