Thermodynamics

- thermodynamics: study of changes in chem.rxn and influences of temp. on those changes – transfer of energy in a chemical or physical change – transferred in form of heat at constant pressure
- system: portion of universe under study
- surroundings: everything in universe but the system
- heat content/enthalpy = total of all forms of energy in substance
    - impossible to measure total heat content
- molar enthalpy: heat content of one mole of substance
- elements in standard state(25°C/101.3kPa) – zero enthalpy
- delta H = enthalpy of products - enthalpy of reactants
- q = delta H
- exo rxn = negative q (heat is lost) – enthalpy of products is lower than that of reactants
- endo rxn = postive q (heat is gained) – enthalpy of products is higher than that of reactants
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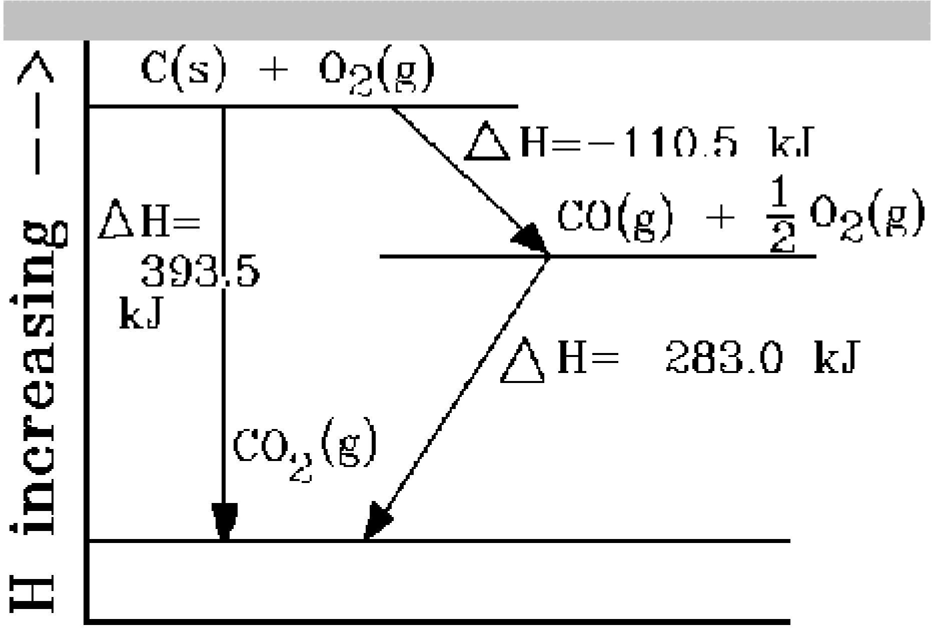
Enthalpy Graph:



Specific Heat

- calorie: energy required to raise one gra of water by 1°C
- calorimeter: measures heat flow associated with chemical reaction
- calorimetry: science of measuring heat flow – observing temp. change when a body absorbs or releases heat

- heat capacity: amount of heat energy required to raise the temp. of a given amount of a substance by one degree
- Heat Capacity (C) = Heat abosrbed, or released by an object (Q)

Increase in Temperature, (delta T)

units = J/g or J/mol°C

- heat capacity depends on amount of substance
- specific heat(c): amount of heat required to raise the temp. of one gram of material by one degree(J/g K)
- Specific Heat (c) = $\frac{\text{Heat capacity (C)}}{\text{Mass (m)}}$ or $\frac{\text{Heat Abosrbed(Q)}}{\text{(Mass) x (Change in Temp.)}}$
- Molar Heat capacity = specific heat capacity x molar mass (J/mol°C)
- water = 4.18 $Jg^{-1}K^{-1}$

Energy Changes during Changes of State:

- particles of solid are arranged in 3D structure
- solid is heated → particles gain energy and vibrate
    - therefore they leave positions and move past one another = liquid
- solid → liquid → vapour delta H increasing, endothermic
- vapour → liquid → solid delta H decreasing, exothermic
- molar heat of fusion (delta H°): heat absorbed by one mol of solid when it melts to a liquid at constant temp./pressure
- molar heat of solidification: heat released by one mol of liquid when it solidifies to a solid at constant temp./pressure (neg. enthalpy of fusion)

Standard Heats of Reaction

- thermochemical data is given by writing the reaction with the delta H° value at the end
- when a reactionis reversed, the sign of the delta H° is also reversed
- if the coefficients of the substances in a chem reaction are multiplied by a factor, then the delta H° value must be multiplied by the same factor

Enthalpy Changes

- enthalpy of formation (delta H^o_f): enthalpy change when one mol of compound is formed from its elements under standard condition
- enthalpy of combustion (delta H^o_c): the enthalpy change when one mol of a substance undergoes complete combustion(completely burned in oxygen) under standard condition
- enthalpy of solution (delta H^o_{soln}): enthalpy change when one mol of a solute is completely dissolved in a sufficient solvent to form a solution of concentration 1 mol/dm^{-3} under standard condition
- enthalpy of neutralisation (delta $H^o_{neutralisation}$): enthalpy change when one mol of acid reacts with one mol of base to form one mol of water and a salt

SEE “Table of Definitions of Types of Enthalpy Changes”

Hess’ Law

eg. (taken from Ms.Pall’s notes)

Suppose we want to know the enthalpy change for the formation of methane, CH_4, from solid carbon(as graphite) and hydrogen gas:

$$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)} \qquad \text{delta H} = ?$$

The enthalpy change for direct combination of the elemtns would be extremely difficult to measure in the lab. We can measure delta H, however, when the elemtns and mehtane burn in oxygen

Reaction	**delta H^o_f (kJ)**
1. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$	-393.5
2. $H_2 + O_{2(g)} \rightarrow H_2O_{(l)}$	-285.8
3. $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$	-890.3
Net: $C_{(s)} + 2H_{2(g)} \rightarrow CH_4$	-74.8

Hess’ Law states that the enthalpy change for the direct reaction(deltaH*net*) is the sum of the enthalpy changes along the alternative path

[deltaH*net* = delta H_1 + 2deltaH$_2$ - (-deltaH$_3$)]

Answer: -74.8 kJ