



AP Chemistry Ultimate Review Packet

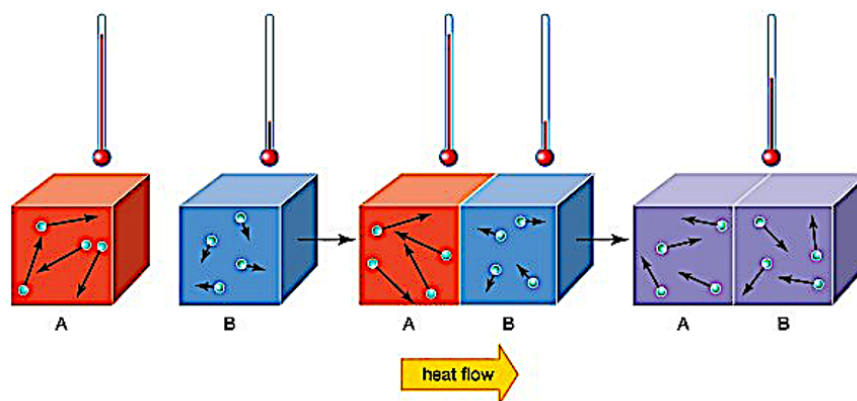
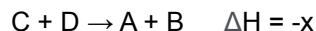
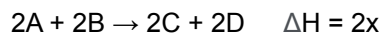
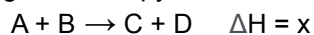
Unit 6: Thermodynamics

Enthalpy

The most important thermodynamic parameter in chemistry is **enthalpy (H)**

- when at constant pressure, change in enthalpy (ΔH) for a reaction is equivalent to the amount of energy *released* or *absorbed* as **heat** during the reaction
 - negative ΔH = exothermic (energy released)
 - positive ΔH = endothermic (energy absorbed)
- lattice energy: energy required to break apart an ionic solid (+)
- hydration energy: energy released when particles are solvated (-)
- dissolution: breaking apart lattice followed by solvation (+/-)

Change in enthalpy is a *stoichiometric value*



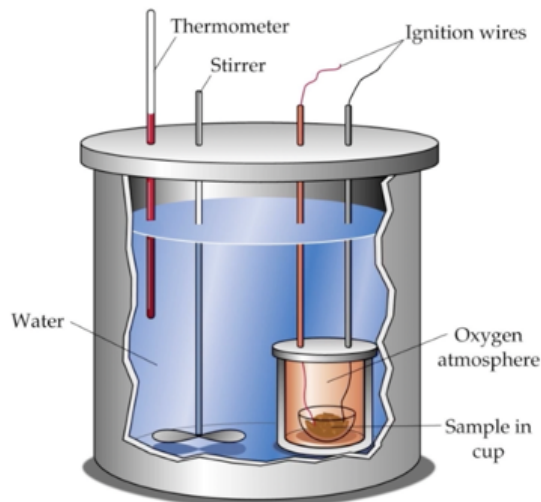
Heat transfer is a transfer of kinetic energy. Faster-moving particles (A: hot) collide with slower-moving particles (B: cold). Continues until thermal equilibrium is reached (A + B: uniform temperature)

- The rate at which an object transfers heat is described by its **heat capacity (C)**
 - this is the energy required to raise the temperature of an *object* by 1°C
 - $C = q/\Delta T$ (measured in $\text{J}/^\circ\text{C}$)
 - depends on amount of substance (more stuff = greater heat capacity)
- The rate at which a substance transfers heat is described by its **specific heat (c)**
 - energy required to raise the temperature of *one gram* of a substance by 1°C
 - $c = q/m\Delta T$ (measured in $\text{J}/\text{g}^\circ\text{C}$)
 - does not depend on amount of substance

We can measure heat transfer to solve for the specific heat of some substance ($q = cm\Delta T$). Measuring heat exchange during a physical or chemical process is called **calorimetry**.

A calorimeter is a well-insulated device that measures temperature changes. We can heat up an object and place it in water to measure temperature change

- $q = cm\Delta T$ for the water
 - known specific heat ($4.184 \text{ J}/\text{g}^\circ\text{C}$), get mass from volume, measure ΔT
 - this tells us the heat absorbed by the water upon heating from the object
- $q = cm\Delta T$ for the object
 - get mass prior, measure ΔT for object (not water)
 - heat absorbed by water = heat released by metal, solve for specific heat





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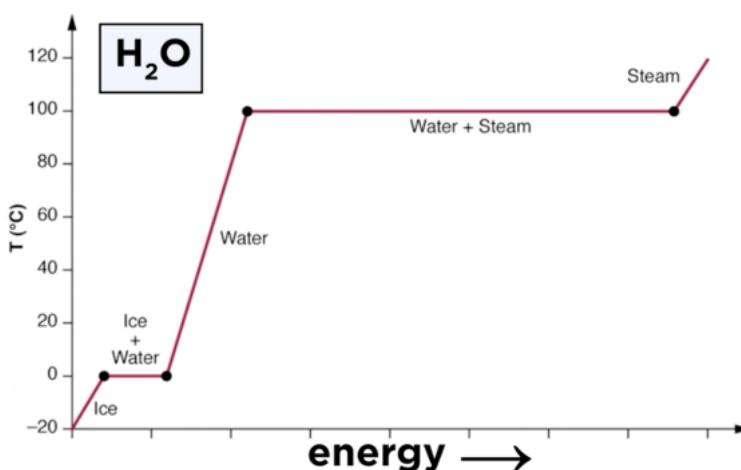
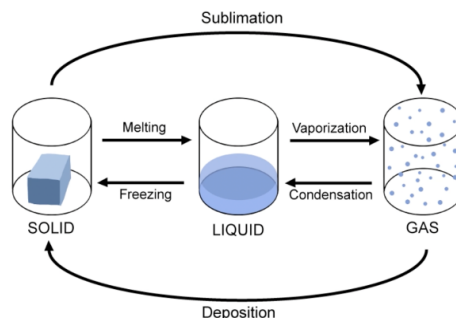
Unit 6: Thermodynamics

Phase changes have associated changes in enthalpy

- Melting/vaporization/sublimation are *endothermic*
- Freezing/condensation/deposition are *exothermic*

Enthalpy of fusion: energy released when freezing/absorbed when melting. This is the energy associated with the solid lattice.
(solid/locked in lattice → liquid/moving freely)

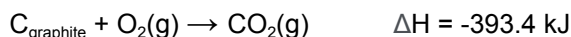
Enthalpy of vaporization: energy released when condensing/absorbed when vaporizing. This is the energy associated with intermolecular forces.
(liquid/interactions → gas/no interactions)



Energy exchange and phases are displayed on a **heating/cooling curve**. The sloped sections represent heating/cooling according to the specific heat of that phase. The flat sections correspond to phase changes (temperature does not change)

We will also want to calculate enthalpy changes for chemical reactions:

1. **Bond enthalpies** - energy associated with breaking/forming bonds
 - look up tabulated bond enthalpies for the relevant types of bonds
(bonds broken – bonds formed) = change in enthalpy
 - be sure to multiply by any relevant stoichiometric coefficients
2. **Enthalpy of formation (ΔH_f°)** - energy associated with forming one mole of a substance from its elements in their standard states at STP



- carbon is graphite rather than diamond
 - oxygen is diatomic rather than ozone, and it is gaseous
 - precisely one mole of the compound is formed
 - (sum of ΔH_f° products – sum of ΔH_f° reactants) = ΔH°
3. **Hess's law** - we can take chemical equations with known enthalpy changes and manipulate/add them so as to get a reaction of interest, and combining their changes in enthalpy in the same way will give the change in enthalpy in question
 - e.g. reaction of interest: $\text{A} + 2\text{B} \rightarrow \text{C} + 2\text{D}$, $\Delta H = ?$
 - reaction 1 = $\text{A} + \text{B} \rightarrow \text{C} + \text{E}$, $\Delta H = x$
 - reaction 2 = $\text{B} + \text{E} \rightarrow 2\text{D}$, $\Delta H = y$
 - add them up to give reaction of interest, $\Delta H = x + y$
 - multiply coefficients by some factor → multiply ΔH by same factor
 - invert direction of equation → invert sign on ΔH