Chemical Reactions

Conservation

- The Law of Conservation of Matter states that matter cannot be created or destroyed in ordinary chemical reactions.
- This means that no atoms can be lost or gained.
- This is the foundation that allows us to balance equations.
- All atoms must be accounted for when comparing the starting substances to the final substances.

Basic Reactions

- When a reaction is written, the substances written on the left are called the reactants.

$$Mg_{(s)} + Cl_{2\,(g)} \rightarrow MgCl_{2\,(s)}$$

- The substances on the right are the products.
- The arrow represents the direction of the reaction.
- The subscripts after each substance is what phase it is found in.
- Possible phases are solid (s), liquid (l), gas (g), and aqueous (aq).
- Aqueous means that it is dissolved in water.

Balancing

- When an equation is written, the substances can not be changed, they are what reacts and are produced so the formulas cannot be modified in any way.
- What can be changed is the number of each substance that can be involved.
- Ex: $CH_4 + O_2 \rightarrow CO_2 + H_2O$
- The hydrogens are not balanced, so I can put a coefficient of 2 in front of the water molecules to get 4 hydrogens on the right side.
- $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$

Finishing the balancing

- Now a 2 needs to be put in front of the oxygen on the left to get 4 on the left side.
- $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- It is now balanced because there is the same number of each element on both sides of the arrow.
- Always start with an element that only appears in one compound on each side of the arrow.
- Never start with one that is in more than one compound on the same side of the arrow, if fact, leave that until last. In this case it would be oxygen that is left until last.

Complicated balancing

- The only complication is that all coefficients must be whole numbers. So try this:
- $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
- $C_2H_6 + O_2 \rightarrow 2CO_2 + H_2O$
- $C_2H_6 + O_2 \rightarrow 2CO_2 + 3H_2O$
- Now the problem. There are 7 oxygens on the right, but can only get an even number on the left.
- In this case, double everything that was already balanced, meaning the carbon and hydrogen containing compounds.

Finishing complicated one

- $2C_2H_6 + O_2 \rightarrow 4CO_2 + 6H_2O$
- Now there are 14 hydrogens on the right which can be balanced easily with a whole number on the left.
- $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
- Always double check to ensure that the coefficients cannot be reduced.

Types of reactions

- There are many different types of reactions that follow patterns so by knowing your reactants, you can predict the products.
- The ones that we cover in here are as follows:
  - Synthesis (composition, direct combination)
  - Decomposition
  - Single replacement
  - Double replacement
  - Combustion

Synthesis

- In a synthesis reaction, two elements or simple compounds are combined to make a larger compound. In this course it will always be elements.
  - $A + B \rightarrow C$
- Where A and B are elements, and C is a compound.
- The phases for A and B can be found on the periodic table since they are elements.
- If C is an ionic compound, then it will be a solid and its formula would be related to the charges each element would prefer to have.
- If C is molecular then the phase would be given or it would be water or CO_2 which would be a gas.

Decomposition

- Decomposition is the opposite of synthesis.
- A large compound will break into smaller elements or simpler compounds.
  - $A \rightarrow B + C$
- If A is ionic, it will be a solid, and if its molecular, its phase will be given.
- If B and C are elements, then the phase can be determined from the periodic table.
- If B and C are simpler compounds, then if ionic, they are solid, and molecular would be given or are gases in the case of water and CO_2.
- Information will be given to determine B and C if they are not elements.

Single replacement

- An element and an ionic compound react to form an element and ionic compound.
  - $A + BC \rightarrow AC + B$
- A on the reactant side and B on the product side are elements whose phases come from the periodic table.
- BC and AC are both aqueous ionic compounds whose formulas come from the charges of the ions.
- Not all single replacement reactions occur. A must be more reactive then the component of BC that it is replacing.

Do not always occur

- Not all single replacement reactions occur. Substance A must be more reactive then the component of BC that it is replacing.
- For metals you check the activity series. The higher the metal on the series, then the more active it is.
- For halogens, simply check its position on the table in column 17. The higher in column 17, the more active it is.
- If substance A is less active then what it is trying to replace, then there is no reaction.

Double replacement

- In these reactions, two ionic compounds that are aqueous (ions in solution)react to form two new ionic compounds.
  - $AB + CD \rightarrow AD + BC$
- This reaction only occurs if one of the products is insoluble, water, or decomposes into a gas. Otherwise nothing has changed, and they are all still ions in solution.
- Check the solubility chart. If both products are soluble, then there was no reaction.

Combustion

- In a combustion reaction, a hydrocarbon fuel will react with oxygen to form carbon dioxide and water.
- Fuel + O_2 → CO_2 + H_2O
- The phase of the hydrocarbon will always be given, and the oxygen, carbon dioxide, and water are always gases.
- The only difference in the equations is what the hydrocarbon is, and what coefficients are necessary to balance the equation.

Summary

Reaction type	Reactants	Products	phases	Occur?
Synthesis	2 elements	1 compound	Element Phases from periodic table Ionic = solid Molecular = given or gas for water and carbon dioxide	Yes
Decomposition	1 compound	2 elements or simple comounds	Element from P.T. Ionic = solid Molecular = given or gas for water and carbon dioxide	Yes
Single replacement	1 element and 1 ionic compound	1 element and 1 ionic compound that's different	Elements = P.T. Ionic = aqueous	Check activity series
Double replacement	2 Ionic compounds	2 different ionic compounds	Reactants are aqueous Products need to be checked	Check solubility chart
Combustion	Fuel plus oxygen	CO_2 and H_2O	Fuel given, everything else is a gas	Yes