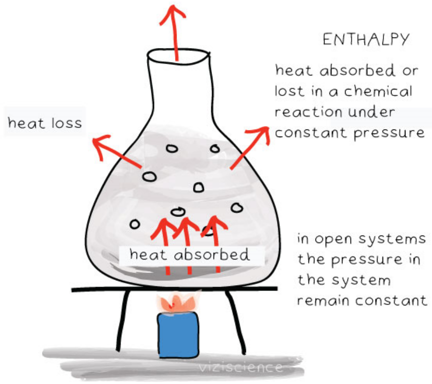
6.2 - Enthalpy and Calorimetry



Enthalpy (H)

Enthalpy is heat gained or lost during a reaction under constant pressure.

So far we have discussed energy change during a process.

Since $\Delta E = q + w$ and $w = -P\Delta V$, we can substitute these into an enthalpy expression:

$$\Delta H = \Delta E + P\Delta V$$

$$\Delta H = (q+w) - w$$

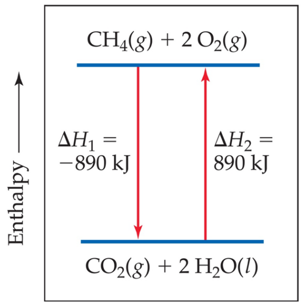
$$\Delta H = q$$

So, at constant pressure, the change in enthalpy *is* the heat gained or lost.

Enthalpy of Reaction

The *change* in enthalpy, ΔH, is the enthalpy of the products minus the enthalpy of the reactants:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$



1. Enthalpy Example

Consider the combustion of propane:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

$$\Delta H = -2221 \text{ kJ}$$

Assume that all of the heat comes from the combustion of propane. Calculate ΔH in which 5.00 g of propane is burned in excess oxygen at constant pressure.

1. Enthalpy Example

Since the equation reports the enthalpy of one mole of propane reacting, we must calculate moles of propane first.

$$5.0\,g\,C_3H_8 \bullet \frac{1\,mol\,C_3H_8}{44.11\,g\,C_3H_8} = 0.113\,mol\,C_3H_8$$

Then, multiply that by the energy associated with the balanced reaction:

$$0.113\,mol\,C_3H_8 \bullet \frac{-2221\,kJ}{1\,mol\,C_3H_8} = \boxed{-252\,kJ}$$

Calorimetry

Science of measuring heat.

Specific heat capacity:

The energy required to raise the temperature of one gram of a substance by one degree Celsius.

Molar heat capacity:

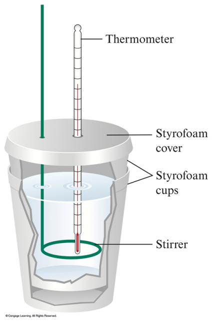
The energy required to raise the temperature of one mole of substance by one degree Celsius.

Calorimetry

If two reactants at the same temperature are mixed and the resulting solution gets warmer, this means the reaction taking place is exothermic.

An endothermic reaction cools the solution.

A Coffee–Cup Calorimeter Made of Two Styrofoam Cups



Calorimetry Math

Energy lost or gained (heat: q):

$q = s \bullet m \bullet \Delta T$ **AP Equation**	s = specific heat capacity (J/°C·g) m = mass of solution (g) ΔT = change in temperature (°C)(final-initial) Note: °C and Kelvins (K) are interchangeable: a 1°C change is the same as a 1 K change.

When solving calorimetry problems, it is important to watch your signs of q.
For instance, the sign of q for a hot item entering cold water will be negative for the process, and the sign of q for the water will be positive.
The magnitude of heat exchange will be the same for both (assuming that the surroundings don't absorb heat).

Calorimerty Examples

2. A 100.0 g sample of water at 90°C is added to a 100.0 g sample of water at 10°C.
The final temperature of the water is:
a) Between 50°C and 90°C
b) 50°C
c) Between 10°C and 50°C

Explain your choice.

b) 50°C. Since both samples have equal mass and are both water, it is reasonable that the resulting temperature is exactly between the original temperatures.

Calorimerty Examples

3. A 100.0 g sample of water at 90.0°C is added to a 500.0 g sample of water at 10.0°C.
The final temperature of the water is:
a) Between 50°C and 90°C
b) 50°C
c) Between 10°C and 50°C

c) Between 10°C and 50°C. Again, both samples are water, but the 10°C sample has five times the mass, so it will have more impact on the final temperature.

Calorimerty Examples

4. Calculate the final temperature of the water (s = 4.18 J/°C m).

Remember: heat lost (-q) by one substance equals heat gained by another (+q).

$$heat\ lost = heat\ gained$$

$$-s \bullet m \bullet \Delta T = +s \bullet m \bullet \Delta T$$

$$-4.18\frac{J}{^\circ C \bullet g} \bullet 100.0g \bullet (T_f - 90.^\circ C) = 4.18\frac{J}{^\circ C \bullet g} \bullet 500.0g \bullet (T_f - 10.^\circ C)$$

$$-(T_f - 90.^\circ C) = 5(T_f - 10.^\circ C)$$

$$-T_f + 90.^\circ C = 5T_f - 50.^\circ C$$

$$-6T_f = -140.^\circ C \qquad \boxed{T_f = 23^\circ C}$$

Calorimerty Examples

5. You have a Styrofoam cup with 50.0 g of water at 10.°C. You add a 50.0 g iron ball at 90. °C to the water. (s_{H2O} = 4.18 J/°C·g and s_{Fe} = 0.45 J/°C·g)

Calculate the final temperature of the water.

$$heat\ lost = heat\ gained$$

$$-s \bullet m \bullet \Delta T = +s \bullet m \bullet \Delta T$$

$$-0.45\frac{J}{^\circ C \bullet g} \bullet 50.0g \bullet (T_f - 90.^\circ C) = 4.18\frac{J}{^\circ C \bullet g} \bullet 50.0g \bullet (T_f - 10.^\circ C)$$

$$-(T_f - 90.^\circ C) = 9.29(T_f - 10.^\circ C)$$

$$-T_f + 90.^\circ C = 9.29T_f - 92.9^\circ C$$

$$-10.29T_f = -182.9^\circ C \qquad \boxed{T_f = 18^\circ C}$$

Homework

Read 6.3 in your textbook.

6.2 Problems in your Booklet
Due: Next Class.