AP Free Response Practice #1 [5 Steps to a 5, 7 points]

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g) \qquad \Delta H = -92.4\ \text{kJ/mol}_{rxn}$$

1. When the reaction above took place at a temperature of 570 K in a reaction vessel of 0.75 L, the following values were measured after the system reached equilium:

   NH_3 = 0.150 mol

   N_2 = 0.375 mol

   H_2 = 0.150 mol

   a. Write the expression for the equilibrium constant, K_c, and calculate its value. [2 points]

   b. Calculate ΔG for this reaction. [1 point]

   c. Describe how the concentration of H_2(g) at equilibrium will be affected by each of the following changes to the system at equilibrium.

      i. The temperature is increased. [1 point]

      ii. The volume of the reaction chamber is increased. [1 point]

      iii. N_2 gas is added to the reaction chamber. [1 point]

      iv. Helium gas is added to the reaction chamber. [1 point]

a.) $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3} = \dfrac{(0.20)^2}{(0.50)(0.20)^3} = \boxed{10.}$

$[NH_3] = 0.150\ \text{mol} / 0.75\ \text{L} = 0.20\ \text{M}$

$[N_2] = 0.375\ \text{mol} / 0.75\ \text{L} = 0.50\ \text{M}$

$[H_2] = 0.150\ \text{mol} / 0.75\ \text{L} = 0.20\ \text{M}$

b.) $\Delta G = -RT \ln K = -(8.314\ \text{J/mol·K})(570\ \text{K}) \ln(10.)$

$= -10{,}912\ \text{J/mol}_{rxn} = \boxed{-11{,}000\ \text{J/mol}_{rxn} \text{ or } -11\ \text{kJ/mol}_{rxn}}$

c.) (i) Blc this rxn is exothermic, stressing the equilibrium by adding heat will cause the rxn to shift left to use up some of the added heat and return to equilibrium, causing $[H_2]$ to increase.

ii) Increasing the volume of the container will decrease the pressure, causing the reaction to shift towards the direction that produces more moles of gas, the reactants, to increase pressure and re-establish equilibrium. Thus, $[H_2]$ will increase.

iii) Adding $N_{2(g)}$ to the reaction container will increase $[N_2]$. To counteract that stress and use up some $N_{2(g)}$ to re-establish equilibrium, the reaction will shift right, using up some $H_{2(g)}$ + thus causing $[H_2]$ to decrease.

iv) He gas is inert, so adding it will have no affect on the equilibrium position, + thus no affect on $[H_2]$.