Fri | Sep 7, 2007

- Chapter 4: Types of Chemical Reactions
  - Precipitation Reactions (Sections 4.5 - 4.8)
  - Acid-Base Reactions (Section 4.9)
  - Oxidation-Reduction Reactions (Section 4.10 - 4.12)

- Exam #1 - Next Friday (Sep 14)
  Attendance is mandatory on Sep 14!

What is a Precipitation Rxn?

A type of reaction in which a solute exceeds its own solubility in the given solution.
Under what types of conditions will precipitation occur?

- Addition of **Excess** Solute
- Removal of **Solvent**
- Change of **Solvent**
- Change of **Temperature**

Questions re: Precipitation Rxns

- How could one **predict** what product would **precipitate** in a given precipitation reaction?
- How would one write a **chemical equation** to represent a precipitation reaction?
Predicting ID of Precipitant

- Know the chemical formulas of each reactant
- “Swap” ions
- Know the solubility rules

Potassium Chromate (yellow)
Silver Nitrate (clear solution)

What is the red precipitate?

K₂CrO₄
AgNO₃

Products: Ag₂CrO₄ and KNO₃

What is the red precipitate?
Solubility Rules

Table 4.1 from Text - VERY IMPORTANT!

<table>
<thead>
<tr>
<th>TABLE 4.1</th>
<th>Simple Rules for Solubility of Salts in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Most nitrate (NO$_3^-$) salts are soluble.</td>
<td></td>
</tr>
<tr>
<td>2. Most salts of Na$^+$, K$^+$, and NH$_4^+$ are soluble.</td>
<td></td>
</tr>
<tr>
<td>3. Most chloride salts are soluble. Notable exceptions are AgCl, PbCl$_2$, and Hg$_2$Cl$_2$.</td>
<td></td>
</tr>
<tr>
<td>4. Most sulfate salts are soluble. Notable exceptions are BaSO$_4$, PbSO$_4$, and CaSO$_4$.</td>
<td></td>
</tr>
<tr>
<td>5. Most hydroxide salts are only slightly soluble. The important soluble hydroxides are NaOH, KOH, and Ca(OH)$_2$ (marginally soluble).</td>
<td></td>
</tr>
<tr>
<td>6. Most sulfide (S$^{2-}$), carbonate (CO$_3^{2-}$), and phosphate (PO$_4^{3-}$) salts are only slightly soluble.</td>
<td></td>
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</table>

Predicting ID of Precipitant

- Know the chemical formulas of each reactant
- “Swap” ions
- Know the solubility rules

What is the red precipitate?

Products: Ag$_2$CrO$_4$ and KNO$_3$
### Chemical Equations

**How would one write a balanced chemical equation describing the precipitation reaction shown?**

\[
K_2CrO_4 + AgNO_3 \rightarrow Ag_2CrO_4 + KNO_3
\]

<table>
<thead>
<tr>
<th>Ions Reacting</th>
<th>Ions in Products</th>
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</thead>
<tbody>
<tr>
<td>2 mol K⁺</td>
<td>1 mol K⁺</td>
</tr>
<tr>
<td>1 mol CrO₄²⁻</td>
<td>1 mol CrO₄²⁻</td>
</tr>
<tr>
<td>1 mol Ag⁺</td>
<td>2 mol Ag⁺</td>
</tr>
<tr>
<td>1 mol NO₃⁻</td>
<td>1 mol NO₃⁻</td>
</tr>
</tbody>
</table>

Balance ions by visual inspection…

---

**How would one write a balanced chemical equation describing the precipitation reaction shown?**

\[
K_2CrO_4 + 2AgNO_3 \rightarrow Ag_2CrO_4 + 2KNO_3
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</tr>
<tr>
<td>2 mol NO₃⁻</td>
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</table>

**Balanced**
Arrhenius Acids and Bases

- Acids are $\text{H}^+$ donors
- Bases are $\text{OH}^-$ donors

Arrhenius Broadened Definition

- Acids increase $[\text{H}^+]$
- Bases increase $[\text{OH}^-]$

Putting brackets around a term means “concentration of” the term.

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What is a titration?
Systematic addition of a reagent until all of another reagent is consumed.

Detection is visual
Indicator = Phenolphthalein
Acidic pH - Colorless
Neutral pH - Pink
What is $[\text{NaOH}]$ when 37.65 mL of NaOH are used to titrate 0.6135g of $\text{KHC}_8\text{H}_4\text{O}_4$?

**Known Information**
- $\text{# mol NaOH} = \text{# mol KHC}_8\text{H}_4\text{O}_4$
- $[\text{NaOH}] = \frac{\text{# mol NaOH}}{\text{vol soln}}$
- $\text{Vol Soln} = 37.65 \times 10^{-3} \text{L}$

\[
0.6135 \text{ g} \times \frac{1 \text{ mol KHC}_8\text{H}_4\text{O}_4}{204.22 \text{ g KHC}_8\text{H}_4\text{O}_4} = 3.004 \times 10^{-3} \text{ mol}
\]

\[
[\text{NaOH}] = \frac{3.004 \times 10^{-3} \text{ mol}}{37.65 \times 10^{-3} \text{ L}} = 0.07979 \text{ M NaOH}
\]

**EXAMPLE 4-10 from Text**
What volume of 0.100 M HCl is needed to neutralize 25.0 mL of a 0.350 M NaOH solution?

- Write a balanced chemical equation from the word problem
- Use rules of stoichiometry to relate terms
- Solve via calculation
Redox Reactions

Redox: a class of reactions characterized by the transfer of electrons.

\[
2 \text{Mg}(s) + O_2(g) \rightarrow 2 \text{MgO}(s)
\]

\[
\downarrow \text{loss} \quad \uparrow \text{gain}
\]

\[
2 \times 2e^- \quad \equiv \quad 1 \times 2 \times 2e^-
\]

Magnesium is oxidized: it gives up electrons as the charge on its atoms increases from 0 to +2.

Oxygen is reduced: it gains electrons as the charge on its atoms decreases from 0 to -2 (i.e., becomes more negative).

Oxidation Number

TABLE 4.3 Rules for Assigning Oxidation States

1. The oxidation state of an atom in an element is 0. For example, the oxidation state of each atom in the substances Na(s), O_2(g), O_3(g), and Hg(l) is 0.
2. The oxidation state of a monatomic ion is the same as its charge. For example, the oxidation state of the Na\(^{+}\) ion is +1.
3. In its covalent compounds with nonmetals, hydrogen is assigned an oxidation state of +1. For example, in the compounds HCl, NH_3, H_2O, and CH_4, hydrogen is assigned an oxidation state of +1.
4. Oxygen is assigned an oxidation state of −2 in its covalent compounds, such as CO, CO_2, SO_2, and SO_3. The exception to this rule occurs in peroxides (compounds containing the \(O_2^{2−}\) group), where each oxygen is assigned an oxidation state of −1. The best-known example of a peroxide is hydrogen peroxide (H_2O_2).

STUDY Table 4.3
Oxidation Numbers (also called oxidation states) are determined for the atoms in covalently bonded compounds by applying the following set of 3 simple rules:

1. The oxidation number of the atoms in a neutral molecule must all up to 0;

   those in an ion must add up to the charge on the ion.

2. Alkali metal (Group I) atoms have oxidation number +1,

   alkaline earth (Group II) atoms have oxidation number +2 in their compounds;

   atoms of Group III elements usually have oxidation number +3 in their compounds.
Oxidation Numbers (also called oxidation states) are determined for the atoms in covalently bonded compounds by applying the following set of simple rules:

3. Fluorine always has an oxidation number of -1 in its compounds.

The other halogens have oxidation number -1 in their compounds, except in compounds with oxygen and with other halogens, in which they can have positive oxidation numbers.

<table>
<thead>
<tr>
<th>Term</th>
<th>Oxidation Number Change</th>
<th>Electron Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidation</td>
<td>Increase</td>
<td>Loss of Electrons</td>
</tr>
<tr>
<td>Reduction</td>
<td>Decrease</td>
<td>Gain of Electrons</td>
</tr>
<tr>
<td>Oxidizing Agent, does the oxidizing</td>
<td>Decrease</td>
<td>Picks Up electrons</td>
</tr>
<tr>
<td>Reducing Agent, does the reducing</td>
<td>Increase</td>
<td>Supplies Electrons</td>
</tr>
<tr>
<td>Substance Oxidized</td>
<td>Increase</td>
<td>Loses Electrons</td>
</tr>
<tr>
<td>Substance Reduced</td>
<td>Decrease</td>
<td>Gains Electrons</td>
</tr>
</tbody>
</table>
Summary

- Know meanings of terms
- Know how to predict a precipitate
- Be able to calculate terms related to acid-base titrations
- Determine oxidation state of an atom
- Write and balance chemical equations for precipitation, acid-base rxns and redox rxns

Study Tips

- Read text
- Work problems from text
- Take practice exams online
- Review lecture notes
- Study in groups

Exam #1
Friday, Sep 14

Need
#2 Pencil
Calculator
Crib Sheet