AP Solution Stoichiometry Name Key

For each of the following; write out the complete balanced equation, full ionic equation, and net ionic equation for the reaction and calculate the concentration of the unknown solution.

1. ***27.4 mL of 0.150 M hydrochloric acid is required to neutralize 30.0 mL of a potassium hydroxide solution of unknown concentration.***

Equations:

$$HCl\,(aq) + KOH\,(aq) \rightarrow KCl\,(aq) + H_2O\,(l)$$

$$H^+(aq) + Cl^-(aq) + K^+(aq) + OH^-(aq) \rightarrow K^+(aq) + Cl^-(aq) + H_2O\,(l)$$

$$H^+(aq) + OH^-(aq) \rightarrow H_2O\,(l)$$

Unknown Concentration:

$$27.4 \text{ mL HCl} \left(\frac{1 \text{ L}}{1000 \text{ mL}}\right)\left(\frac{0.150 \text{ mol HCl}}{1 \text{ L}}\right)\left(\frac{1 \text{ mol KOH}}{1 \text{ mol HCl}}\right) = 0.00411 \text{ mol KOH}$$

$$[KOH] = \frac{0.00411 \text{ mol}}{0.0300 \text{ L}} = \boxed{0.137 \text{ M KOH}}$$

2. ***33.5 mL of 0.200 M sodium hydroxide is required to neutralize 22.5 mL of a sulfuric acid solution of unknown concentration.***

Equations:

$$2NaOH\,(aq) + H_2SO_4\,(aq) \rightarrow Na_2SO_4\,(aq) + 2H_2O\,(l)$$

$$2Na^+(aq) + 2OH^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq) + 2H_2O\,(l)$$

$$2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O\,(l)$$

or

$$H^+(aq) + OH^-(aq) \rightarrow H_2O\,(l)$$

Unknown Concentration:

$$33.5 \text{ mL NaOH} \left(\frac{1 \text{ L}}{1000 \text{ mL}}\right)\left(\frac{0.200 \text{ mol NaOH}}{1 \text{ L}}\right)\left(\frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaOH}}\right) = 0.00335 \text{ mol } H_2SO_4$$

$$[H_2SO_4] = \frac{0.00335 \text{ mol}}{0.0225 \text{ L}} = \boxed{0.149 \text{ M } H_2SO_4}$$

For each of the following; write out the complete balanced equation, full ionic equation, and net ionic equation for the reaction and calculate the molarity, mass, or volume of reagent/product depending on the question.

3. ***29.8 g of ammonia gas needs to be completely reacted by a 0.250M sulfuric acid solution.***

Equations:

$$2NH_3\,(g) + H_2SO_4\,(aq) \rightarrow (NH_4)_2SO_4\,(aq)$$

$$2NH_3\,(g) + 2H^+\,(aq) + SO_4^{2-}\,(aq) \rightarrow 2NH_4^+\,(aq) + SO_4^{2-}\,(aq)$$

$$2NH_3\,(g) + 2H^+\,(aq) \rightarrow 2NH_4^+\,(aq)$$

How much (mL) 0.250 M sulfuric acid solution would be required?

$$29.8\,g\,NH_3 \left(\frac{1\,mol\,NH_3}{17.034\,g}\right)\left(\frac{1\,mol\,H_2SO_4}{2\,mol\,NH_3}\right)\left(\frac{1\,L}{0.250\,mol\,H_2SO_4}\right)\left(\frac{1000\,mL}{1\,L}\right) = 3498\,mL\,H_2SO_4$$

$$= \boxed{3.50 \times 10^3\,mL\,H_2SO_4}$$

4. ***51.5mL of 0.50M nitric acid was required to completely react a spill of crystalline strontium hydroxide.***

Equations:

$$2HNO_3\,(aq) + Sr(OH)_2\,(aq)^{*} \rightarrow Sr(NO_3)_2\,(aq) + 2H_2O\,(l)$$

$$2H^+\,(aq) + 2NO_3^-\,(aq) + Sr^{2+}\,(aq) + 2OH^-\,(aq) \rightarrow Sr^{2+}\,(aq) + 2NO_3^-\,(aq) + 2H_2O\,(l)$$

$$2H^+\,(aq) + 2OH^-\,(aq) \rightarrow 2H_2O\,(l)$$

*as soon as (aq) HNO_3 is spilled on it, the crystal will dissolve in the water present

How much did the sample of strontium hydroxide weigh?

$$51.5\,mL\,HNO_3 \left(\frac{1\,L}{1000\,mL}\right)\left(\frac{0.50\,mol\,HNO_3}{1\,L}\right)\left(\frac{1\,mol\,Sr(OH)_2}{2\,mol\,HNO_3}\right)\left(\frac{121.64\,g}{1\,mol\,Sr(OH)_2}\right) = \boxed{1.6\,g\,Sr(OH)_2}$$

5. ***95mL of a 0.24M silver nitrate is required to completely react 80mL of sodium iodide.***

Equations:

$$AgNO_3(aq) + NaI(aq) \rightarrow NaNO_3(aq) + AgI(s)$$

$$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + I^-(aq) \rightarrow Na^+(aq) + NO_3^-(aq) + AgI(s)$$

$$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$$

What was the concentration of the sodium iodide solution?

$$95\text{ mL } AgNO_3 \left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{0.24\text{ mol } AgNO_3}{1\text{ L}}\right)\left(\frac{1\text{ mol NaI}}{1\text{ mol } AgNO_3}\right) = 0.0228\text{ mol NaI}$$

$$[NaI] = \frac{0.0228\text{ mol}}{0.080\text{ L}} = \boxed{0.29\text{ M NaI}}$$

6. What characteristic did problems 1-5 all have in common? (ie: what type of problem do they represent?)

- Double Displacement (except #3)
- All are acid/base reactions
- All are solution stoich problems using molarity ($\frac{mol}{L}$) as a conversion factor.
- All were not limiting reagent problems (perfect amounts were combined for neutralization, ie neither acid or base left over)

7. ***8.4g of magnesium acetate is combined with 7.31g of potassium hydroxide in water, creating a final volume solution of 250 mL.***

Equations: $Mg(C_2H_3O_2)_2\ (aq) + 2KOH\ (aq) \rightarrow 2KC_2H_3O_2\ (aq) + Mg(OH)_2\ (s)$

$Mg^{2+}(aq) + 2C_2H_3O_2^-(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow 2K^+(aq) + 2C_2H_3O_2^-(aq) + Mg(OH)_2(s)$

$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2\ (s)$

How much precipitate would be produced? (Need to know limiting reagent)

① $8.4\text{ g } Mg(C_2H_3O_2)_2 \left(\frac{1\text{ mol}}{142.40\text{ g}}\right) = 0.059\text{ mol } Mg(C_2H_3O_2)_2$ (limiting)

$7.31\text{ g KOH} \left(\frac{1\text{ mol}}{56.11\text{ g}}\right) = 0.130\text{ mol KOH}$ (excess)

HAVE

② $0.059\text{ mol } Mg(C_2H_3O_2)_2 \left(\frac{2\text{ mol KOH}}{1\text{ mol } Mg(C_2H_3O_2)_2}\right) = 0.118\text{ mol KOH Needed}$

③ $0.059\text{ mol } Mg(C_2H_3O_2)_2 \left(\frac{1\text{ mol } Mg(OH)_2}{1\text{ mol } Mg(C_2H_3O_2)_2}\right)\left(\frac{58.33\text{ g}}{1\text{ mol } Mg(OH)_2}\right) = 3.4\text{ g } Mg(OH)_2$

What would be the concentration of the aqueous product?

$0.059\text{ mol } Mg(C_2H_3O_2)_2 \left(\frac{2\text{ mol } KC_2H_3O_2}{1\text{ mol } Mg(C_2H_3O_2)_2}\right) = 0.118\text{ mol } KC_2H_3O_2$

$[KC_2H_3O_2] = \frac{0.118\text{ mol}}{0.250\text{ L}} = 0.47\text{ M } KC_2H_3O_2$

How many more grams of either reactant (determine the right one) must be added so that each is completely reacted? Need more limiting reactant → how much to react all the excess?

① $0.130\text{ mol KOH (excess)} \left(\frac{1\text{ mol } Mg(C_2H_3O_2)_2}{2\text{ mol KOH}}\right) = 0.065\text{ mol } Mg(C_2H_3O_2)_2$ needed

② 0.065 mol (need) − 0.059 mol (have) = 0.007 mol (short)

③ $0.007\text{ mol } Mg(C_2H_3O_2)_2 \left(\frac{142.40\text{ g}}{1\text{ mol}}\right) = 0.997\text{ g } Mg(C_2H_3O_2)_2$

$= 1.0\text{ g}$ (s.f.)

8. ***55.4mL of a 0.38M potassium hydroxide solution is mixed with 76.0mL of a 0.29M hydrochloric acid solution.***

Equations: $KOH\,(aq) + HCl\,(aq) \rightarrow KCl\,(aq) + H_2O\,(l)$

$K^+(aq) + OH^-(aq) + H^+(aq) + Cl^-(aq) \rightarrow K^+(aq) + Cl^-(aq) + H_2O\,(l)$

$H^+(aq) + OH^-(aq) \rightarrow H_2O\,(l)$

Determine the mL of water produced.

$55.4\text{ mL KOH}\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{0.38\text{ mol}}{1\text{ L}}\right) = 0.02105\text{ mol KOH}$ *limiting (1:1 ratio)

$76.0\text{ mL HCl}\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{0.29\text{ mol}}{1\text{ L}}\right) = 0.02204\text{ mol HCl}$

$0.02105\text{ mol KOH}\left(\frac{1\text{ mol }H_2O}{1\text{ mol KOH}}\right)\left(\frac{18.02\text{ g}}{1\text{ mol}}\right)\left(\frac{1\text{ mL}}{1\text{ g}}\right) = \boxed{0.38\text{ mL }H_2O}$

Determine the grams of salt produced.

$0.02105\text{ mol KOH}\left(\frac{1\text{ mol KCl}}{1\text{ mol KOH}}\right)\left(\frac{74.55\text{ g}}{1\text{ mol KCl}}\right) = \boxed{1.6\text{ g KCl}}$

Calculate the concentration of excess acidic/basic ion (H^+/OH^-).

0.02204 mol HCl (have)
-0.02105 mol HCl (neutralized by KOH)
0.00099 mol HCl (excess)

$0.00099\text{ mol HCl}\left(\frac{1\text{ mol }H^+}{1\text{ mol HCl}}\right) = 0.00099\text{ mol }H^+$

$\frac{0.00099\text{ mol }H^+}{0.1314\text{ L (total volume after mixing)}} = \boxed{0.0075\text{ M }H^+}$ excess

How many additional mL of either reactant (determine the right one) would be required to neutralize the solution? More KOH needed (HCl left over in excess)

$0.00099\text{ mol HCl}\left(\frac{1\text{ mol KOH}}{1\text{ mol HCl}}\right)\left(\frac{1\text{ L}}{.38\text{ mol KOH}}\right)\left(\frac{1000\text{ mL}}{1\text{ L}}\right) = \boxed{2.6\text{ mL KOH}}$ needed

9. How were questions 7 & 8 different from questions 1-5? (ie: what type of problem do they represent?)

- Limiting Reagent Problems
- Solving for amount of excess left over, how much more limiting would be needed to use it up, etc in addition to theoretical yield