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Name:________________

# Neutralization Practice – Supplemental Worksheet KEY

1. A salt is produced in the reaction between an acid and a base. A salt is a(n) ionic compound in which the anion is neither $O^{2-}$ nor $OH^{-}$.

2. Identify the salts among the following compounds:

   $CaO$, $HClO_4$, $Na_2SO_4$, $NH_3$, $CH_4$, $CH_3NH_2$, $Ba(OH)_2$, $H_2C_2O_4$, $H_2O_2$, $K_2O$, $NH_4Cl$, $Fe(OH)_3$, $C_6H_6$, $HOCN$, $Li_3PO_3$.

3. Write down the products of the following neutralization reactions, balance the equations and name the salts:

   a. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ sodium sulfate

   b. $2\ H_3PO_4 + 3\ Ca(OH)_2 \rightarrow Ca_3(PO_4)_2 + 6H_2O$ calcium phosphate

   c. $2\ HClO_4 + Sr(OH)_2 \rightarrow Sr(ClO_4)_2 + 2H_2O$ strontium perchlorate

   d. $2\ HNO_3 + Ba(OH)_2 \rightarrow Ba(NO_3)_2 + 2H_2O$ barium nitrate

   e. $CH_3COOH + NaOH \rightarrow NaCH_3COO + H_2O$ sodium acetate

   f. $HF + LiOH \rightarrow LiF + H_2O$ lithium fluoride

   g. $H_2SO_3 + Ba(OH)_2 \rightarrow BaSO_3 + 2H_2O$ barium sulfite

   h. $HCN + KOH \rightarrow KCN + H_2O$ potassium cyanide

   i. $H_2CO_3 + 2\ NaOH \rightarrow Na_2CO_3 + 2H_2O$ sodium carbonate

   j. $2\ HIO + Ca(OH)_2 \rightarrow Ca(IO)_2 + 2H_2O$ calcium hypoiodite

4. What volume of a 0.025 M lithium hydroxide solution, LiOH, is needed to react completely with 75 mL of a 0.50 M nitric acid solution, $HNO_3$? Do not forget to write a balanced chemical equation!

$$HNO_3 + LiOH \rightarrow LiNO_3 + H_2O$$

$$\left|\frac{75\ mL\ HNO_3\ soln}{}\right|\frac{1\ L\ HNO_3\ sol'n}{1000\ mL\ HNO_3\ sol'n}\left|\frac{0.50\ mol\ HNO_3}{1\ L\ HNO_3\ sol'n}\right|\frac{1\ mol\ LiOH}{1\ mol\ HNO_3}\left|\frac{1\ L\ LiOH\ sol'n}{0.025\ mol\ LiOH}\right|$$
$$= 1.5\ L\ LiOH\ sol'n$$

***Strategy used: Since the molarity of the LiOH solution is known, calculating the number of moles of LiOH in the solution allows the determination of the volume. The problem gives the molarity and volume of the $HNO_3$ solution which allows***

***the calculation of the number of moles of nitric acid. The stoichiometric ratio is then used to determine the number of moles of LiOH.***

**Stepwise Explanation**:

First, calculate the number of moles of nitric acid that reacted (Note: Do not forget to convert the volume of the acid to liters!)

$$\left|\frac{75\ mL\ HNO_3\ soln}{}\right|\frac{1\ L\ HNO_3\ sol'n}{1000\ mL\ HNO_3\ sol'n}\left|\frac{0.50\ mol\ HNO_3}{1\ L\ HNO_3\ sol'n}\right| = 0.0375\ mol\ HNO_3$$

Second, use the stoichiometric ratio from the chemical equation to figure out the corresponding number of moles of LiOH:

$$\frac{0.0375\ mol\ HNO_3}{}\left|\frac{1\ mol\ LiOH}{1\ mol\ HNO_3}\right| = 0.0375\ moles\ of\ LiOH$$

Finally, use the molarity of the LiOH solution and the calculated number of moles of LiOH to calculate the volume used.

$$\frac{0.0375\ mol\ LiOH}{}\left|\frac{1\ L\ LiOH\ sol'n}{0.025\ mol\ LiOH}\right| = 1.5\ L\ of\ LiOH\ solution$$

5. What volume of a 0.025 M calcium hydroxide, $Ca(OH)_2$, solution is needed to completely neutralize 75 mL of a 0.50 M perchloric acid solution, $HClO_4$?

$$Ca(OH)_2 + 2HClO_4 \rightarrow Ca(ClO_4)_2 + 2H_2O$$

$$\left|\frac{75\ mL\ HClO_4\ soln}{}\right|\frac{1\ L\ HClO_4\ sol'n}{1000\ mL\ HClO_4\ sol'n}\left|\frac{0.50\ mol\ HClO_4}{1\ L\ HClO_4\ sol'n}\right|\frac{1\ mol\ Ca(OH)_2}{2\ mol\ HClO_4}\left|\frac{1\ L\ Ca(OH)_2\ sol'n}{0.025\ mol\ Ca(OH)_2}\right|$$
$$= 0.75\ L\ Ca(OH)_2\ sol'n$$

***Strategy used: Same strategy as the previous problem. Since the molarity of the $Ca(OH)_2$ solution is known, calculating the number of moles of $Ca(OH)_2$ in the solution allows the determination of the volume. The problem gives the molarity and volume of the $HClO_4$ solution which allows the calculation of the number of moles of perchloric acid. The stoichiometric ratio is then used to determine the number of moles of $Ca(OH)_2$.***

**Stepwise Explanation**:

First, calculate the number of moles of perchloric acid that reacted (Note: Do not forget to convert the volume of the acid to liters!)

$$\left|\frac{75\ mL\ HClO_4\ soln}{}\right|\frac{1\ L\ HClO_4\ sol'n}{1000\ mL\ HClO_4\ sol'n}\left|\frac{0.50\ mol\ HClO_4}{1\ L\ HClO_4\ sol'n}\right| = 0.0375\ mol\ HClO_4$$

Second, use the stoichiometric ratio from the chemical equation to figure out the corresponding number of moles of ***$Ca(OH)_2$***:

$$\frac{0.0375\ mol\ HClO_4}{} \left| \frac{1\ mol\ Ca(OH)_2}{2\ mol\ HClO_4} \right| = 0.01875\ moles\ of\ Ca(OH)_2$$

Finally, use the molarity of the LiOH solution and the calculated number of moles of LiOH to calculate the volume used.

$$\frac{0.01875\ mol\ Ca(OH)_2}{} \left| \frac{1\ L\ Ca(OH)_2\ sol'n}{0.025\ mol\ Ca(OH)_2} \right| = 0.75\ L\ of\ Ca(OH)_2\ solution$$

6. A 10.0 mL sample of 0.20 M chloric acid solution is required to neutralize 20.0 mL of sodium hydroxide solution, NaOH.

   a. What is the molarity of the sodium hydroxide solution?

$$HClO_3 + NaOH \rightarrow NaClO_3 + H_2O$$

$$\left| \frac{10.0\ mL\ HClO_3\ soln}{} \right| \frac{1\ L\ HClO_3\ sol'n}{1000\ mL\ HClO_3\ sol'n} \left| \frac{0.20\ mol\ HClO_3}{1\ L\ HClO_3\ sol'n} \right| \frac{1\ mol\ NaOH}{1\ mol\ HClO_3}$$
$$= 2.0 \times 10^{-3}\ mol\ NaOH$$

$$Molarity = \frac{2.0 \times 10^{-3}\ mols\ NaOH}{0.020\ L\ NaOH\ soln} = 0.10\ M\ NaOH\ sol'n$$

*Strategy used: One needs to calculate the number of moles of NaOH and use the given volume of the NaOH sol'n to determine the molarity. So, use the given molarity and volume of HClO3 sol'n to calculate the number of moles of the acid and use the stoichiometric ratio to calculate the corresponding number of moles of NaOH. The given volume of the NaOH sol'n is then used to determine the molarity.*

   b. What is the molarity of the salt that forms?

$$\left| \frac{10.0\ mL\ HClO_3\ soln}{} \right| \frac{1\ L\ HClO_3\ sol'n}{1000\ mL\ HClO_3\ sol'n} \left| \frac{0.20\ mol\ HClO_4}{1\ L\ HClO_4\ sol'n} \right| \frac{1\ mol\ NaClO_3}{1\ mol\ HClO_3}$$
$$= 2.0 \times 10^{-3}\ mol\ NaClO_3$$

Note that the volume of the final solution is: 20.0 mL (NaOH sol'n) + 10.0 mL ($HClO_3$ sol'n) = 30 mL or 0.030 L

$$Molarity = \frac{2.0 \times 10^{-3}\ mols\ NaClO_3}{0.030\ L\ soln} = 0.067\ M\ \ NaClO_3$$

Strategy Used: One needs to calculate the number of moles of $NaClO_3$ and use the TOTAL volume of the sol'n to determine the molarity of the salt.

7. A 10. mL sample of 0.20 M hydrochloric acid solution is required to neutralize 20. mL of barium hydroxide, $Ba(OH)_2$.

   a. What is the molarity of the barium hydroxide solution?

$$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$$

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$$\left|\frac{10.0\ mL\ HCl\ soln}{}\right|\frac{1\ L\ HCl\ sol'n}{1000\ mL\ HCl\ sol'n}\left|\frac{0.20\ mol\ HCl}{1\ L\ HCl\ sol'n}\right|\frac{1\ mol\ Ba(OH)_2}{2\ mol\ HCl} = 1.0\times10^{-3}\ mol\ \ Ba(OH)_2$$

$$Molarity = \frac{1.0\times10^{-3}\ mols\ NaOH}{0.020\ L\ NaOH\ soln} = 0.05\ M\ \ Ba(OH)_2\ sol'n$$

b. What is the molarity of the salt that forms?

$$\left|\frac{10.0\ mL\ HCl\ soln}{}\right|\frac{1\ L\ HCl\ sol'n}{1000\ mL\ HCl\ sol'n}\left|\frac{0.20\ mol\ HCl}{1\ L\ HCl\ sol'n}\right|\frac{1\ mol\ BaCl_2}{2\ mol\ HCl} = 1.0\times10^{-3}\ mol\ BaCl_2$$

Note that the volume of the final solution is: 20.0 mL ($Ba(OH)_2$ sol'n) + 10.0 mL (HCl sol'n) = 30 mL or 0.030 L

$$Molarity = \frac{1.0\times10^{-3}\ mols\ BaCl_2}{0.030\ L\ soln} = 0.033\ M\ \ BaCl_2$$

*Strategy Used: Same as number 3.*

8. We use 625.0 mL of a sodium hydroxide, NaOH, solution to completely neutralize 4.50 grams of phosphoric acid.
   a. What is the molarity of the NaOH solution?

$$3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$$

$$\left|\frac{4.50\ g\ H_3PO_4}{}\right|\frac{1\ mol\ H_3PO_4}{98.0\ g\ H_3PO_4}\left|\frac{3.0\ \ mol\ NaOH}{1\ mol\ H_3PO_4}\right| = 0.138\ mols\ NaOH$$

Molarity of the NaOH solution:

$$Molarity = \frac{0.138\ moles\ NaOH}{0.625\ L\ soln} = 0.221\ M\ solution$$

   b. What are the name and the mass of the salt that forms?

Name of the salt: sodium phosphate

Mass of the salt:

$$\left|\frac{4.50\ g\ H_3PO_4}{}\right|\frac{1\ mol\ H_3PO_4}{98.0\ g\ H_3PO_4}\left|\frac{1\ \ mol\ Na_3PO_4}{1\ mol\ H_3PO_4}\right|\frac{164\ g\ \ Na_3PO_4}{1\ \ mol\ Na_3PO_4} = 7.53\ g\ Na_3PO_4$$

*Strategy used: Use the number of moles of phosphoric acid and the stoichiometric ratio to determine the number of moles of the salt. Then, use the molar mass of the salt, 164 g/mol to determine its mass.*

9. What volume of 0.405 M KOH solution is needed to react completely with 2.15 g of copper (II) sulfate, $CuSO_4$? The products of the chemical reaction are copper (II) hydroxide and potassium sulfate.

$$2KOH + CuSO_4 \rightarrow Cu(OH)_2 + K_2SO_4$$

$$\left|\frac{2.15\ g\ CuSO_4}{}\right|\frac{1\ mol\ CuSO_4}{159.6\ g\ CuSO_4}\left|\frac{2\ \ mol\ KOH}{1\ mol\ CuSO_4}\right|\frac{1\ L\ KOH\ sol'n}{0.405\ mol\ KOH} = 0.0665L\ KOH\ sol'n$$