Practice – Mixing Strong Acids and Bases

1.) Calculate the pH resulting from mixing $50.0\ mL\ 0.150\ M\ NaOH$ with $50.0\ mL\ 0.200\ M\ HCl$.

Answer -

1.) Equations - $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ **1:1 *ratio of acid to base***

2.) Dilution Calculation - $[H^+] = \frac{(0.200)(0.050)}{(0.100)} = 0.100\ M$

$[OH^-] = \frac{(0.150)(0.050)}{(0.100)} = 0.0750\ M$

3.) Calculate excess – Since reaction is 1:1

$H^+_{(aq)}$	+	$OH^-_{(aq)}$	→
$0.100\ M$		$0.0750\ M$	
$-\ 0.0750\ M$		$-\ 0.0750\ M$	
$0.025\ H^+\ left\ over$		0	

4.) Calculate pH - Since base = $pH = -\log[0.025]$ $pH = 1.60$

2.) Calculate the pOH resulting from mixing $75.0\ mL\ 0.200\ M\ HBr$ with $225.0\ mL\ 0.150\ M\ KOH$.

Answer -

1.) Equations - $HBr_{(aq)} + KOH_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ **1:1 *ratio of acid to base***

2.) Dilution Calculation - $[H^+] = \frac{(0.200)(0.075)}{(0.300)} = 0.0500\ M$

$[OH^-] = \frac{(0.150)(0.2250)}{(0.300)} = 0.1125\ M$

3.) Calculate excess – Since reaction is 1:1

$H^+_{(aq)}$	+	$OH^-_{(aq)}$	→
$0.0500\ M$		$0.1125\ M$	
$-\ 0.0500\ M$		$0.0500\ M$	
0		$0.0625\ M\ OH^-\ left\ over$	

4.) Calculate pOH - Since base = $pOH = -\log[0.0625]$ $pOH = 1.20$

3.) Calculate the pH when $100.0\ mL$ of $5.00\ g\ LiOH$ is mixed with $100.0\ mL$ of $6.00\ g\ HCl$.

Answer -

1.) Equations - $HCl_{(aq)} + LiOH_{(aq)} \rightarrow LiCl_{(aq)} + H_2O_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ **1:1 *ratio of acid to base***

2.) Dilution Calculation - $[H^+] = 5.00\ g \times \frac{1\ mol}{23.95\ g} \times \frac{1}{0.100\ L} = 2.08768\ M$ $\frac{(2.08768)(0.100)}{(0.200)} = 1.04384\ M$

$[OH^-] = 6.00\ g \times \frac{1\ mol}{35.8045\ g} \times \frac{1}{0.100\ L} = 1.6758\ M$ $\frac{(1.6758)(0.100)}{(0.200)} = 0.83788\ M$

3.) Calculate excess – Since reaction is 1:1 $H^+_{(aq)}$ + $OH^-_{(aq)}$ →

$$\begin{array}{ll} 1.04384\ M & 0.83788\ M \\ -\ 0.83788\ M & -\ 0.83788\ M \\ \hline 0.205\ H^{\mp}\ left\ over & 0 \end{array}$$

4.) Calculate pH - Since base = $pH = -\log[0.205]$ $pH = 0.69$

4.) How much $HCl_{(g)}$, in grams, would need to be added to $1.00\ L$ of $0.0120\ M\ LiOH$ solution, to make a final solution with a pH of 11.30?

Answer –

1.) Equations - $HCl_{(aq)} + LiOH_{(aq)} \rightarrow LiCl_{(aq)} + H_2O_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ **1:1 *ratio of acid to base***

2.) Calculate pOH - Since base = pOH $pOH = 14 - pH$ $14.00 - 11.30 = 2.70$

$[OH^-] = anti\log[-pOH]$ $[OH^-] = 0.0019953\ M$

3.) Calculate excess – Since reaction is 1:1

$$\begin{array}{lll} & H^+_{(aq)} + & OH^-_{(aq)} \rightarrow \\ & x\ M & 0.0120\ M \\ & -\ x\ M & -\ x\ M \\ \hline & 0 & 0.0019953\ M\ OH^-\ left\ over \end{array}$$

$[H_3O^+] =$ $0.0120 - x = 0.0019953$ $x = 0.100\ M$

4.) Moles of acid - $[H^+] =$ $\frac{0.100\ mol}{1\ L} \times \frac{36.46\ g}{1\ mol} \times 1\ L =$ $0.36\ g$

5.) How much, in grams, NaOH would need to be added to $0.750\ L$ of $0.055\ M\ HBr$ solution, to make a final solution with a pH of 1.75?

Answer –

1.) Equations - $HBr_{(aq)} + NaOH_{(aq)} \rightarrow NaBr_{(aq)} + H_2O_{(l)}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ **1:1 *ratio of acid to base***

2.) Change pH to $[H^+]$ - $[H^+] = anti\log[-1.75]$ $[H^+] = 0.017783\ M$

3.) Calculate excess – Since reaction is 1:1

$$\begin{array}{lll} & H^+_{(aq)} + & OH^-_{(aq)} \rightarrow \\ & 0.055\ M & x\ M \\ & -\ x\ M & -\ x\ M \\ \hline & 0.017783\ M\ H^+\ left\ over & 0 \end{array}$$

$[OH^-] =$ $0.055 - x = 0.017783$ $x = 0.037217\ M$

4.) Moles of base - $[OH^-] =$ $\frac{0.037217\ mol}{1\ L} \times \frac{40.00\ g}{1\ mol} \times 0.750\ L =$ $1.1\ g$

6.) What mass of $Mg(OH)_2$ would need to be added to $0.400\ L$ of $0.0175\ M\ HCl$ solution, to make a final solution with a pH of 3.55?

Answer –

1.) Equations - $2\ HCl_{(aq)} + Mg(OH)_{2\ (s)} \rightarrow MgCl_{2\ (aq)} + 2\ H_2O_{(l)}$

$2\ H^+_{(aq)} + Mg(OH)_{2\ (s)} \rightarrow 2\ H_2O_{(l)}$ $\mathbf{2:1\ ratio\ of\ acid\ to\ base}$

2.) Change pH to $[H^+]$ - $[H^+] = antilog[-3.55]$ $[H^+] = 0.00028183\ M$

3.) Calculate excess – Since reaction is $2:1$ $2\ H^+_{(aq)}$ + $OH^-_{(aq)}$ →

	$0.0175\ M$	$x\ M$
	$-2x\ M$	$-1x\ M$
	$0.000281\ M\ H^+\ left\ over$	0

$[OH^-] =$ $0.0175 - 2x = 0.000281$ $x = 0.008609\ M$

4.) Moles of base - $[OH^-] =$ $\frac{0.008609\ mol}{1\ L} \times \frac{82.64\ g}{1\ mol} \times 0.400L =$ $0.28\ g$