Unit 6, Lesson 03: Calculations Involving Strong Acids and Bases

1. Calculate the pH of the following solutions:

a) 0.025 M LiOH (aq)

LiOH is a strong base, from Group I $\therefore$ [OH^{1-}] = [LiOH]

pOH = – log [OH^{1-}]

= – log [0.025]

= 1.60206

pH = 14 – pOH

= 14 – 1.60206

= 12.40

2 sig digs in the concentration gives 2 decimals in the pH

b) 3.00 HI (aq)

HI is a strong acid $\therefore$ [H_3O^{1+}] = [HI]

pH = – log [H_3O^{1+}]

= – log [3.00]

= – 0.477

3 sig digs in the concentration gives 3 decimals in the pH

c) 0.060 M $Ba(OH)_2$ (aq)

$Ba(OH)_2$ is a strong base, from Group II $\therefore$ [OH^{1-}] = 2 x [$Ba(OH)_2$] = 0.12 M

pOH = – log [OH^{1-}]

= – log [0.12]

= 0.9208

pH = 14 – pOH

= 14 – 0.9208

= 13.08

2 sig digs in the concentration gives 2 decimals in the pH

d) 5.00 M H_2SO_4 (aq)

> remember, only the first proton (H+) in H_2SO_4 ionizes significantly unless the acid is very dilute

H_2SO_4 is a strong acid ∴ $[H_3O^{1+}] = [H_2SO_4]$

pH $= -\log[H_3O^{1+}]$

$= -\log[5.00]$

$= -0.699$

3 sig digs in the concentration gives 3 decimals in the pH

e) 25 mL of 15.0 M HNO_3 stock solution diluted to 1.0 L of solution

Calculate the concentration of the diluted acid using the dilution equation: $C_1V_1 = C_2V_2$
* both volumes must be in the same units, convert 25 mL to L by dividing by 1000

$$C_1V_1 = C_2V_2$$

$$0.025\text{ L} \times 15.0\text{ M} = C_2 \times 1.0\text{ L}$$

$$C_2 = \frac{0.025\text{ L} \times 15.0\text{ M}}{1.0\text{ L}}$$

$$= 0.375\text{ M}$$

HNO_3 is a strong acid, therefore:
$[H_3O+] = [HNO_3] = C_2$

pH $= -\log[H_3O^{1+}]$

$= -\log[0.375]$

$= 0.43$

2 sig digs in the concentration gives 2 decimals in the pH

f) 3.66 g of NaOH dissolved in 400.0 mL of solution

$$3.66\text{ g NaOH} \times \frac{1\text{ mol}}{40.00\text{ g}} = 0.09150\text{ mol}$$

$$c = \frac{n}{V}$$

$$= \frac{0.0915\text{ mol}}{0.4000\text{ L}}$$

$$= 0.22875\text{ M}$$

NaOH is a strong base, from Group I
∴ $[OH^{1-}] = [NaOH]$

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

$= -\log[0.22875]$

$= 0.64064$

pH $= 14 - \text{pOH}$

$= 14 - 0.64064$

$= 13.359$ (3 decimal places)

g) 500.0 mL of 6.00 H_2SO_4 solution diluted to 3.00 L of solution

Calculate the concentration of the diluted acid using the dilution equation: $C_1V_1 = C_2V_2$
* both volumes must be in the same units, convert 500.0 mL to L by dividing by 1000

$$C_1V_1 = C_2V_2$$

$$0.5000 \text{ L} \times 6.00 \text{ M} = C_2 \times 3.00 \text{ L}$$

$$C_2 = \frac{0.5000 \text{ L} \times 6.00 \text{ M}}{3.00 \text{ L}}$$

$$= 1.000 \text{ M}$$

H_2SO_4 is a strong acid, therefore:
$[\, H_3O+ \,] = [\, H_2SO_4 \,] = C_2$

$$pH = -\log [\, H_3O^{1+} \,]$$

$$= -\log [1.000\,]$$

$$= 0.000$$

3 sig digs in the concentration gives 3 decimals in the pH

h) 8.55 g of solid $Mg(OH)_2$ dissolved in 2.00 L of solution

$$8.55 \text{ g } Mg(OH)_2 \times \frac{1 \text{ mol}}{58.33 \text{ g}} = 0.1465798 \text{ mol}$$

$$c = \frac{n}{V}$$

$$= \frac{0.1465798 \text{ mol}}{2.00 \text{ L}}$$

$$= 0.07329 \text{ M}$$

$Mg(OH)_2$ is a strong base, from Group II
$\therefore [\, OH^{1-} \,] = 2 \times [\, Mg(OH)_2 \,]$

$$= 0.14658 \text{ M}$$

$$pOH = -\log [\, OH^{1-} \,]$$

$$= -\log [0.14658\,]$$

$$= 0.83393$$

$$pH = 14 - pOH$$

$$= 14 - 0.83393$$

$$= 13.166$$

3 sig digs in the concentration gives 3 decimals in the pH

i) 2.50 g of CaO (s) dissolved in 500.0 mL of solution

CaO reacts with water to produce OH^{1-} : $CaO (s) + H_2O (l) \rightarrow Ca^{2+} (aq) + 2\ OH^{1-} (aq)$

$$2.50 \text{ g CaO} \times \frac{1 \text{ mol}}{56.08 \text{ g}} = 0.044579 \text{ mol}$$

$$c = \frac{n}{V}$$

$$= \frac{0.044579 \text{ mol}}{0.5000 \text{ L}}$$

$$= 0.089158 \text{ M}$$

CaO is a strong base, from Group II

$\therefore [\ OH^{1-}\ ] = 2 \times [\ CaO\ ]$

$= 0.178317$ M

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

$$= -\log [\ 0.178317\ ]$$

$$= 0.74881$$

$$pH = 14 - pOH$$

$$= 14 - 0.178317$$

$$= 13.251 \quad \text{(3 decimal places)}$$

3 sig digs in the concentration gives 3 decimals in the pH

2. In all of these examples, the pH of the acids is very low and the pH of the bases is very high. Suggest a reason why.

All of these substances are strong acids and bases and their concentrations are fairly high (above 0.10 M). They completely ionize/dissociate in water to produce high concentrations of H_3O+ and OH– ions, so the acids have very low pH and the bases have very high pH.

If, however, the concentration of HCl (a strong acid) was only 0.0000100 M, the pH would be only 4.000, showing that the pH of a solution depends on both the strength and concentration of the acid.

$$[\ H_3O+\ ] = [\ HCl\ ]$$

$$pH = -\log [\ H_3O^{1+}\ ]$$

$$= -\log [\ 0.0000100\ ]$$

$$= 4.000$$