Thermochemistry Notes

Energy is defined as the ability to do work. In the context of this chemistry course, this means that work is done when an object moves some distance in response to a force being applied.

Work = force x distance.

Part I. Types of energy

        Mechanical Energy
                Potential or stored energy
                        Wound up spring
                        Gasoline before burning

                Kinetic energy or energy of motion
                        Moving objects

        Nonmechanical energy
                Chemical energy
                Electrical energy
                Electromagnetic (radiant) energy
                Sound energy
                Heat energy
                Magnetic energy

Units for measuring energy
                Joule (J)
                Calorie (cal)

Energy is often converted from one form to another. In a car the chemical energy of the fuel is converted to heat energy, which is then converted to mechanical energy as gases expand to force the pistons to move.

Part II. Law of Conservation of Mass/Energy
        As with the conservation of mass, energy cannot be either created or destroyed in a reaction.
        Einstein's research led to the discovery that mass can be converted into energy ($E=mc^2$)

Part III. 2 Thermochemical Reactions:
        A. Exothermic reactions
        Energy (heat) is released as the products of the reaction have less potential energy than
        reactants. ($HC + O_2$ ➔ $CO_2 + H_2O$).
                Burning
                Rusting of iron
                Condensation
                Freezing

        B. Endothermic reactions
        Energy (heat) is absorbed as the products of the reaction have more potential energy than

reactants.
Photosynthesis
Melting and evaporation

Part IV: **How do we measure energy?**

1st way: $q = mc\Delta t$

Heat energy-   Each substance has its own specific heat capacity which is defined as the amount of heat required to raise one mass unit one °C   (J/g-°C or cal/g-°C)

Heat (Q) = Mass x change in temp (Δt) x specific heat (c)

$$q = mc\Delta t$$

$$c = \frac{Q}{m\Delta t}$$

(note: In problems where it is necessary to report the final temperature,
add or subtract Δt from initial temperature depending on whether
reaction is endothermic or exothermic)

For drill problems using this calculation, go to
http://science.widener.edu/svb/tutorial/waterheatcsn7.html

Part V. Kinetic theory of Heat and Temperature

All matter is made of uncountable numbers of particles. All particles are in constant motion. Even solid objects are in motion, even though we cannot detect motion. With two bodies in contact, energy will transfer from the body with the higher energy to the body with the smaller amount of energy until the temperature is the same. Melting of ice is an example of this transfer. Heat enters melting ice, but as long as both solid and liquid are present the temperature does not change. The energy is being used to rearrange the molecules. The potential energy of the liquid water is higher than the ice, therefore the melting of ice is endothermic. Evaporation of sweat is another example.

Part IV. **Enthalpy (ΔH) - 2nd way to measure energy**

Enthalpy is defined as the quantity of heat transferred in a reaction.
The equation **$\Delta H_{reaction} = H_{products} - H_{reactants}$** illustrates how heat is calculated. The coefficients in a thermochemical reaction indicate the number of moles involved. It is possible to use fractions as coefficients in this kind of equation.

In an exothermic reaction the amount of heat released is included in the equation:
$2H_2 + O_2 \rightarrow 2H_2O + 483.6kJ$

In an endothermic reaction heat is one of the reactants: $2H_2O + 483.6kJ \rightarrow 2H_2 + O_2$
halving or doubling the amounts will change the amount of heat transferred correspondingly.

Part VII. Types of Delta Hs.

Molar Enthalpy of Formation (ΔH_f)
The enthalphy change that occurs when one mole of a compound is formed at standard state (25°C and 1atm). Compounds that release a great deal of heat upon formation are very stable. Defined in terms of one mole of product.

Molar Enthalpy of Combustion (ΔH_c)
The enthalpy change that occurs during the complete combustion of 1 mole of a substance. Defined in terms of one mole of reactant.

Standard values of ΔH_f and ΔH_c are available in many reference books. To calculate overall ΔH, use Hess's Law, which states that *the overall enthalpy change in a reaction is equal to the sum of the enthalpy changes in the individual steps in the reaction, independently of the route taken.* This approach can help calculate the heat transferred when standard amounts are unavailable.

1. If a reaction is reversed, the sign of ΔH must be reversed.
2. Multiply the coefficients of the known equations so that when added together they give the desired thermochemical equation. Multiply the ΔH by the same factor.

ΔH_{rxn} = sum of [(ΔH_f of products)] - sum of [ΔH_f of reactants]

See sample problems A and B pp 540-541.

Part VIIII. Reaction Tendency and Entropy
Energy change is only one of two factors that allow us to predict whether a reaction will mover towards completion. The other is a measure of the **randomness** of the reaction or **entropy (S).** Dissolving liquids, mixing gases, and formation of solutions are reactions that increase the entropy of a system. A positive value for ΔS increases the randomness or disorder of a system.

The tendency in nature is to decrease the enthalpy and to increase the entropy (negative ΔH and positive value for ΔS. The universe is trending towards chaos.