AP Worksheet 7c (Le Châtelier's Principle)

For the following reaction, write how each of the changes will affect the indicated quantity. (For a chemical added, write how it would respond after the addition.

$$NO_2(g) \rightleftarrows 2NO(g) + O_2(g) \qquad \Delta H^\circ = +62kJ$$

Change	$[NO_2]$	[NO]	$[O_2]$	K value
1. Some NO_2 added				
2. Some O_2 added				
3. Some NO_2 removed				
4. Some O_2 removed				
5. The temperature is increased				
6. The temperature is decreased				
7. Pressure is increased (and the container volume decreased)				
8. Pressure is decreased (so the container volume increases)				

1. Assume that each of the reactions below are at equilibrium. Using your knowledge of Le Châtelier's principle, explain carefully how the system will respond to the change.

   a. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ Change: The volume is increased

   b. $2NO_2(g) \rightleftharpoons NO_3(g) + NO(g)$ Change: More NO is added

2. The Haber process is used to produce ammonia commercially.

   a. 1.00 mol of N_2 and 3.00 mols of H_2 are mixed together to produce ammonia according to the reaction below. At equilibrium in a 1.00 L vessel, only 50.0% of the N_2 that was present originally remains. Calculate K_c for this reaction at this temperature.

   $$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H = -92 \text{ kJ}$$

b. Predict how each of the following chanes would affect the percentage of ammonia in the equilibrium mixture.

(i) Adding a catalyst

(ii) Increasing the total pressure

(iii) Using a high temperature

3. Consider the Haber Process described in number 2. Under typical conditions a mixure of 1 mole of nitrogen gas to every 3 moles of hydrogen gas are exposed to the temperatures shown in the table below and equilibrium is established. In each case, the system is under a total pressure of 10.0 atm.

Temperature in $^{\circ}C$	Partial pressure of NH_3 in atm
355	0.741
455	0.211
555	0.081

a. For each temperature, calculate the partial pressure of each reactant.

b. For each temperature, calculate K_p.

c. Explain how the data is consistent with the ΔH for the reaction.

d. The experiment is repeated and the conditions adjusted so the total pressure is 40.0 atm. The partial pressure of ammonia at equilibrium under these conditions is 11.4 atm.

(i) Without doing any calculations, comment upon the significance of the data in terms of Le Châtelier's principle.

(ii) Calculate K_p under the new conditions.

e. The reaction is often carried out using a catalyst. What is the purpose of the catalyst and how does it affect the value of K for the reaction?