Equilibrium Theory

1. When a system is at equilibrium, what can be said about:
   a) the rates of the forward and reverse processes?
   b) the amount (concentration) of the reactants and products?
   c) What's happening at the macroscopic level?
   d) What's happening at the microscopic level?

2. Give at least one condition that must be met for a system to remain at equilibrium.

Equilibrium Theory

Why does the water in a glass disappear over time, while it doesn't change in a sealed container? Describe what is happening at the molecular level.

Equilibrium Theory

1. For a system to be at equilibrium, what must be true about the:

   a) Rates of the forward and reverse processes?

   b)Concentrations of the reactants and products?

2. Give 2 **conditions** that must be met in order for a system to be able to reach an equilibrium.

Calculating Keq

Calculate the value of K_{eq} for the following reaction if the concentrations at equilibrium were found to be $[N_2O]=1$ mol/L and $[H_2O]=2$ mol/L.

$$NH_4NO_{3(S)} \text{ <----> } N_2O_{(g)} + 2H_2O_{(g)}$$

Which reaction is favoured at equilibrium?

Calculating Keq

Given the reaction $\mathbf{A_{(s)} + 2B_{(aq)} <----> 2C_{(aq)}}$. The equilibrium concentrations were found to be [A]=2.5mol/L, [B]=2.5mol/L and [C]=0.1mol/L. Calculate Keq AND state which side of the reaction is favoured.

ICE Problems

1. For the reaction $\mathbf{H_2 + I_2 <----> 2HI}$. If initially there were 2.4 moles of I_2 and 2.4 moles of H_2 in a 1.0L container, and at equilibrium there was found to be 1.0mol of HI, determine the equilibrium constant for the reaction.

2. state which side of the reaction is favoured at equilibrium. Explain why.

ICE Problems

For the reaction **$H_2 + I_2$ <----> 2HI** Keq = 46

If initially there were 2.4 moles of I_2 and 2.4 moles of H_2 in a 1.0L container, determine the concentration of HI at equilibrium.

ICE Problems

Keq= 78.0 for the reaction $A_{(s)} + 2B_{(g)} <----> 2C_{(g)}$

If 4 moles of A and 6 moles of B are placed in a 2.0L container, determine the concentration of C at equilibrium. **Hint...watch out for the states!!!**

Reaction Quotient

Keq = 1.5 for the reaction **$H_2 + I_2$ <----> 2HI**

A system containing the above reaction was found to have the following concentrations: **$[H_2] = 2mol/L$** **$[I_2] = 1mol/L$** **$[HI] = 2mol/L$**

Is the system at equilibrium? If not, which reaction is favoured?

Reaction Quotient

Keq = 0.5 for the reaction **$3H_2 + N_2$ <----> $2NH_3$** (assume all gases)

A system containing the above reaction was found to have the following concentrations: **$[H_2] = 2mol/L$** **$[N_2] = 1mol/L$** **$[NH_3] = 2mol/L$**

Is the system at equilibrium? If not, which reaction is favoured?

When the system reaches equilibrium, which side will be favoured?

LeChatelier's Principle

1. Given the reaction $\mathbf{2H_{2(g)} + O_{2(g)} <----> 2H_2O_{(g)} + 200\,kJ}$ Determine the shift:

   a) Increase concentration of Hydrogen gas

   b) Decrease concentration of oxygen gas

   c) Increase pressure

   d) Remove energy

   e) Add a catalyst.

LeChatelier's Principle

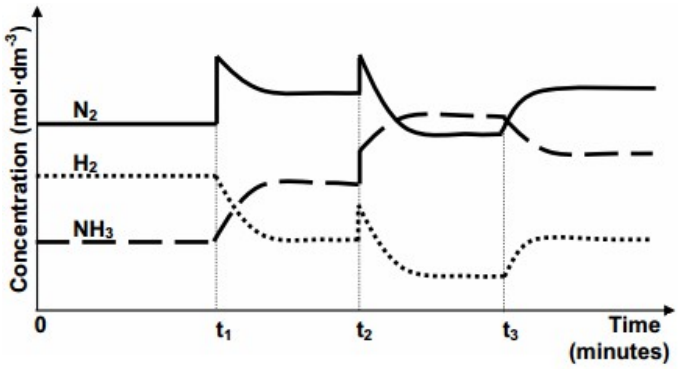
Given the reaction

$$\boldsymbol{CH_4(g) + H_2O(g) <----> CO(g) + 3H_2(g) \qquad \Delta H = +206\ kJ}$$

State two ways to shift the equilibrium to the "right" and produce more CO.

LeChatelier's Principle

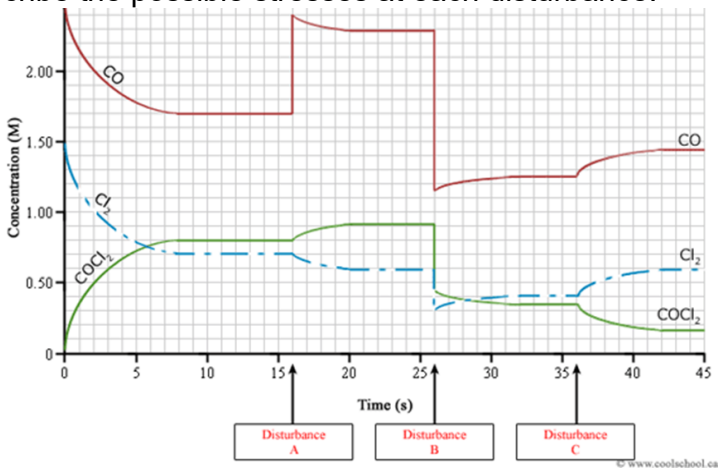
Use the following graph to describe the possible stresses at t1 and t3 for the following reaction: **$2N_2 + 3H_2 \rightarrow 2NH_3 + Heat$**



LeChatelier's Principle

Use the following graph to describe the possible stresses at each disturbance:

***Energy* + *CO* + Cl_2 ⟷ $COCl_2$**



ICE Problems

Find Keq for the reaction 2A + B <----> 2C if initially 2moles of A and 4 moles of B are placed in a 2.0L container. At Equilibrium 1.0 moles of C are found.

LeChatelier's Principle

Given the following equilibrium system, state the shifts for each of the stresses below

$$H_2(g) + Cl_2(g) \leftrightarrow 2HCl(g) \qquad H = -49.7\ kJ$$

a) Increase volume of container

b) Decrease temperature

c) Remove HCl

d) add a catalyst

Ksp

Calculate the molar solubility of strontium fluoride, $SrF_{2,}$ if the Ksp of SrF_2 = 2.8 x 10^{-9}

Now Determine the solubility in grams/250mL

Ksp

Calculate the concentration of Aluminum ions in a solution of Aluminum sulphate, $Al_2(SO_4)_{3,}$ if the Ksp is 8.0 x 10^{-11}

Ksp

$AuCl_3$ has a solubility product of 3.2×10^{-25}. Calculate the solubility of $AuCl_3$ in a 0.2mol/L $MgCl_2$ solution.

Ksp

Calculate the Ksp for bismuth sulfide (Bi_2S_3), which has a solubility of 5.1×10^{-13} g/L.

Ksp

If 2 x 10^{-3} g of an imaginary insoluble salt $Fe(OH)_3$ is all that can be dissolved in 100 ml of water at 25°C, calculate the Ksp.

Common Ion, Ksp

Which will dissolve more Lead (II) Chloride: Pure water or 0.1mol/L $FeCl_3$?

Find the solubility of lead (II) chloride in a 0.1mol/L solution of $FeCl_3$ if the Ksp of lead (II) chloride is $2x10^{-8}$

Common Ion

Determine the molar solubility of lead (II) iodide ($K_{sp} = 9.8 \times 10^{-9}$)

a) in pure water

b) in 0.1 mol/L magnesium iodide solution