

## Lesson 29: Thermodynamics II

text: 466-473

what to know:

- standard Gibbs function and chemical reactions, §11-6
- temperature and Gibbs function, §11-6
- relationship between Gibbs free-energy and equilibrium, §11-7
- life does not violate the second law of thermodynamics p-476-477
- Clausius-Clapeyron Equation , section 11-8

questions:

1. Relate  $\Delta G$  and  $\Delta G^\circ$ .

When are they equal?

Are they both zero at equilibrium?

Do they always have the same sign?

Are both affected by a change in the concentrations of reactants and products?

2. For what are  $\Delta G_f^\circ$ 's useful?

3. For each of the following systems tell whether the thermodynamic function is zero, greater than zero or less than zero. For e, tell whether the equilibrium constant is one, greater than one or less than 1.

a.  $\Delta S_{\text{sys}}^\circ$  for the reaction,  $\text{NH}_4\text{Cl}(\text{s}) \rightleftharpoons \text{NH}_3(\text{g}) + \text{HCl}(\text{g})$

b.  $\Delta S_{\text{surr}}^\circ$  for the reaction,  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

c.  $\Delta S_{\text{universe}}^\circ$  for the process,  $\text{H}_2\text{O}(\text{s}) \rightleftharpoons \text{H}_2\text{O}(\text{l})$ :

- 1) at 0.0 °C.
- 2) at -20 °C.
- 3) at +30 °C.

d.  $\Delta G^\circ$  for the process,  $\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{l})$ :

- 1) at 120 °C.
- 2) at 60 °C.

e.  $K_{\text{eq}}$  for the reaction,  $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$  ( $\Delta G^\circ$  is -2.60 kJ)

f.  $\Delta G^\circ$  for the reaction,  $3\text{O}_2(\text{g}) \rightleftharpoons 2\text{O}_3(\text{g})$  ( $\Delta H^\circ$  is positive):

- 1) at high temperatures.
- 2) at low temperatures.