Chapter 4 Part 1

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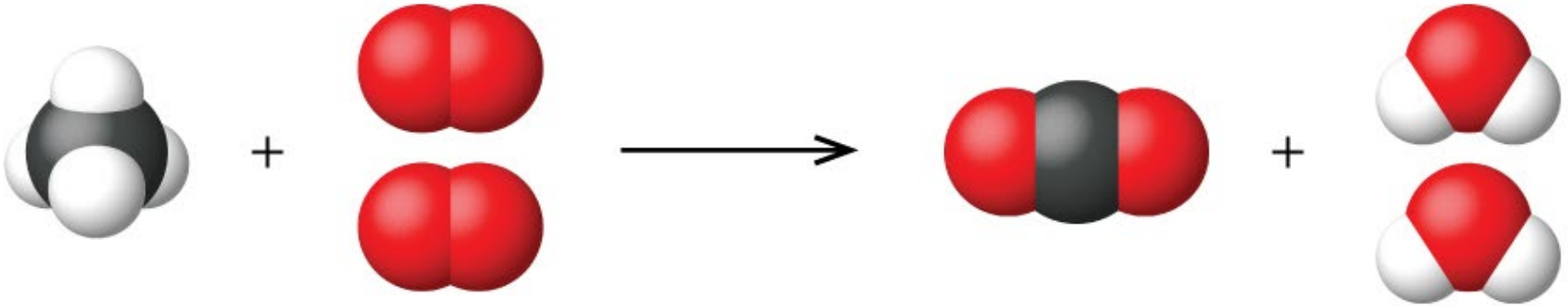
Chemical Equations

Reactants

Products

Coefficients

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$



Balancing Chemical Equations General Strategy

- Balance the most unique elements first (often metals)
- Next balance the nonmetals
- Then balance the hydrogens
- Lastly balance the oxygen

Balancing Chemical Equations Tips

- Remember that you can only change the coefficient values and NOT the subscripts
- If an element appears as a polyatomic ion on both sides of the equation, balance the polyatomic ion on both sides as a whole instead balancing the individual atoms
- Always count the number of atoms of each element on each side to make sure that the equation is balanced
- When the equation is balanced, the coefficients should be in their lowest whole number ratio

Balancing Chemical Equations

1. $\_\_ NaNO_3 + \_\_ PbO \rightarrow \_\_ Pb(NO_3)_2 + \_\_ Na_2O$
2. $\_\_ AgI + \_\_ Fe_2(CO_3)_3 \rightarrow \_\_ FeI_3 + \_\_ Ag_2CO_3$
3. $\_\_ C_2H_4O_2 + \_\_ O_2 \rightarrow \_\_ CO_2 + \_\_ H_2O$
4. $\_\_ ZnSO_4 + \_\_ Li_2CO_3 \rightarrow \_\_ ZnCO_3 + \_\_ Li_2SO_4$
5. $\_\_ V_2O_5 + \_\_ CaS \rightarrow \_\_ CaO + \_\_ V_2S_5$

Balancing Chemical Equations

Identify the balanced reaction.

A. $N_2(g) + H_2(g) \rightarrow NH_3(g)$

B. $N_2(g) + 3\ H_2(g) \rightarrow NH_3(g)$

C. $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

D. $2\ N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

E. $3\ N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

Additional Information in Chemical Equations

$$CH_4(g) + 2\ O_2(g) \longrightarrow CO_2(g) + 2\ H_2O(g)$$

- (g) means a gaseous pure substance
- (l) means a liquid pure substance
- (s) means a solid pure substance
- (aq) means the substance in aqueous solution where water is the solvent and the substance is the solute

Synthesis (Combination) Reaction

$$A + B \rightarrow AB$$

Ex. $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

Decomposition Reaction

$$AB \rightarrow A + B$$

Ex. $2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$

Single Replacement Reactions

$$AB + C \rightarrow CB + A$$

Ex. $CuCl_2(aq) + Mg(s) \rightarrow MgCl_2(aq) + Cu(s)$

Double Replacement (Metathesis) Reactions

$$AB + CD \rightarrow AD + CB$$

Ex. $2\ NaI(aq) + Pb(ClO_4)_2(aq) \rightarrow 2\ NaClO_4(aq) + PbI_2(s)$

Acid–Base Reactions

- Acid–base reactions are double-replacement reactions
- Acid–base reactions are also called neutralization reactions
- An acid is a type of compound usually written with H at the beginning of its formula.
- A base is a type of compound often written with OH at the end of its formula because many bases are hydroxide compounds.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

$$\text{acid} \quad + \quad \text{base} \quad \rightarrow \quad \text{a salt} \quad + \quad \text{water}$$

$$H_2SO_4(aq) + 2\ KOH(aq) \rightarrow K_2SO_4(aq) + 2\ H_2O(l)$$

Combustion Reactions

- Combustion is the rapid combination of a substance with oxygen.
- Hydrocarbon fuels undergo combustion to produce carbon dioxide and water vapor.

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$

Types of Chemical Reactions

Identify the reaction type for each of the following equations.

A. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$
B. $MgI_2(aq) + 2\ AgNO_3(aq) \rightarrow 2\ AgI(s) + Mg(NO_3)_2(aq)$
C. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
D. $2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(l)$

Types of Chemical Reactions

Identify the single-replacement reaction.

A. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
B. $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$
C. $Mg(OH)_2(aq) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + 2\ H_2O(l)$
D. $2\ MgO(s) \rightarrow 2\ Mg(s) + O_2(g)$
E. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$

Aqueous Solutions

- A solid compound that readily dissolves in water is soluble in water.
- A compound that remains solid when mixed with water is said to be insoluble in water.
- The notation NaCl(aq) tells you that sodium chloride has been mixed with water, and that is has dissolved.
- In a reaction of aqueous substances, a notation such as AgCl(s) tells you that silver chloride, even though mixed with water, has not dissolved.

Solubility Rules (Memorize these!)

Soluble Ions	Exceptions
$Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4{}^+$	None
$C_2H_3O_2{}^-, NO_3{}^-, ClO_3{}^-, ClO_4{}^-$	None
Cl^-, Br^-, I^-	Ag^+ & Pb^{2+}
$SO_4{}^{2-}$	$Ag^+, Pb^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}$

Determining Solubility

- Soluble ions make compounds soluble unless they are paired with one of their exceptions
- If neither the cation nor ion in a compound are soluble, the compound is insoluble

Solubility and Dissociation

Identify whether the following compounds will or will not be soluble in water. If soluble, write the dissolved ion products

A. PbS

B. $AgNO_3$

C. CaI_2

D. NH_4Cl

Dissociation

What are the products of the dissociation of $K_2SO_4(aq)$?

A. $K(aq) + 2\ SO_4(aq)$
B. $2\ K(aq) + SO_4(aq)$
C. $2\ K^+(aq) + SO_4^{2-}(aq)$
D. $K^+(aq) + 2\ SO_4^{2-}(aq)$

Precipitation Reactions

- Precipitation reactions are double replacement reactions that lead to the formation of a precipitant
- A precipitants is an insoluble ionic compound
- Precipitants must be a product and are determined by the solubility rules

Precipitation Reactions

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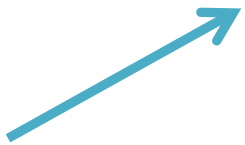
Ex. $Pb(NO_3)_2(aq) + 2\ KI(aq) \rightarrow PbI_2\ (s) + 2\ KNO_3(aq)$



Is a precipitant because it is an insoluble ionic product of a double replacement reaction

Addition of Lead(II) nitrate to Potassium Iodide

$$Pb(NO_3)_2(aq) + 2\ KI(aq) \rightarrow PbI_2\,(s) + 2\ KNO_3(aq)$$

Predicting Products of Precipitation Reactions

1. Assign charges of reactant ions
2. Predict the products of the double replacement reaction
3. Write a balanced equation of the reaction

Precipitation Reactions

Predict the products of the following reactions and identify whether they will have precipitants. (You will have to balance the new equation.)

A. $Pb(CH_3COO)_2 + AlPO_4 \rightarrow$

B. $FeSO_4 + NaCl \rightarrow$

C. $Sr(ClO_3)_2 + NH_4F \rightarrow$

Precipitation Reactions

Predict the products of this precipitation reaction.

$$Na_2S(aq) + AgC_2H_3O_2(aq) \rightarrow$$

A. $NaC_2H_3O_2\ (aq) + Ag_2S(s)$
B. $NaC_2H_3O_2\ (aq) + Ag_2S(aq)$
C. $NaAg(aq) + S(C_2H_3O_2)_2(aq)$
D. $Na_2S(aq) + AgC_2H_3O_2(aq)$

Writing Net Ionic Equations

1. Assign charges of reactant ions
2. Predict the products of the double replacement reaction
3. Write a balanced equation of the reaction
4. Identify the soluble compounds and label the physical states
5. Write the soluble compounds as separate ions
6. Identify spectator ions
7. Remove spectator ions and write the reaction using only the remaining species. If every substance is soluble, and thus the only things remaining are spectator ions, and there is no reaction

Writing Net Ionic Equations

Predict the products of the double replacement reaction

$$AgNO_3 + CaBr_2 \rightarrow$$

Writing Net Ionic Equations

1. Assign charges of reactant ions

$$\overset{+1\ -1}{AgNO_3} + \overset{+2\ -1}{CaBr_2} \rightarrow$$

Writing Net Ionic Equations

2. Predict the products of the double replacement reaction

$$AgNO_3 + CaBr_2 \rightarrow AgBr + Ca(NO_3)_2$$

Writing Net Ionic Equations

3. Write a balanced equation of the reaction

$$2\ AgNO_3 + CaBr_2 \rightarrow 2\ AgBr + Ca(NO_3)_2$$

Writing Net Ionic Equations

4. Identify the soluble ions and label the physical states

$$2\ AgNO_3(aq) + CaBr_2(aq) \rightarrow 2\ AgBr(s) + Ca(NO_3)_2(aq)$$

Writing Net Ionic Equations

5. Write the soluble compounds as separate ions

$$2\ AgNO_3(aq) + CaBr_2(aq) \rightarrow 2\ AgBr(s) + Ca(NO_3)_2(aq)$$

$$2\ Ag^+(aq) + 2\ NO_3^-(aq) + Ca^{2+}(aq) + 2\ Br^-(aq) \rightarrow 2AgBr(s) + Ca^{2+}(aq) + 2\ NO_3^-(aq)$$

This is called the overall or total ionic equation

Writing Net Ionic Equations

6. Identify spectator ions

$$2\ AgNO_3(aq) + CaBr_2(aq) \rightarrow 2\ AgBr(s) + Ca(NO_3)_2(aq)$$

$$2\ Ag^+(aq) + 2\ NO_3^-(aq) + Ca^{2+}(aq) + 2\ Br^-(aq) \rightarrow 2AgBr(s) + Ca^{2+}(aq) + 2\ NO_3^-(aq)$$

Writing Net Ionic Equations

7. Remove spectator ions and write the reaction using only the remaining species

$$2\ AgNO_3(aq) + CaBr_2(aq) \rightarrow 2\ AgBr(s) + Ca(NO_3)_2(aq)$$

$$2\ Ag^+(aq) + \cancel{2\ NO_3^-(aq)} + \cancel{Ca^{2+}(aq)} + 2\ Br^-(aq)$$
$$\rightarrow 2AgBr(s) + \cancel{Ca^{2+}(aq)} + \cancel{2\ NO_3^-(aq)}$$

$$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$$

This is the net ionic equation

Net Ionic Equations

Provide the net ionic equation for the following reaction:

$$Na_2CO_3 + MgBr_2 \rightarrow$$

Net Ionic Equations

Provide the net ionic equation for the following reaction:

$$MgSO_4 + NaOH \rightarrow$$

Net Ionic Equations

Provide the net ionic equation for the following reaction:

$$NiCl_2 + NaBr \rightarrow$$

Precipitation Reactions

Identify the spectator ions in the reaction below

$$Na_2S(aq) + 2\ AgClO_{3(aq)} \rightarrow 2\ NaClO_3(aq)\ +\ Ag_2S(s)$$

A. $2\ Na^+$ and S^{2-}
B. $2\ Na^+$ and $2\ ClO_3^-$
C. $2\ Ag^+$ and S^{2-}
D. $2\ Ag^+$ and $2\ ClO_3^-$
E. $2\ ClO_3^-$ only