Nutrition and units

calories

- A calorie is the old chemistry metric unit for energy.
- A calorie is the amount of energy required to raised 1 g of water 1 degree Celsius.
- In science, there was a broad unification movement to make all sciences use the same units.
- A joule was the amount of energy commonly used in physics.
- It is the amount of energy required to accelerate a 1 kg object 1 m/s^2 for 1 m, or apply 1 N of force for 1 m.

Nutrition and Calories

- Calorie is an energy measurement just like joules.
- Calories reported on food labels are actually kilocalories (it does have to be capitalized).
- 1 Cal = 1000 cal = 4.183 kJ
- The calories in a food are the amount of energy released during the metabolism reaction of that food.

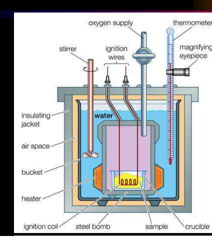
Elsewhere

- Other countries are switching their food labels to match the science standard.

Bomb Calorimeter

- In the past food, was placed in a bomb calorimeter, a sealed container to stop heat transfer, and burned to check the amount of energy released.
- The heat was used to heat water and it could be calculated.
- This led to some problems as certain things we eat are indigestible, but they are burnable

Bomb Calorimeter



Better calculations

- Now, the amount of proteins, carbohydrates, and fats are separated and measured.
- We can calculate the caloric content from that and get a much better measure of the energy content of food.

Energy content in foods

- carbohydrate – 4 Cal/g
- protein – 4 Cal/g
- fat – 9 Cal/g
- There is more you need from food than just energy (vitamins, minerals etc.).
- There is a certain amount of Calories you need to function.
- This amount differs for each person, and differs over time.
- Striking an appropriate balance between these is a healthy diet.

Continued…

- The energy from food is used by your body for everything it does (powering muscles, building new cells, controlling body temperature etc.).
- If you take in less than you need your body cannot function properly (car without gas).
- If you take in more than you use, it is stored as fat or glycogen, organic compounds that can be digested later.

Storage

- The ability of your body to store energy is NOT bad.
- You would have to eat every hour of your life to survive if you couldn't store energy.
- Excess long term storage of fat is not healthy for your body.
- Several methods of removing the excess fat are not healthy either.

Enthalpy

- ~A measure of heat energy content of a reaction.
- The symbol for enthalpy is H
- Enthalpy can only be measured as a change from a standard state.
- Negative values mean the energy is released (exothermic).
- Positive value mean the energy is absorbed (endothermic).

How is that different from q

- q is the change in heat energy.
- Enthalpy is the change in heat energy per mole for a process or reaction.
- $\Delta H = q/n$
- so it is measured in J/mol
- $2\ H_2 + O_2 \rightarrow 2\ H_2O$ $\Delta H = -572$ kJ/mol
- This means if the reaction is run once with 2 moles of H_2 and one mole of O_2, 572 kJ of energy are released

Hess's Law

- ~In going from a set of reactants to a set of products the change in enthalpy will be the same regardless of how it changed.
- There is more than one way for a set of reactants to produce a set of products. The overall energy change will be the same no matter how you get there.

Hess's Law

- In essence, sometimes different equations can added together to represent another equation.
- In this case, you would add the enthalpy of reaction, ΔH, of the equations to determine value of the new equation.
- Compounds that appear on both reactant and product side will cancel out.

Hess's Law example

- $N_2 + O_2 \rightarrow 2\ NO$ $\Delta H = 180$ kJ
- $2NO + O_2 \rightarrow 2\ NO_2$ $\Delta H = \underline{-112\ \text{kJ}}$
- 68 kJ
- Or
- $N_2 + 2\ O_2 \rightarrow 2\ NO_2$ $\Delta H = 68$ kJ

Manipulating enthalpy values

- If an equation needs to be doubled, tripled, halved… you multiply the value of the enthalpy by that number.
- $2\ H_2 + O_2 \rightarrow 2\ H_2O$ $\Delta H = -572$ kJ/mol
- $4\ H_2 + 2\ O_2 \rightarrow 4\ H_2O$ $\Delta H = -1144$ kJ/mol
- $H_2 + \frac{1}{2}\ O_2 \rightarrow H_2O$ $\Delta H = -286$ kJ/mol
- If an equation needs to be reversed the magnitude is the same, but the sign is opposite
- $2\ H_2O \rightarrow 2\ H_2 + O_2$ $\Delta H = 572$ kJ/mol

Another Hess's Law example

$C_{graphite} + O_2 \rightarrow CO_2$ $\Delta H = -394$ kJ/mol
$C_{diamond} + O_2 \rightarrow CO_2$ $\Delta H = -396$ kJ/mol

- Calculate ΔH for the conversion of graphite to diamond:
- $C_{graphite}(s) \rightarrow C_{diamond}(s)$

ΔH for the reverse of a reaction will be the opposite sign.

Answer to Hess's Law example

This equation
$C_{graphite}(s) \rightarrow C_{diamond}(s)$
Reverses the diamond
$C_{graphite} + O_2 \rightarrow CO_2$ $\Delta H = -394$ kJ/mol
$CO_2 \rightarrow C_{diamond} + O_2$ $\Delta H = +396$ kJ/mol

- CO_2 and O_2 cancel out

$\Delta H = 2$ kJ/mol

Example problem

- Hydrazine, N_2H_4, is a colorless liquid used in rocket fuel. What is the enthalpy of the reaction for the formation of hydrazine
- $N_2 + 2\ H_2 \rightarrow N_2H_4$ ΔH = ?
- Given the equations
- $N_2H_4 + O_2 \rightarrow N_2 + 2\ H_2O$ ΔH = -622 kJ/mol
- $2\ H_2 + O_2 \rightarrow 2\ H_2O$ ΔH = -572 kJ/mol

Answer

- $N_2 + 2\ H_2O \rightarrow N_2H_4 + O_2$ ΔH = 622 kJ/mol
- $2\ H_2 + O_2 \rightarrow 2\ H_2O$ ΔH = -572 kJ/mol

- $N_2 + 2\ H_2 \rightarrow N_2H_2$ ΔH = 50. kJ/mol

Another

$C_2H_4 + H_2 \rightarrow C_2H_6$

Calculate the enthalpy for the above reaction using the following enthalpy values.

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ΔH = -1411 kJ/mol

$2\ C_2H_6 + 7\ O_2 \rightarrow 4CO_2 + 6H_2O$ ΔH = -3120 kJ/mol

$H_2 + ½\ O_2 \rightarrow H_2O$ ΔH = -286 kJ/mol

Answer

- Calculate the enthalpy for the above reaction using the following enthalpy values.
- $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ΔH = -1411 kJ
- $2CO_2 + 3H_2O \rightarrow C_2H_6 + 7/2\ O_2$ ΔH = 1560 kJ
- $H_2 + ½\ O_2 \rightarrow H_2O$ ΔH = -286 kJ

- $C_2H_4 + H_2 \rightarrow C_2H_6$ ΔH = -137 kJ