THERMODYNAMICS

Calorimetry and Enthalpy

LAWS OF THERMO

- Zeroth Law:
  - Heat flows from hot to cold
- First Law:
  - Energy and matter are conserved
- Second Law:
  - Matter tends towards chaos
- Third Law:
  - Entropy of a pure crystal at 0 K is zero
**ENTHALPY**
- Heat and temperature
- Heat, amount of substance and $\Delta T$
- Endothermic (+) or Exothermic (-)
- Calculate:
  - Calorimetry
  - Table of standard values
  - Hess’s Law
  - Stoichiometry
  - Bond energies

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**Heat and Temperature**

**Molecular Workbench activity**

http://workbench.concord.org/database/activities/308.html

Heat – the sum of all of the energy in a system.

Temperature – the average kinetic energy of the particles in the system.

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**Heat, amount of substance and temperature change**

Do the **Before Class Activity**

http://genchem1.chem.okstate.edu/BCEActivities/Personal/PLE15.php
Calorimetry: Constant Pressure

\[ q_{\text{hot}} = -q_{\text{cold}} \]
\[ q_{\text{metal}} = -q_{\text{water}} \]
\[ q_{\text{solv}} = -q_{\text{water \ and \ solute}} \]
\[ q_{\text{rxn}} = -q_{\text{solution}} \]

If the heat capacity of the calorimeter is given have to include the heat absorbed or released by the calorimeter.

\[ q = \text{mass} \times \text{specific heat} \times \Delta T \]

Heat Flow: Solution Process

Look at simulation

http://genchem1.chem.okstate.edu/BCEActivities/Personal/PLE17.php

Calorimetry: Bomb Calorimeter

\[ q_{\text{rxn}} = -(q_{\text{water}} + q_{\text{calorimeter}}) \]
\[ q_{\text{water}} = \text{mass}_{\text{water}} \times \text{specific heat}_{\text{water}} \times \Delta T_{\text{water}} \]
\[ q_{\text{calorimeter}} = \text{heat capacity}_{\text{calorimeter}} \times \Delta T_{\text{calorimeter}} \]
\[ \Delta T_{\text{calorimeter}} = \Delta T_{\text{water}} \]
Predicting exothermic or endothermic reactions

- Enthalpy - $\Delta H$
- Energy content + endo - exo

Units on $\Delta H^\circ$

Enthalpy has units of $\text{kJ mol of reaction}^{-1}$

Units are important!

Formation Reactions

Elements in their standard state forming 1 mol of product in its standard state.
**Hess’ Law**

State function use to determine $\Delta H^\circ$ for new reactions.

\[ G24 \text{ – G28} \]

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**Enthalpy of reaction**

\[ \Delta H^\circ_{\text{rxn}} = \Sigma m \Delta H^\circ_f(\text{products}) - \Sigma n \Delta H^\circ_f(\text{reactants}) \]

\[ G29 \text{ – G40} \]

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**Bond Energy**

\[ \Delta H^\circ_{\text{rxn}} = \Sigma m \text{BE}(\text{reactants}) - \Sigma n \text{BE}(\text{products}) \]

\[ G41 \text{ – G42} \]