

$$a. \frac{[NH_4^+][OH^-]}{[NH_4OH]} = K_{eq}$$

$$b. \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]} = K_{eq}$$

$$c. K_{eq} = \frac{[H_2O][NH_4^+][C_2H_3O_2^-]}{[NH_4OH][HC_2H_3O_2]}$$

$$d. \frac{[Na^+][Cl^-][HCN]}{[Na^+][CN^-][H^+][Cl^-]} = K_{eq}$$

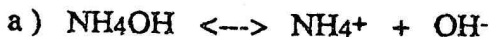
$$e. \frac{[Al^{3+}][Cl^-]}{[AlCl_3]} = K_{eq}$$

$$f. \frac{[H^+][HS^-]}{[H_2S]} = K_{eq}$$

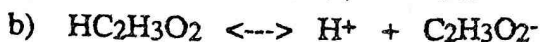
$$g. \frac{[FeS][H^+]^2}{[Fe^{2+}][H_2S]} = K_{eq}$$

CHEMICAL EQUILIBRIUM

1. Write the expression for the equilibrium constant for each of the following equilibria:



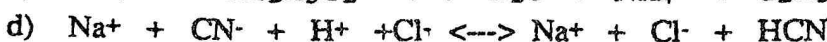
$$K_{eq} =$$



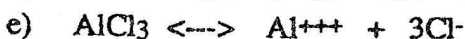
$$K_{eq} =$$



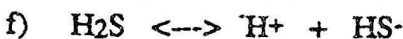
$$K_{eq} =$$



$$K_{eq} =$$



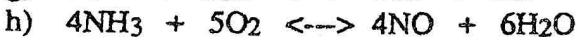
$$K_{eq} =$$



$$K_{eq} =$$



$$K_{eq} =$$



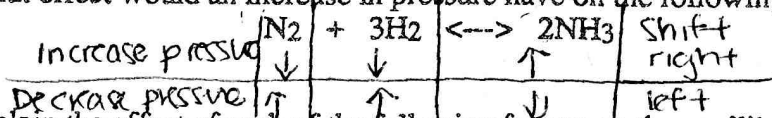
$$K_{eq} =$$

2. If an equilibrium reaction releases energy in the form of heat in the forward reaction, what is the effect of increasing the temperature? If the equilibrium system releases heat in the reverse reaction, what is the effect of an increase in temperature?

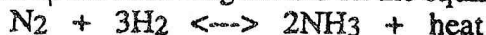
INCREASING TEMP - reaction shifts ~~right~~ left

REVERSE INCREASE TEMP RXN shifts right

3. What effect would an increase in pressure have on the following? ... a decrease in pressure?



4. Explain the effect of each of the following factors on the equilibrium:



a. increase temperature shift left

d. decrease pressure shift left

b. add more H_2 shift right

e. placing all reactants into 1/2 the volume shift right

c. add more NH_3 shift left

5. a. At a given temperature, the K_{eq} for the gas phase reaction: $H_2 + I_2 \rightleftharpoons 2HI$ is 4×10^{-6} . If the concentrations of H_2 and I_2 at equilibrium are 2×10^{-4} , find the concentration of HI .

$$4 \times 10^{-6} = \frac{[HI]^2}{[H_2][I_2]} = \frac{[HI]^2}{(2 \times 10^{-4})(2 \times 10^{-4})}$$

b. At a given temperature, the reaction $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$, all gases, produced the following concentrations: $H_2O = 0.5 M$; $CO = 0.2 M$; $H_2 = 3.2 M$; $CO_2 = 4.2 M$. Find the value of K_{eq} at that temperature.

$$K_{eq} = \frac{[CO_2][H_2]}{[CO][H_2O]} = \frac{4.2 M (3.2 M)}{0.2 M (0.5 M)} = 134 = K_{eq}$$

c. If the temperature of the reactants in part b is changed, the K_{eq} becomes 2.4×10^{-3} . If all of the concentrations except CO are then adjusted to the values given in b, what is the new concentration of CO ?

$$2.4 \times 10^{-3} = \frac{(4.2)(3.2)}{X(0.5)}$$

$$X = [CO] = 7.5 \times 10^{-5} M$$

shouldn't X be on the bottom? gops!

6. Given: $2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4$

$$K_{eq} = \frac{[(\text{NH}_4)_2\text{SO}_4]}{[\text{NH}_3]^2 [\text{H}_2\text{SO}_4]}$$

a. What is the equilibrium constant expression?

b. If the concentration (in moles per liter) after the reaction of NH_3 , H_2SO_4 , and $(\text{NH}_4)_2\text{SO}_4$ are 2, 3, 4, respectively, what is K_{eq} ?

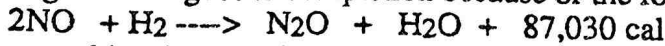
$$K_{eq} = \frac{4M}{(2M)^2 (3)} = \boxed{.33}$$

c. If the concentration of NH_3 is increased, what happens to the equilibrium?

d. If pressure is added, what happens to the equilibrium? *shift right*

e. If heat is added, what happens to K_{eq} ? *increases assuming reaction is endothermic*

7. The following reaction goes to completion because of the formation of un-ionized water:



What effect would an increase in temperature have on its rate?

The reaction would shift left

8. The equilibrium constant for the reaction $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$ is 2.6×10^{-4} at 4000°C .

What would be the concentration in moles per liter of nitrogen and oxygen at equilibrium if

0.25 mole of NO were placed in a 1 liter container and then heated to 4000°C ? $2.6 \times 10^{-4} = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$

9. One liter of HI was heated to 500°C under constant pressure until equilibrium was established according to the equation $2\text{HI} \rightleftharpoons \text{H}_2 + \text{I}_2$. Analysis showed the following concentrations: $[\text{H}_2] = 0.42 \text{ M}$, $[\text{I}_2] = 0.42 \text{ M}$, $[\text{HI}] = 3.52 \text{ M}$. Calculate the value of K_{eq} .

$$K_{eq} = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2} = \frac{.42(.42)}{3.52^2} = \boxed{.014}$$

$$2.6 \times 10^{-4} = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$$

$$x^2 = 240$$

$$[\text{N}_2] = [\text{O}_2] = 15M$$

10. Three reactions exist in equilibrium:

	K_{eq}
$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$	1.7×10^{-6}
$\text{Cl}_2 + \text{H}_2 \rightleftharpoons 2\text{HCl}$	3.4×10^{-2}
$\text{F}_2 + \text{H}_2 \rightleftharpoons 2\text{HF}$	5.1×10^{-4}

- Which reaction has more products present at equilibrium? HCl
- Which reaction has more reactants present at equilibrium? NH_3

11. The following is the potential energy diagram for the reversible reaction



- Is the forward or reverse reaction favored by an increase in temperature? Explain. *reverse*
- Explain which reaction is favored because of energy of activation. *forward*
- Explain the effect of a catalyst on this curve. *lower activation energy curve would lower*

