States of Matter

- Solid (s)
- Liquid (*l*)
- Gas (g)
- Aqueous (aq)
  - A solid dissolved in water → solution
  - Example: $NaCl_{(s)} + H_2O$ vs $NaCl_{(aq)}$

Predicting States of Matter

Tips

- The following are gases at room temperature:
  - Elements − hydrogen, nitrogen, oxygen, fluorine, chlorine
  - ammonia
  - carbon monoxide and carbon dioxide
  - nitrogen monoxide and nitrogen dioxide
  - sulfur dioxide and sulfur trioxide
  - hydrogen-compounds (e.g. hydrogen chloride and hydrogen cyanide)

Tips

- Acids are always aqueous.
- Any phrases that refer to being dissolved or in solution means the compound is aqueous.
- Liquids − bromine, mercury, and water
- All other elements are solids. When in doubt, so are most other compounds, particularly ionic compounds.

Composition and Decomposition Reactions

- Must Use:
  - Common Sense
  - Tips
    - Ionic Compounds are solids
    - Molecular Compounds either liquid or gas
    - Diatomics usually gas

Examples

$$S_{(s)} + H_{2(g)} \rightarrow H_2S_{(g)}$$

$$Cu_{(s)} + S_{(s)} \rightarrow CuS_{(s)}$$

$$O_{2(g)} + 2\,H_{2(g)} \rightarrow 2\,H_2O_{(l)}$$

$$2\,KClO_{3(s)} \rightarrow 2\,KCl_{(s)} + 3\,O_{2(g)}$$

Single Replacement

$$AX_{(aq)} + B_{(s) \text{ or } (g)} \rightarrow BX_{(aq)} + A_{(s) \text{ or } (g)}$$

$$CuSO_{4(aq)} + Fe_{(s)} \rightarrow Cu_{(s)} + FeSO_{4(aq)}$$

$$2\,KI_{(aq)} + Cl_{2(g)} \rightarrow 2\,KCl_{(aq)} + I_{2(g)}$$

Double Replacement

- Reactants are always aqueous
- Products are either:
  - One aqueous and one solid (ppt)
  - Both aqueous (soluble so no solid forms)

Double Replacement – 2 types

1. Reaction of 2 ionic salts

$2\ KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow 2\ KNO_3 + PbI_2$

Are any solids produced?

Use a solubility chart to figure this out…

Solubility Chart

- s – Soluble, a solid will not form
- si – Slightly soluble, a solid may form then dissolve, compound is solid
- i – Insoluble, a solid ppt will form

Double Replacement – 2 types

1. Reaction of 2 ionic salts

$2\ KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow 2\ KNO_3 + PbI_{2(s)}$

Are any solids produced?

Use a solubility chart to figure this out…

Examples

$$Na_2SO_{4(aq)} + BaCl_{2\,(aq)} \rightarrow BaSO_{4(s)} + 2\,NaCl_{(aq)}$$

$$NaNO_{3(aq)} + KCl_{(aq)} \rightarrow KNO_3 + NaCl$$

no ppt

Double Replacement – 2 types

2. Neutralization Reaction: acid + base

$Acid_{(aq)} + Base_{(aq)} \rightarrow Water + Soluble\ Salt$

$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow H_2O_{(\ell)} + Na_2SO_{4\,(aq)}$

Combustion

$$C_xH_y + O_{2(g)} \rightarrow CO_{2\,(g)} + H_2O_{(g)}$$