

## Single and double replacement (Homework)

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1.

On the basis of the general solubility rules given in Table 7.1, predict the identity of the precipitate that forms when aqueous solutions of the following substances are mixed. Indicate which rules from the table apply to each case. (Type your answer using the format H<sub>2</sub>O for H<sub>2</sub>O and (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> for (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>. If no precipitate forms, type NONE. Select all that apply.)

General Rules for Solubility of Ionic Compounds (Salts) in Water at 25 °C

1. Most nitrate (NO<sub>3</sub><sup>-</sup>) salts are soluble.
2. Most salts of Na<sup>+</sup>, K<sup>+</sup>, and NH<sub>4</sub><sup>+</sup> are soluble.
3. Most chloride salts are soluble. Notable exceptions are AgCl, PbCl<sub>2</sub>, and Hg<sub>2</sub>Cl<sub>2</sub>.
4. Most sulfate salts are soluble. Notable exceptions are BaSO<sub>4</sub>, PbSO<sub>4</sub>, and CaSO<sub>4</sub>.
5. Most hydroxide compounds are only slightly soluble.\* The important exceptions are NaOH and KOH. Ba(OH)<sub>2</sub> and Ca(OH)<sub>2</sub> are only moderately soluble.
6. Most sulfide (S<sup>2-</sup>), carbonate (CO<sub>3</sub><sup>2-</sup>), and phosphate (PO<sub>4</sub><sup>3-</sup>) salts are only slightly soluble.\*

\*The terms *insoluble* and *slightly soluble* really mean the same thing: such a tiny amount dissolves that it is not possible to detect it with the naked eye.

Table 7.1

(a) mercury(I) nitrate, Hg<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>, and potassium chloride, KCl

(b) potassium chloride, KCl, and iron(II) sulfate, FeSO<sub>4</sub>

(c) lead(II) nitrate, Pb(NO<sub>3</sub>)<sub>2</sub>, and hydrochloric acid, HCl

(d) calcium nitrate, Ca(NO<sub>3</sub>)<sub>2</sub>, and sodium chloride, NaCl

(e) barium nitrate, Ba(NO<sub>3</sub>)<sub>2</sub>, and sodium sulfate, Na<sub>2</sub>SO<sub>4</sub>

(f) iron(III) chloride, FeCl<sub>3</sub>, and phosphoric acid, H<sub>3</sub>PO<sub>4</sub>

2.

On the basis of the general solubility rules given in Table 7.1, write a balanced molecular equation for the precipitation reactions that take place when the following aqueous solutions are mixed. If no precipitation reaction is likely for the reactants given, explain why. (Type your answer using the

format  $(\text{NH}_4)_2\text{CO}_3$  for  $(\text{NH}_4)_2\text{CO}_3$ . If there is no reaction, type NR in all answer boxes. Use the lowest possible coefficients.)

(a) ammonium chloride,  $\text{NH}_4\text{Cl}$ , and sulfuric acid,  $\text{H}_2\text{SO}_4$

(b) potassium carbonate,  $\text{K}_2\text{CO}_3$ , and tin(IV) chloride,  $\text{SnCl}_4$   
 $2 \text{K}_2\text{CO}_3(aq) + 1 \text{SnCl}_4(aq) \rightarrow 1 \text{Sn}(\text{CO}_3)_2(s) + 4 \text{KCl}(aq)$

(c) ammonium chloride,  $\text{NH}_4\text{Cl}$ , and lead(II) nitrate,  $\text{Pb}(\text{NO}_3)_2$

(d) copper(II) sulfate,  $\text{CuSO}_4$ , and potassium hydroxide,  $\text{KOH}$   
 $1 \text{CuSO}_4(aq) + 2 \text{KOH}(aq) \rightarrow 1 \text{Cu}(\text{OH})_2(s) + 1 \text{K}_2\text{SO}_4(aq)$

(e) sodium phosphate,  $\text{Na}_3\text{PO}_4$ , and chromium(III) chloride,  $\text{CrCl}_3$

(f) ammonium sulfide,  $(\text{NH}_4)_2\text{S}$ , and iron(III) chloride,  $\text{FeCl}_3$

3.

For each of the following precipitation reactions, complete and balance the equations. Indicate which product is the precipitate and which rules apply. (Type your answer using the format  $(\text{NH}_4)_2\text{CO}_3$  for  $(\text{NH}_4)_2\text{CO}_3$ . Use the lowest possible coefficients.)

(a)  $\text{Ba}(\text{NO}_3)_2(aq) + (\text{NH}_4)_2\text{SO}_4(aq) \rightarrow ?$

(b)  $\text{CoCl}_3(aq) + \text{NaOH}(aq) \rightarrow ?$

(c)  $\text{FeCl}_3(aq) + (\text{NH}_4)_2\text{S}(aq) \rightarrow ?$

4.

What salt would form when each of the following strong acid/strong base reactions takes place? (Type your answer using the format  $\text{H}_3\text{PO}_4$  for  $\text{H}_3\text{PO}_4$ ,  $(\text{NH}_4)_2\text{CO}_3$  for  $(\text{NH}_4)_2\text{CO}_3$ ,  $[\text{NH}_4]^+$  for  $\text{NH}_4^+$ , and  $[\text{Ni}(\text{CN})_4]^{2-}$  for  $\text{Ni}(\text{CN})_4^{2-}$ .)

(a)  $\text{HCl}(aq) + \text{KOH}(aq) \rightarrow$

(b)  $\text{RbOH}(aq) + \text{HNO}_3(aq) \rightarrow$

(c)  $\text{HClO}_4(aq) + \text{NaOH}(aq) \rightarrow$

5.

Identify each of the following unbalanced reaction equations as belonging to one or more of the following categories: precipitation, acid-base, or oxidation-reduction. (Select all that apply.)

(a)  $\text{Zn}(s) + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu}(s)$

(b)  $\text{KOH}(aq) + \text{CuSO}_4(aq) \rightarrow \text{Cu}(\text{OH})_2(s) + \text{K}_2\text{SO}_4(aq)$

(c)  $\text{NO}(g) + \text{O}_2(g) \rightarrow \text{NO}_2(g)$

(d)  $\text{HCl}(aq) + \text{KOH}(aq) \rightarrow \text{H}_2\text{O}(l) + \text{KCl}(aq)$

