# Chemical Reactions

1) Chemical reaction – process by which one or more substances are changed into one or more different substances.

2) Reactants – substances undergoing chemical change.

3) Products – resulting substances from the reaction.

4) Chemical Equation – represents with symbols and formulas, the identities and relative molecular or molar amounts of the reactants and products in a chemical reaction.

5) Example: $A + X \rightarrow AX$

reactant — yeild — product

6) Characteristics of Chemical equations:
   1) The equation must represent the facts.
   2) The equation must have the correct formulas in the reactants and products.
   3) The law of conservation of mass must be satisfied.

7) Coefficient – small whole number that appears in front of a formula in a chemical equation.

8) Word equation- an equation in which the reactants and products in a chemical reaction are represented by words.

9) Formula equation- represents the reactants and products of a chemical reaction by their symbols or formulas.

10) Example: Carbon + Oxygen → Carbon Dioxide (Word Form)

reactants yield product

$C + O_2 \rightarrow CO_2$ (Formula Form)

11) Steps for balancing chemical equations:

1) Make sure the chemical formulas are correct in the products and reactants.
2) Check to see what is out of balance.
3) Check for group ions that stay together on both sides.
4) Save one atom, diatomic, then $H_2O$ molecules for last.
5) See what looks the worst and balance it first.

12) Example #1 Hydrogen + Chlorine → Hydrogen Chloride

$\_\_H_2 + \_\_Cl_2 \rightarrow \_\_\overset{+1}{H}\overset{-1}{Cl}$

$\underline{1}\,H_2 + \underline{1}\,Cl_2 \rightarrow \underline{2}\,HCl$

Example #2 Zinc + Phosphoric Acid → Zinc Phosphate + Hydrogen

$$Zn + \overset{+1}{H}\ \overset{-3}{PO_4} \rightarrow \overset{+2}{Zn}\ \overset{-3}{PO_4} + H$$

$$\underline{3}\ Zn + \underline{2}\ H_3PO_4 \rightarrow \underline{1}\ Zn_3(PO_4)_2 + \underline{3}\ H_2$$

13) 5 Types of Chemical Reactions

(1) Synthesis or Composition Rx. - 2 or more substances combined to form one.

$$A + X \rightarrow AX$$

Ex. #1

$$\_H_2 + \_O_2 \rightarrow \_H_2O$$

Ex. #2

$$\_Na + \_Cl_2 \rightarrow \_NaCl$$

(2) Decomposition Rx. - One substance breaks down to form two or more substances.

$$AX \rightarrow A + X$$

Ex. #1

$$\_CaCO_3 \rightarrow \_CaO + \_CO_2$$

Ex. #2

$$\_H_2O \rightarrow \_H_2 + \_O_2$$

(3) Cation Replacement Rx -

$$A + BX \rightarrow AX + B$$

↑ lower electronegativity (A) ↑ replaced (B)

$\_\overset{+2}{Be}\overset{-1}{Cl_2} + \_K \rightarrow \_\overset{+1}{K}\overset{-1}{Cl} + \_Be$

(4) Anion Replacement Rx

$$Y + AX \rightarrow AY + X$$

Higher electronegativity (Y) ↑ replaced (X)

$\_\overset{+2}{Zn}\overset{-1}{I_2} + \_F_2 \rightarrow \_ZnF_2 + \_I_2$

(5) Double Replacement or Ionic Rx.

$$AX + BY \rightarrow BX + AY$$

↑ Cations ↑ Cation — replace

$\_\overset{+1}{Na_2}\overset{-2}{SO_4} + \_\overset{+3}{Fe}(\overset{-1}{OH})_3 \rightarrow \_\overset{+3}{Fe_2}(\overset{-2}{SO_4})_3 + \_\overset{+1}{Na}\overset{-1}{OH}$

(12) (4)

14) Combustion reactions - a substance combines with oxygen, releasing a large amount of energy in the form of heat and light.

15) Example of balancing chemical equations.

Sodium + Oxygen → Sodium Oxide

Step 1: Correct Formula's in reactant and product side.

$\_\_ Na + \_\_ O_2 \rightarrow \_\_ \overset{+1}{Na}_2\overset{-2}{O}$

Step 2: Check to see what is out of balance

Note: 1 Na → 2 Na
2 O → 1 O
reactant side   product side

Step 3: Check for group ions staying together in the reaction.

Note: No group ions

Step 4: Save one atom, diatomic, water for last.

Note: Save Na for last
Save $O_2$ for next to last

Step 5: Balance what looks the worst.
Note: Balance O first

$\underline{4}\ Na + \underline{1}\ O_2 \rightarrow \underline{2}\ Na_2O$    Synthesis Rx.

(122)   (5)

16) Mole - amount of a substance that is contained in avogadro's number of particles.

17) Avogadro's Number. - $6.022 \times 10^{23}$ particles of anything.

18) Molar Mass - Mass of 1 mole of a substance.

19) Calculations using mole:

Example #1: 55.61 G $H_2$ = ______ mole $H_2$

MW. $H_2$ = 2.02 G/mole

$$\left(55.61\,G\right)\left(\frac{mole}{2.02\,G}\right) = 27.5 \text{ mole } H_2$$

Example #2: 6.25 mole $H_2$ = ______ G $H_2$

$$\left(6.25 \text{ mole } H_2\right)\left(\frac{2.02\,G}{mole}\right) = 12.6\,G\,H_2$$

Example #3: 3.15 mole $H_2$ = ______ molecule $H_2$

$6.022 \times 10^{23}$ molecules $H_2$/1 mole $H_2$

$$\left(3.15 \text{ mole } H_2\right)\left(\frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mole } H_2}\right) = 1.90 \times 10^{23} \text{ molecules } H_2$$

20) Calculating molar mass of Compounds (Sum of atomic masses)

Example:

1) NaCl

1 Na = 22.990
1 Cl = 35.453
57.443 G/mole

2) $CaCl_2$

1 Ca = = 40.078
2 Cl = 35.453 = 70.906
110.984 G/mole
110.98 G/mole Sig. Figs

3) $Al_2(CO_3)_3$

2 Al = 26.982 = 53.964
3 C = 12.011 = 36.033
9 O = 16.00 = 144.0
233.997 G/mol
234.0 G/mol Sig. Figs

4) $Mg_3(PO_4)_2 \cdot 3H_2O$

3 Mg = 24.305 = 72.915
2 P = 30.974 = 61.948
8 O = 16.00 = 120.0
3 $H_2O$ = 18.02 = 54.06
308.923 G/mol
308.9 G/mol

21) % Composition by mass:

Example:

$CO_2$

$$1\ C = \quad = 12.01$$
$$2\ O = 16.00 = 32.00$$
$$44.01\ G/mole$$

$$\%C = \frac{12.01}{44.01} \times 100 = 27.29\ \%$$

$$\%O = \frac{32.00}{44.01} \times 100 = 72.71\ \%$$

$Fe_2(SO_4)_3$

$$2\ Fe = 55.845 = 111.69$$
$$3\ S = 32.065 = 96.195$$
$$12\ O = 16.00 = 192.0$$
$$399.885\ G/mol.$$

**399.9 G/mol**

$$\%Fe = \frac{111.69}{399.9} \times 100 = 27.93\ \%$$

$$\%S = \frac{96.195}{399.9} \times 100 = 24.05\ \%$$

$$\%O = \frac{192.00}{399.9} \times 100 = 48.01\ \%$$

22) Thermochemistry - study of the transfer of energy as heat that accompany chemical reactions and physical changes.

23) Calorimeter - device used measure the heat released in a combustion reaction of a substance.

24) Calorie - amount of heat energy needed to raise the temperature of 1 gram of Water one degree Celsius.

25) Joule - SI unit of heat.

26) Calculation of Heat energy: Note: 1 cal = 4.19 J

Example #1

450. J = ______ cal

$$\left(450.\ J\right)\left(\frac{1\ cal}{4.19\ J}\right) = 107\ cal$$

#2

6500. cal = ______ J

$$\left(6500.\ cal\right)\left(\frac{4.19\ J}{1\ cal}\right) = 27240\ J$$

27) Specific heat - amount of energy required to raise the temperature of 1 gram of a substance by 1 °C.

28) Specific heat formula:

$$C_p = \frac{q}{(m)(\Delta t)}$$

$C_p$ = Specific heat at given pressure

$q$ = energy lost or gained

$m$ = Mass of substance

$\Delta t$ = change in temp.

Units used

$C_p = \frac{J}{g \cdot {}^\circ C}$ or $\frac{J}{g \cdot {}^\circ K}$ or $\frac{Cal}{g \cdot {}^\circ C}$

$q$ = J or Cal

$m$ = g or Kg

$\Delta t$ = °C or °K

29) Example #1 Determine the specific heat of a material if a 35 G sample absorbed 48 J as it was heated from 293°K to 313°K.

$m = 35\,G \quad q = 48\,J \quad \Delta T = 293^\circ K - 313^\circ K = 20.0^\circ K \quad C_p = \_\_\_\_$

$$C_p = \frac{q}{(m)(\Delta t)} = \frac{48\,J}{(35\,G)(20.0^\circ K)} = \boxed{.069 \frac{J}{G \cdot {}^\circ K}}$$

Example #2 How much heat is absorbed by 25.5 g of Water when its temperature is increased from 25.0°C to 65.0°C? Specific Heat ($H_2O$) = $4.184 \frac{J}{G \cdot {}^\circ C}$

125 (B)

Continue Example #2

$m = 25.5\,g$ $\Delta T = 65.0°C - 25.0°C = 40.0°C$ $C_p = 4.184 \frac{J}{G \cdot °C}$ $q =$ ____

$$C_p = \frac{q}{m\,\Delta T}$$

$$q = (C_p)(m)(\Delta T) = \left(4.184 \frac{J}{G\,°C}\right)(25.5\,g)(40.0°C) = 4268\,J$$

$$= \boxed{4270\,J}$$

30) Calorie Conversion - Note: Use of units has different meaning in different text.

| lower case | Capital | |
|---|---|---|
| calorie | Calorie | Kcal |

1000 calorie = 1 Calorie = 1 Kcal

31) Endothermic reaction - energy is going into the reaction to make it go.

32) Exothermic reaction - energy is given off as the reaction goes.

33) Factors that effect the rate of reactions:

1) Nature of reactants - types of bonds involved.
2) Surface Area -
3) Temperature -
4) Concentration -
5) Catalyst - substance the speeds up the reaction without being changed itself.