

## Enthalpy (H)

$\Delta H$ =Heat(q) at constant pressure.  
from  $H=U+PV$  see the other  
handout for more info.

### Phase change

$\Delta H^\circ_{\text{fus}} > 0$   
 $\Delta H^\circ_{\text{vap}} > 0$   
 $\Delta H^\circ_{\text{sub}} > 0$   
 $\Delta H^\circ_{\text{fus}} < \Delta H^\circ_{\text{vap}}$

### Temp. changes

$\Delta H^\circ = nC_p \Delta T$  or  
 $\Delta H^\circ = mC_{sp} \Delta T$  or  
 $\Delta H^\circ = Cp \Delta T$  Cp for calorimeter

**Know your units and the  
direction of heat flow**

### Algebra for $\Delta H$ :

change the direction change the  
sign

multiply thru by a number  
multiply the  $\Delta H$  by the number

**Hess's law:** If you can add up  
the rxn's to get another rxn then  
you can add up the  $\Delta H_{\text{rxn}}$ 's to  
get the  $\Delta H_{\text{rxn}}$  for the final rxn.

### Using $\Delta H^\circ_f$ to cal. $\Delta H^\circ_{\text{rxn}}$

$\Delta H^\circ_{\text{rxn}} = \sum (\text{coef.}) \Delta H^\circ_f(\text{products})$   
-  $\sum (\text{coef.}) \Delta H^\circ_f(\text{reactants})$

$\Delta H^\circ_f$  (the standard enthalpy of  
formation)

**$\Delta H^\circ_f$  is define as:**  $\Delta H$   
when 1 mole of a cmpd is  
formed from its elements as they  
are found in their natural state at  
standard conditions.

### Standard conditions

298.15K (not 0°C like STP) and  
**1 atm each gas 1M each  
aq sol'n.**

For all elements in their natural  
state at standard conditions

$\Delta H^\circ_f = 0$

## Entropy (S)

Entropy=disorder  
 $S=0$  at zero degrees K  
Entropy of the universe is  
always increasing.  
More disorder is good (positive)

### Phase changes

$\Delta S^\circ_{\text{fus}} = S(\text{liquid}) - S(\text{solid})$   
 $\Delta S^\circ_{\text{vap}} = S(\text{gas}) - S(\text{liquid})$   
 $\Delta S^\circ_{\text{fus}} < \Delta S^\circ_{\text{vap}}$   
 $S(\text{solid}) < S(\text{liquid}) < S(\text{gases})$   
 $\Delta S^\circ_{\text{fus}} = \Delta H^\circ_{\text{fus}} / T(\text{freezing pt})$   
 $\Delta S^\circ_{\text{vap}} = \Delta H^\circ_{\text{vap}} / T(\text{boiling pt})$

### Temp. changes

$\Delta S^\circ = nC_p \ln(T_2/T_1)$  or  
 $\Delta S^\circ = mC_{sp} \ln(T_2/T_1)$   
these are not given in the text if  
the prof. doesn't give it you  
don't need it. T's in K

### Algebra for S:

Same as H because it is a state  
function too.

### Hess's Law

Same as H (state function).

### Using $S^\circ$ to cal $\Delta S^\circ_{\text{rxn}}$

same as H  
co's times pro's - co's times re's  
 $S^\circ$  is the amount of disorder at  
standard conditions not change in  
disorder and not for forming one  
mole. It is just the disorder of  
one mole of the cmpd or  
element. It is related to amount  
at zero degrees K which is zero.  
 $S^\circ$  for elements is **not** zero  
because we are not talking about  
formation.

## Gibbs Free Energy (G)

$\Delta G$  Change in free energy also  
the max. amount of energy  
available to perform work.  
**MOST USEFUL: Predicts  
spontaneity.**

If **neg.** it's spont. going  $\Delta$   
If **pos.** it's not spont. going  $\Delta$   
If **zero** it's at eqlb

### Phase changes

At normal melting or boiling  
point you're at eqlb so  $\Delta G = \text{zero}$

### Temp. changes

see equation relating H and S to  
 $\Delta G$

$$\Delta G = \Delta H - T \Delta S$$

more on this one below

### Algebra for $\Delta G$ :

Same as H because it is a state  
function too.

### Hess's Law

Same as H (state function)

### Using $\Delta G^\circ_f$ to cal $\Delta G^\circ_{\text{rxn}}$

same as H  
co's times pro's - co's times re's  
defined reaction for  $\Delta G^\circ_f$  is also  
the same as  $\Delta H^\circ_f$  elements  
natural elements  $\Delta G^\circ_f = 0$   
 $\Delta G^\circ_f$  elements = zero

### Other equations for $\Delta G$

$$\Delta G = \Delta H - T \Delta S \text{ or}$$

$\Delta G^\circ = \Delta H^\circ - T^\circ \Delta S^\circ$  at  
standard conditions (**\*Temp.  
can be different then  
standard conditions**)

$$\Delta G = RT \ln(Q/K)^*$$

At standard conditions **Q=1**

so

$$\Delta G^\circ = -RT \ln(K)$$

R=8.314J/mole·K

T in K

\*same equation as below, right?!

$$\Delta G = \Delta G^\circ + RT \ln Q$$