Le Châtelier's Principle

1. Nitrogen monoxide, a major air pollutant, is formed in automobile engines from the endothermic reaction of nitrogen gas and oxygen gas.
   a) Write the equilibrium reaction equation including the term "energy" in the equation.
   b) What is the direction of the equilibrium shift if the concentration of oxygen is increased? Products
   c) What is the direction of the equilibrium shift if the pressure is increased? No change
   d) What is the direction of the equilibrium shift if the temperature is decreased? reactants
   e) Gasoline burns better at higher temperatures. What is one disadvantage of operating automobile engines at higher temperatures? more pollutant ($NO_{(g)}$) produced

energy + $\frac{1}{2}N_{2(g)}$ + $\frac{1}{2}O_{2(g)}$ → $NO_{(g)}$

2. In a sealed container, nitrogen monoxide gas and oxygen gas react to form nitrogen dioxide gas and are allowed to come to equilibrium. The reaction of nitrogen monoxide and oxygen is exothermic.
   a) Write the equilibrium reaction equation including the term "energy" in the equation.
   b) What is the direction of the equilibrium shift if the temperature is decreased. products
   c) What is the direction of the equilibrium shift if the $[NO_{(g)}]$ is decreased. reactants
   d) What is the direction of the equilibrium shift if the $[NO_{2(g)}]$ is increased. reactants
   e) What is the direction of the equilibrium shift if the volume of the system is decreased. products

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ + energy

3. The following is an equilibrium mixture:

$$\underset{\text{faint yellow}}{Fe^{3+}(aq)} + \underset{\text{colourless}}{SCN^{-}(aq)} \rightleftharpoons \underset{\text{red}}{FeSCN^{2+}(aq)}$$

Predict the colour change in the mixture when each of the following changes is made:
   a) a crystal of KSCN(s) is added to the system more red
   b) a crystal of $FeCl_3$(s) is added to the system more red
   c) a crystal of NaOH(s) is added to the system more yellow

Le Châtelier's Principle

—from Hebden: Chemistry 12

1. Use Le Châtelier's Principle to describe the effect of the following changes on the position of the equilibrium:

A. The equilibrium is: $N_2O_3(g) \rightleftharpoons NO(g) + NO_2(g)$
   a) increase the [NO] R
   b) increase the $[N_2O_3]$ P
   c) add a catalyst No change
   d) increase the pressure by decreasing the volume R

B. The equilibrium is: $2\ H_2(g) + 2\ NO(g) \rightleftharpoons N_2(g) + 2\ H_2O(g)$
   a) decrease the $[N_2]$ P
   b) decrease the pressure by increasing the volume R
   c) decrease the [NO] R

C. The equilibrium is: $2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g) + 566\ kJ$
   a) increase the temperature R
   b) add a catalyst No change
   c) increase the $[O_2]$ P

D. The equilibrium is: $I_2(g) + Cl_2(g) \rightleftharpoons 2\ ICl(g)\ \Delta H = +35.0\ kJ$
   a) decrease the temperature R
   b) decrease the $[Cl_2]$ R
   c) increase the pressure by decreasing the volume No change

2. Describe the effect (increase, decrease or no change) on the concentration of the bold-faced substance by each of the given changes.

A. The equilibrium is: $N_2(g) + \mathbf{3\ H_2(g)} \rightleftharpoons 2\ NH_3(g)$ $\Delta H = -92.0\ kJ$
   a) increase the $[N_2]$ ↓
   b) increase the volume ↑
   c) increase the temperature ↑
   d) add a catalyst —

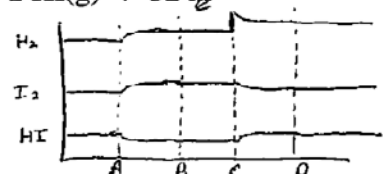
B. The equilibrium is: $2\ HF(g) \rightleftharpoons \mathbf{F_2(g)} + H_2(g)$ $\Delta H = +536.0\ kJ$
   a) decrease the $[H_2]$ ↑
   b) decrease the volume —
   c) decrease the temperature ↓

C. The equilibrium is: $SnO_2(s) + 2\ CO(g) \rightleftharpoons Sn(s) + \mathbf{2\ CO_2(g)}$ $\Delta H = +13.0\ kJ$
   a) increase the [CO] ↑
   b) add a catalyst —
   c) increase the temperature ↑

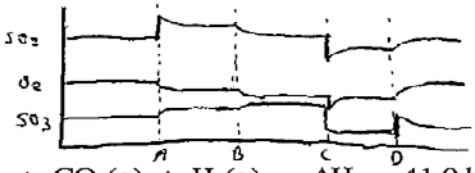
3. Show the equilibrium adjustment in each of the following situations graphically:
***Note that the relative positioning of the molecules is not relevant

all [ ] should go up. but no shift in equil.

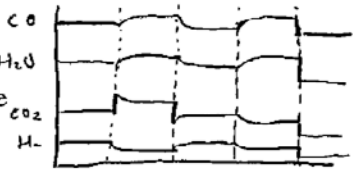
A. The equilibrium is: $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g) + 52\ kJ$
   a) increase the temperature
   b) decrease the volume
   c) inject some $I_2(g)$
   d) add a catalyst



B. The equilibrium is: $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$ $\Delta H = -197.0\ kJ$
   a) inject some $SO_2(g)$
   b) decrease the temperature
   c) increase the volume
   d) increase the $[SO_3(g)]$



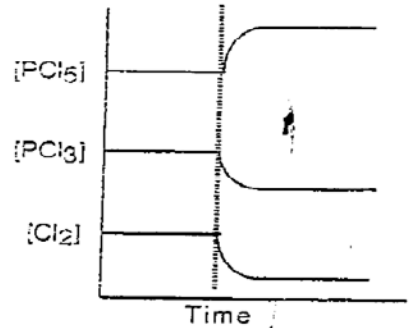
C. The equilibrium is: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ $\Delta H = -41.0\ kJ$
   a) inject some $CO_2(g)$
   b) remove some $CO_2(g)$
   c) increase the temperature
   d) decrease the pressure by increasing the volume



4. Interpret the following graphs in terms of the changes which must have been imposed on the equilibrium:

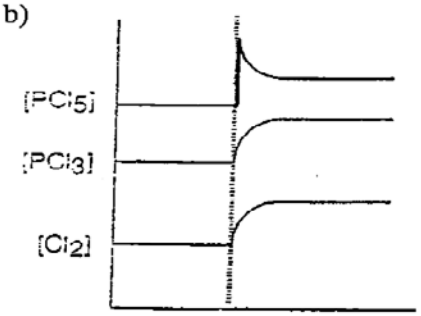
A. The equilibrium is: $PCl_5(g) + 92.5\ kJ \rightleftharpoons PCl_3(g) + Cl_2(g)$

a)



cooled down

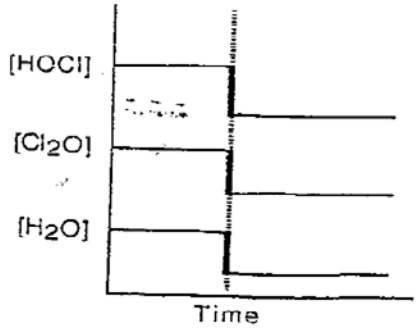
b)



add PCl5

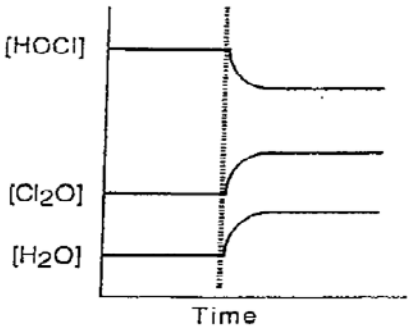
B. The equilibrium is: $H_2O(g) + Cl_2O(g) \rightleftharpoons 2\,HOCl(g) + 70\ kJ$

a)



increase volume

b)



heated up