Thermodynamics R and R Worksheet
7/26/24

1) Solid NH_4NO_3 is placed in a beaker containing water at 25 °C. When the solid has completely dissolved, the temperature of the solution is 23.5 °C.

(a) Was the process exothermic or endothermic?

(b) Did the entropy of the system increase?

2) Predict whether each of the following processes results in an increase in entropy in the system. (Define reactants and products as the system.)
a) Atmospheric water vapor condenses as dew (liquid water) at 0 °C and 1 atm pressure.

b) An exothermic reaction of Al(s) and $Br_2(\ell)$ forms $Al_2Br_6(s)$

c) The endothermic decomposition of solid $CaCO_3$ at 800 °C to produce an equilibrium mixture containing solid $CaCO_3$, solid CaO, and gaseous CO_2

d) One mol of AgCl(s) decomposes, forming 1.0 mole of Ag(s) and 0.5 mol $Cl_2(g)$.

3) Calculate the standard entropy change for the formation of 1.0 mol of the following compounds from the elements at 25 °C.

a) HCl(g)

b) $Ca(OH)_2(s)$

4) Is the reaction $Si(s) + 2\ Cl_2(g) \rightarrow SiCl_4(g)$ spontaneous under standard conditions at 298.15 K? Answer this question by calculating ΔS°(system), ΔS°(surroundings), and ΔS°(universe). (Define reactants and products as the system.)

5) Gaseous iodine monochloride can be decomposed into iodine and chlorine gases according to the following chemical equation $2\ ICl(g) \rightarrow I_2(g) + Cl_2(g)$

a) Calculate $\Delta_r G°$ for this reaction at 298 K using values for the standard free energies of formation of the products and reactant. Is this reaction reactant-favored or product-favored at equilibrium?

b) Calculate the value of $\Delta_r G$ at 298 K for this reaction if the reactant and products are mixed with the following partial pressures: 1.0 atm ICl, 1.0×10^{-3} atm I_2, and 1.0×10^{-3} atm Cl_2. Is the reaction spontaneous under these conditions?

6) Calculate the standard free energy change for burning one mole of methane using values for standard free energies of formation of the products and reactants and assuming the products are all gases. Is the reaction product-favored at equilibrium?

$$CH_4(g) + 2\ O_2(g) \rightarrow 2\ H_2O(g) + CO_2(g)$$

7) Calculate the standard free energy change, $\Delta_r G°$, for the formation of methane from carbon and hydrogen at 298 K, using tabulated values of Δ_f H° and S°. Is the reaction product-favored or reactant-favored at equilibrium?

$$C(\text{graphite}) + 2\ H_2(g) \rightarrow CH_4(g)$$

8) The value of K_{sp} for AgCl(s) at 25 °C is 1.8×10^{-10}. Determine $\Delta_r G°$ for the process $Ag^+(aq) + Cl^-(aq) \rightleftharpoons AgCl(s)$ at 298.15 K.