1

## Observing Chemical Reactions

Changes in physical properties are indicative of a chemical reaction.

Physical Properties:
- Color
- Solubility
- Density
- Hardness
- Mp/bp
- Odor
- Energy Changes

2

## Reading Chemical Equations

Reactant(s) $\rightarrow$ Product(s)

Name compounds by the rules we learned in chapter 3

3

## Chemical Equations: *Coefficients*

$$2\ K + Cl_2 \rightarrow 2\ KCl$$

2 K denotes how many react.

The 2 relates to everything which follows in the compound.

4

## Chemical Equations: Subscripts and Superscripts

$2\ K + Cl_2 \rightarrow 2\ KCl$

- $Cl_2$ denotes 2 atoms of chlorine in a chlorine molecule
- Subscripts refer only to the element immediately preceding
- Superscripts will denote the charge on an ion

$MgO + H_2O \rightarrow Mg^{2+} + 2\ OH^-$

5

## Chemical Equations: State

$2\ K\ (s) + Cl_2\ (g) \rightarrow 2\ KCl\ (s)$

*(s)(l)(g)(aq)* denote the *state* of the molecules

aq = aqueous = dissolved in *water*

6

## Chemical Equations

- Equations to chemists are like sentences to readers; they specify exactly what happens in a reaction.
- You should be able for the exam to "read" a chemical equation.

$SO_4^{2-} + BaCl_2\ (aq) \rightarrow BaSO_4\ (ppt) + 2\ Cl^-$

$AgNO_3\ (aq) + NaCl \rightarrow AgCl\downarrow + NaNO_3\ (aq)$

7

## Chemical Equations Must Be Balanced

There must be an equal number of atoms of each element on both sides of the equation.

$2\ K(s) + Cl_2(g) \rightarrow KCl(s)$ is not balanced

$2\ K(s) + Cl_2(g) \rightarrow 2\ KCl(s)$ is balanced

8

## Balancing Equations by Inspection

Don't change formulas of molecules or subscripts.

Don't forget that if you use a coefficient, all of the atoms in the molecule are increased.

Consider the substance with the most atoms first

9

## Sample Test Question

Balance the following reactions, or indicate that they are balanced as written.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

$C_8H_{18}\ (l) + O_2\ (g) \rightarrow CO_2 + H_2O$

$Fe_2O_3\ (s) + C\ (s) \rightarrow Fe\ (s) + CO_2\ (g)$

$SO_2 + O_2 \rightarrow SO_3$

$C_6H_{12}O_{6(aq)} \rightarrow CO_{2(g)} + CH_3CH_2OH_{(aq)}$

$(NH_4)_2SO_4 + BaCl_2 \rightarrow BaSO_4\ (ppt) + NH_4Cl$

10

## The Mole

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

1 molecule 2 molecules 1 molecule 2 molecules

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

1 mol 2 mol 1 mol 2 mol

11

## Avagadro and the Moles

Avagadro's number- $6.02 \times 10^{23}$

1 mole (mol) is $6.02 \times 10^{23}$ atoms or $6.02 \times 10^{23}$ molecules (or …)

$6.02 \times 10^{23}$ *particles* = 1 mol

12

## Molar Mass

Use *formula weight* to determine *molar mass*

$CH_4$

1 C = 12.011 amu = 12.011 amu

1 H = 1.0079 amu = 4.032 amu

formula weight = 16.043 amu

molar mass = 16.043 g/mol

13

## Mole Calculations

Watch subscripts, especially around parentheses

14

## Sample Test Questions

Sucrose has the formula $C_{12}H_{22}O_{11}$. What is the formula weight of sucrose?

Calculate the molar mass of $Fe_2(NO_3)_3$.

What is the formula weight and the molar mass of copper (II) sulfate heptahydrate?

15

## Conversions

- Show your work on the exam
- Set up unit cancellation
- Show units you end up with

16

## Sample Test Question

What mass of sucrose, $C_{12}H_{22}O_{11}$, should be weighed out if I want 1.54 mol sucrose?

Next semester: 30 g sucrose, how many moles?

17

## Stoichiometry

Stoichiometry- ratio of products to reactants

AKA mole ratio

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

18

## Sample Test Question

Using the following balanced equation, how many moles of $CO_2$ will I end up with, beginning with 1.5 mol of C?

$$2\ Fe_2O_3\ (s) + 3\ C\ (s) \rightarrow 4\ Fe\ (s) + 3\ CO_2\ (g)$$

Using the previous balanced equation, how many moles of Fe will I end up with, beginning with 1.17 mol of $Fe_2O_3$?

19

## Theoretical Yield Calculations

1. Convert mass into moles
2. Do stoichiometry
3. Convert moles back to mass

Stoichiometry is an exact number

20

## Sample Test Questions

Using the following balanced chemical reaction, calculate the theoretical yield of carbon dioxide if you burn 1.25g $C_4H_{10}$ in excess oxygen.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

21

## Limiting Reagent

One thing always runs out first- this is known as the limiting reagent.

In order to determine the limiting reagent, calculate the theoretical yield for both (all) reactants.

22

## Sample Test Question

Using the following equation, identify the limiting reagent if you burn 1.25g $C_4H_{10}$ in 16.9g of $O_2$.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

23

## Percent Yield

$$\text{Percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

24

## Sample Test Question

Calculate the percent yield if you begin with 1.25g $C_4H_{10}$ in 16.9g of $O_2$, and end up with 3.32g of $CO_2$.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

25

## Sample Test Question

Determine the limiting reagent of the following reaction if you begin with 12.63g HCl and 11.59g of NaOH.

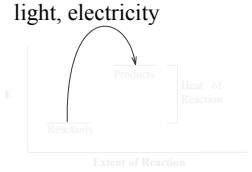
$$HCl + NaOH \rightarrow NaCl + H_2O$$

Determine the percent yield in question 10 if you obtain 16.59g NaCl.

26

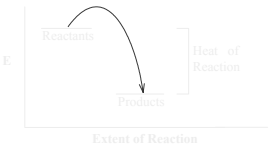
## Chemical Reactions and Energy Changes

All chemical reactions involve a change in energy: heat, light, electricity




Endothermic reaction- take up heat from surroundings (cold to the touch).

Reactants are lower energy state than products.




Exothermic reaction- produce heat (hot to the touch).

Products are lower energy state than reactants.

27

## Sample Test Questions

50.0 mL of 2 N HCl at 23.0°C is added to a *calorimeter* containing 50.0 mL 2 N NaOH at 23.0°C. The temperature is observed to increase to 37.0°C. Is the neutralization of acid an exothermic or endothermic reaction?

What is the *heat of reaction* in the above experiment?