

Wkst: Gibbs Free energy

1. What is Gibb's free energy? What is its symbol?

Gibb's free energy (G) - maximum amount of useful work that can be obtained by a system

2. What is the equation for Gibbs Free Energy (ΔG)?

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

\uparrow \uparrow \uparrow
 Enthalpy temp in K entropy

3. Why is it such a useful state function?

It can be used to indicate the direction of Spontaneity of a Rn, Based on values of the system.

4. What sign must ΔG have to indicate a ~~spontaneous~~ process?

Thermodynamically favorable process.

$-\Delta G$

5. At what temperatures would the following processes be ^{TFD.} spontaneous?

To solve determine what sign of ΔG from $\Delta G = \Delta H - T\Delta S$

o $+\Delta S, -\Delta H$ $\Delta G = -\Delta H - T\Delta S$ This Rn will occur at Any temp
 $\Delta G = -$

o $-\Delta S, -\Delta H$ $\Delta G = -\Delta H - T(-\Delta S)$ This Rn will occur at Low TEMPS
 $= -\Delta H + T\Delta S$ as long as T is not large

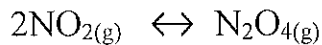
o $+\Delta S, +\Delta H$ $\Delta G = +\Delta H - T(+\Delta S)$ This Rn will occur at high TEMPS
 $\Delta G = -$ as long as $T \uparrow$

o $-\Delta S, +\Delta H$ $\Delta G = +\Delta H - T(-\Delta S)$ This Rn is not Thermodynamically Favorable at any temp
 $= \text{never } -$

Ke?

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6. For the following constant pressure process



- o ΔH° is -58.03 kJ and ΔS° is -176.6 J/K. What is the value of ΔG° at 298K?

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

$$= -58.03 \text{ kJ} \left(\frac{1000 \text{ J}}{1 \text{ kJ}} \right) - (298 \text{ K}) \left(\frac{-176.6 \text{ J}}{\text{K}} \right)$$

$$\Delta G = -58030 \text{ J} + 52620 \text{ J}$$

$$\Delta G = -5410 \text{ J}$$

- o At what temperature is $\Delta G^\circ = 0$ (assume ΔH° and ΔS° are not temp. dependent).

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

$$T = \frac{\Delta H}{\Delta S}$$

$$T = \frac{+58030 \text{ J}}{-176.6 \text{ J/K}}$$

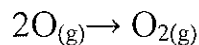
$$T = 328.6 \text{ K}$$

- o Would ΔG° be negative above or below that temp?

ΔG° would be - at any temp below 328.6 K.

Anything above would cause $T\Delta S$ to overcome the $\Delta H = -58030 \text{ J}$ and cause ΔG to be +

7. For the following constant pressure process



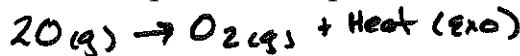
- o Sign of ΔH ? why?

$-\Delta H$ when bonds are formed process is exo

- o Sign of ΔS ? why?

$-\Delta S$ we are going from 2 separate atoms to 1 molecule
 \therefore less disordered \therefore less entropy

- o Would this process be spontaneous at low or high temperatures?



or solve thinking $\Delta G = \Delta H - T\Delta S$
 (-H) (+S)

* only thermodynamically favorable @ low temps

8. ΔG° gives us important information about the Equilibrium position of a reaction.

9. The value of ΔG depends on the Concentration and Pressure of reactants and products. Therefore the value of ΔG changes as a reaction proceeds.

10. At equilibrium the value for ΔG is Zero.

11. Provide an equation for the following relationships:

- o Relates ΔG° to K

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

\uparrow
 8.3145 J
 mol·K

~ Equilibrium Constant

- When would you use this equation?

When solving for the standard free energy of a system or for the equilibrium constant when given the ΔG°

12. What is the equation used to solve for the free energy of reaction using the free energy of formation?

$$\Delta G_{\text{Rxn}}^\circ = \sum \Delta G_{\text{products}}^\circ - \sum \Delta G_{\text{reactants}}^\circ$$

13. What is entropy?

Measure of disorder • Also Entropy also represents the amount of energy in a system not available for useful work

14. Why do things tend toward disorder?

- o A. There are more paths to disorder: Think of deck of cards

- o B. Less Energy required to be disordered:

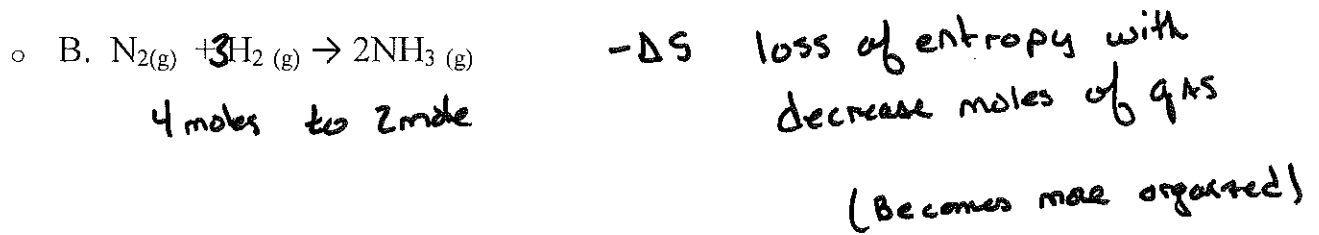
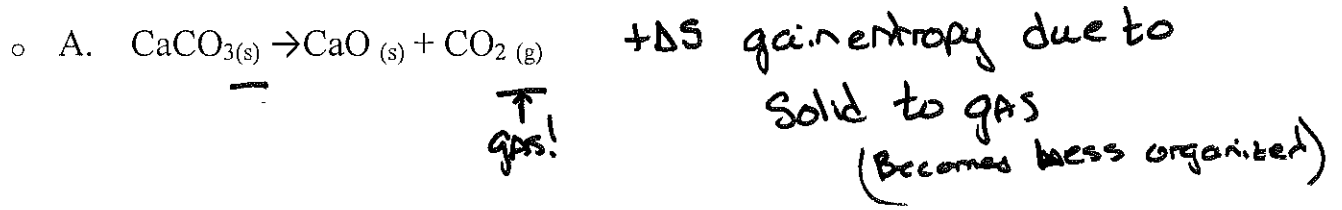
15. What state of matter has the highest entropy?

Solids - most organized

Liq - middle

Gas - least organized \therefore \uparrow entropy

16. Determine the sign of ΔS :



* Note:

a $-\Delta S$ value implies a decrease in disorder

$\therefore +\Delta S$ implies a \uparrow in disorder