4.1 Introduction for Reactions

A physical change occurs when a substance undergoes a change in properties but not a change in composition. Examples of physical changes:

- Changes in the phase of a substance (solid, liquid, gas)
- Formation/separation of mixture of substances .

A chemical change occurs when substances are transformed into new substances, typically with different compositions. Examples of chemcial changes:

- Production heat or light
- Formation of a gas
- Formation of a precipitat
- Color change

4.2 Net Ionic Equations

All physical and chemical processes can be represented symbolically by balanced equations. Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass is conserved in chemical reactions.

Balnced molecularl equations show all species participating in a reaciton. These equations indicate that mass is conserved.

$$2\,\mathrm{NaOH}_{(aq)} + \mathrm{CuSO_4} \longrightarrow \mathrm{Na_2So_4}_{\,(aq)} + \mathrm{Cu(OH)}_{2(s)}$$

Complete ionic equations show ions in squarous soluion as sprate charged particles. This type of equations can be used to idenify spectator ions.

$$2\,\mathrm{Na^+}_{(aq)} + 2\,\mathrm{OH^-}_{(aq)} + \mathrm{Cu^{2+}}_{(aq)} + \mathrm{SO_4}^{2-} \longrightarrow 2\,\mathrm{Na^+}_{(aq)} + \mathrm{SO_4}^{2-}_{(aq)} + \mathrm{Cu(OH)}_{2(s)}$$

Net ionic quations do not iclude spectator ions. It is useful to represent only the substnaces undergoing a chemical change

$$2\,\mathrm{OH^-}_{(aq)} + \mathrm{Cu^{2+}} \longrightarrow \mathrm{Cu(OH)}_{2(s)}$$

Balanced molecular, complete ionic, and net ionic equations are different symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is being used.

4.3 Representations of Reactions

Balanced chemical equations in their various forms can be translated into symbolic particulate representations.

4.4 Physical and Chemical Changes

Processes that involve the breaking and/or formation of chemical bonds are typically classified as chemical processes. Processes that involve only changes in intermolecular interactions, such as phase changes, are typically classified as physical processes.

Sometimes physical processes involve the breaking of chemical bonds. For example, plausible arguments could be made of the dissolution of salt in water, as either a physical or chemical process, involves breaking of ionic bonds, and the formation of ion-dipole interactions between ions and solvent.

4.5 Stoichiometry

Because atoms must be conserved during a chemical process, it is possible to calculate product amounts by using known reactant amounts, or to calculate reactant amounts using known product amounts. Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations involving the mole concept.

Stoichiometric calculations can be combined with the ideal gas law and calculations involving the molarity to quantitatively study gases and solutions.

4.6 Introduction to Titration

Titrations may be used to determine the concentration of an analyte in solution. The titrant has a known concentration of species that reacts specifically and quantitatively with the analyte. The equivalence point of the titration occurs when the analyte is totally consumed by the reading species in the titrant. The equivalence point is often indicated by a change in property (such as color) that occurs when the equivalence point is reached. This observable event is called the endpoint of the titration.

> *When titrations come up on the AP Exam and you are given a value of products or reactants, you can assume that there is no limiting reagent.*

Often during an acid-base titration, a pH meter can be used to monitor the progress of the titration to produce a triration curve. It can be used to dertimine the equivolence point of the titration. The point on the curce where the pH change is the greatest indicates teh volume of teh titrant needed to react witht eh analyte in stoichiometric ratios.

Not all titrations are acid-base titrations. A redox reacton can be used otdetermine the concetration of an uknoinw solution

4.7 Types of Chemical Reactions

Acid-Base Reactions

Acid-base reactions involve transfer of one or more protons between chemical species and a neutralization reaction occurs. Brønsted-Lowry acid-base reatoins invovle the transfer of one or more protons from the acid to the base. A Brønsted-Lowry acid is a proton doner and a Brønsted-Lowry base is a proton acceptor. The products of a Brønsted-Lowry acid-base reaxrtion are often water and an ionic cmpund (salt).

In an acid-base reaction, every acid has a conjugate base formed by removing an H^+ and each base has a conjugate acid by adding an H^+. Two sets of conjugat acid-base paris can be identified in every acid-base reaction.

Oxideation-Reduction Reactions

Oxidation-reduction reactions involve transfer of one or more electrons between chemical species, as indicated by changes in oxidation numbers of the involved species. The substance that loses electrons is oxidized adn teh substance that gains electrons is reduced. Combustion is an importation subclass of oxidation-reduction reactions, in which a species reacts with oxygen gas. In the case of hydrocarbons, carbon dioxide and water are products of complete combustion. In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced.

> *Will not be assessed on the meaning of the terms “reducing agent” and “oxidizing agent”*

Oxidation Numbers

- Atoms in their elemetnal fomr have oxidation numbers of 0
- Monoatomic ions have oxidation numbers equal to their charge
- Oxygen in a compound mostoften has an oxidation number of -2
    - EXCEPT in perosides (like H_2O_2), where oxigen has an oxidation number of -1
- Hydrogen usually is +1 when bonded to a nonmetal and -1 when bonded to a metala
- Fluorine always has an oxidation number of -1

Oxidation numbers may be assigned to each of the atoms in the reactants and products; this is often an effective way to identify the oxidized and reduced species in a redox reaction.

The sum of all oxidation numbers in a neutral comound is 0. The sum of all oxidatin numbers in a polyatomic ion equals the charge.

Precipitation Reactions

Precipitation reactions frequently involve mixing ions in aqueous solution to produce an insoluble or sparingly soluble ionic compound. All sodium, potassium, ammonium, and nitrate salts are soluble in water.

> *Shoudl be something here*

4.8 Introduction to Acid-Base Reactions

By definition, a Brønsted-Lowry acid is a proton donor and a Brønsted-Lowry base is a proton acceptor. A conjugate acid was the former base that accepted a proton. A conjugate base was the former acid that donated a proton

Only in aqueous solutions, water plays an important role in many acid-base reactions, as its molecular structure allows it to accept protons from and donate protons to dissolved species.

> *Will not be assessed on Lewis acid-base concepts*

4.9 Oxidation-Reduction (Redox) Reactions

Balanced chemical equations for redox reactions can be constructed from half-reactions.

Given:

$$Al_{(s)} + Cu^{2+}_{(aq)} \rightarrow Al^{3+}_{(aq)} + Cu_{(s)}$$

Separate into half reactions:

$$Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-$$

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

The same number of electrons must be conserved. Therefore:

$$2(Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-) = 2Al_{(s)} \rightarrow 2Al^{3+}_{(aq)} + 6e^-$$

$$3(Cu^{2+}_{(aq)} + 2e^- \rightarrow 3Cu_{(s)}) = 3Cu^{2+}_{(aq)} + 6e^- \rightarrow 3Cu_{(s)}$$

Combine:

$$2Al_{(s)} + 3Cu^{2+}_{(aq)} + 6e^- \rightarrow 2Al^{3+}_{(aq)} + 6e^- + 3Cu_{(s)}$$

Cancel the e^-:

$$2Al_{(s)} + 3Cu^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Cu_{(s)}$$