**18.1: Chemical Equilibrium**

1. How do reversible reactions relate to equilibrium?
2. At equilibrium, rate is constant/equal. At equilibrium, concentration is constant/equal
3. Write the equilibrium constant expressions (Keq) for  \alpha A + \beta B \rightleftharpoons \sigma S + \tau T2NaHCO3(s) Na2CO3(s) + CO2(g) + H2O(g)
4.  \alpha A + \beta B \rightleftharpoons \sigma S + \tau TCalculate Keq for N2(g) + 3H2(g) 2NH3(g), given that [N2] = 3.0 M, [H2] = 4.0 mol, and [NH3] = 6.0 mol
5. When K is large (> 1) there are more products/reactants at equilibrium.
6. When K is small (< 1) there are more products/reactants at equilibrium

**18.2: Le Châtelier’s principle**

1. Define Le Châtelier’s principle.
2. What factors affect equilibrium?
3. When equilibrium shifts to the left, it means that more reactants/products are being created.

When equilibrium shifts to the right, it means that more reactants/products are being created.

1. When volume increases, pressure ↑ or ↓ and equilibrium shifts to the side with the most/least moles.

When volume decreases, pressure ↑ or ↓ and equilibrium shifts to the side with the most/least moles.

1. Temperature changes equilibrium by changing \_\_\_\_\_\_\_\_\_\_\_\_\_\_
2.  \alpha A + \beta B \rightleftharpoons \sigma S + \tau TUsing the chemical formula 2NO(g) + Br2(g) 2NOBr(g) + heat what happens to equilibrium if…
   1. Add NO?
   2. Add NOBr?
   3. Remove NOBr?
   4. Remove NO?
   5. Increase pressure?
   6. Decrease pressure?
   7. Increase volume?
   8. Decrease volume?
   9. Increase temp? What happens to K?
   10. Decrease temp? What happens to K?

**18.3: Solubility equilibria**

1. The Solubility Product Expression (Ksp) is equilibrium between a solid/liquid/gas and its \_\_\_\_\_\_\_\_\_\_\_\_

*\*Ksp is always small because it measures something that is* ***barely*** *dissolved – they barely dissociate*

1. Knowing [Cu2+] = 1.76x10‑7 *M*, what is the value of Ksp for Cu(OH)2? Show all work.
2. Given Ksp = 2.2x10‑20 for Cu(OH)2, find the ion concentration of hydroxide. Show all work.
3. What is the common ion effect?
4. What can the ion product, Qsp, tell us when it is compared to Ksp?
5. Will a precipitate of FeCl2 form when 1.00 L of 0.150M iron (II) chloride solution is mixed with 2.00 L of 0.0333M sodium hydroxide solution? What direction will equilibrium shift? Ksp = 4.9x10-17.

**19.1, 19.2: Acids and Bases**

1. List some characteristics of acids and bases
2. An Arrhenius acid increases the concentration of \_\_\_\_\_\_\_\_\_ when dissolved in water.

An Arrhenius base increases the concentration of \_\_\_\_\_\_\_\_\_ when dissolved in water.

1. A Brønsted-Lowry acid is a \_\_\_\_\_\_\_\_\_ ion acceptor/donor.

A Brønsted-Lowry base is a \_\_\_\_\_\_\_\_\_ ion acceptor/donor

1. Identify the conjugate acid-base pairs in the following:

 \alpha A + \beta B \rightleftharpoons \sigma S + \tau T \alpha A + \beta B \rightleftharpoons \sigma S + \tau TNH+(aq) + OH-(aq) NH3(aq) + H2O(l) CO32-(aq) + H2O(l) HCO3-(aq) + OH-(aq)

1. A weak acid’s conjugate base will be weak/strong. A strong acid’s conjugate base will be weak/strong.
2. In water, strong acids and bases will \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In water, weak acids and bases will \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. In relation to conductivity (conducting electricity), how do strong and weak acids/bases differ?

**19.3: pH**

1. pH measures acidity/basicity by measuring [H+] or [OH-] ion concentration.

pOH measures acidity/basicity by measuring [H+] or [OH-] ion concentration.

1. Draw and label a pH scale using arrows, numbers, and the following words: neutral, acidic, and basic.
2. The lower pH, the more acidic/basic a solution is. If you decrease [H+] concentration, pH increases/decreases
3. What are two methods used to measure pH?
4. Calculate the pH and pOH of the following:
   1. [OH­-] = 6.5x10-4 *M* b.[H+] = 0.025 *M*
5. Calculate the pH of each of the following solutions:
   1. .050 mol/L HNO3 b. 2.4x10-5 *M* Mg(OH)2
6. Calculate [H+] and [OH­-] from the following pHs:
   1. pH = 6.50 b. pH = 11.05

**19.4: Neutralization**

1. Define neutralization.
2. Strong acid + strong base → \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What is a titration?
4. What is a buffer?
5. A titration took 25 mL of 5 *M* NaOH to neutralize 1000 mL of HCl. What was the concentration HCl?

**18.1: Chemical Equilibrium**

1. How do reversible reactions relate to equilibrium? ***Reversible reactions are in equilibrium***
2. At equilibrium, rate is of the constant/**equal**. At equilibrium, concentration is **constant**/equal
3.  \alpha A + \beta B \rightleftharpoons \sigma S + \tau TWrite the equilibrium constant expressions (Keq) for 2NaHCO3(s) Na2CO3(s) + CO2(g) + H2O(g) **Keq = [CO2][H2O]**
4.  \alpha A + \beta B \rightleftharpoons \sigma S + \tau TCalculate Keq for N2(g) + 3H2(g) 2NH3(g), given that [N2] = 3.0 M, [H2] = 4.0 mol, and [NH3] = 6.0 mol

***[6.0]2***

***[3.0][4.0]3***

***[NH3]2***

***[N2][H2]3***

**Keq = = = .188**

1. When K is large (> 1) there are more **products**/reactants at equilibrium.
2. When K is small (< 1) there are more products/**reactants** at equilibrium

**18.2: Le Châtelier’s principle**

1. Define Le Châtelier’s principle. ***When equilibrium is stressed, it will try to reduce the stress.***
2. What factors affect equilibrium? ***Temperature, pressure & volume, and concentration***
3. When equilibrium shifts to the left, it means that more reactants/**products** are being created.

When equilibrium shifts to the right, it means that more **reactants**/products are being created.

1. When volume increases, pressure ↑ or **↓** and equilibrium shifts to the side with the most/**least** moles.

When volume decreases, pressure **↑** or ↓ and equilibrium shifts to the side with the **most**/least moles.

1. Temperature changes equilibrium by changing ***the value of K***
2.  \alpha A + \beta B \rightleftharpoons \sigma S + \tau TUsing the chemical formula 2NO(g) + Br2(g) 2NOBr(g) + heat what happens to equilibrium if…
   1. Add NO? ***shift right***
   2. Add NOBr? ***shift left***
   3. Remove NOBr? ***shift right***
   4. Remove NO? ***shift left***
   5. Increase pressure? ***shift left***
   6. Decrease pressure? ***shift right***
   7. Increase volume? ***shift right***
   8. Decrease volume? ***shift left***
   9. Increase temp? ***shift left*** What happens to K? **↓**
   10. Decrease temp? ***shift right*** What happens to K? **↑**

**18.3: Solubility equilibria**

1. The Solubility Product Expression (Ksp) is equilibrium between a **solid**/liquid/gas and its ***ions***

*\*Ksp is always small because it measures something that is* ***barely*** *dissolved – they barely dissociate*

1. Knowing [Cu2+] = 1.76x10‑7 *M*, what is the value of Ksp for Cu(OH)2? Show all work.

*** \alpha A + \beta B \rightleftharpoons \sigma S + \tau TCu(OH)2 Cu2+(aq) + 2OH- (aq)***

***Ksp = [Cu2+][OH-]2 1 Cu : 2 OH- Ksp = [Cu2+][2Cu2+]2***

***Ksp = [* 1.76x10‑7*][2·*1.76x10‑7*]2Ksp = 2.2x10-20***

1. Given Ksp = 2.2x10‑20 for Cu(OH)2, find the ion concentration of hydroxide. Show all work.

*** \alpha A + \beta B \rightleftharpoons \sigma S + \tau TCu(OH)2 Cu2+(aq) + 2OH- (aq) Ksp = [Cu2+][OH-]2  x=[Cu2+]; 2x=[OH-]***

***2.2x10-20 = x(2x)2 2.2x10-20 = 4x3 x3=5.5x10-21 x=1.8x10-7***

***[OH-] = 2x = 2(1.8x10-7) [OH-] = 3.5x10-7 mol/L***

1. What is the common ion effect? ***When solutions containing the same ion are mixed, it’s less likely to dissolve***
2. What can the ion product, Qsp, tell us when it is compared to Ksp? ***if a precipitate will form***
3. Will a precipitate of FeCl2 form when 1.00 L of 0.150M iron (II) chloride solution is mixed with 2.00 L of 0.0333M sodium hydroxide solution? What direction will equilibrium shift? Ksp = 4.9x10-17.

**FeCl2 Fe2+ + 2Cl-**

**Qsp = [Fe2+][Cl-]2 [Fe2+] = .150 M x 1/3 = .05 M [Cl-] = .0333 M x 2/3 = .0222 M**

**Qsp = [.05][.0222]2 = 2.46x10-5 > Ksp (4.9x10-17)**

**equilibrium shifts left, forms more reactants, and a precipitate forms**

**19.1, 19.2: Acids and Bases**

1. List some characteristics of acids and bases **Acids: sour, turns litmus red, corrodes metals**

**Bases: bitter, turns litmus blue, doesn’t react with metals**

1. An Arrhenius acid increases the concentration of **[H+] or [H3O+]** when dissolved in water.

An Arrhenius base increases the concentration of **[OH-]** when dissolved in water.

1. A Brønsted-Lowry acid is a ***hydrogen*** ion acceptor/**donor**.

A Brønsted-Lowry base is a ***hydrogen*** ion **acceptor**/donor

1. Identify the conjugate acid-base pairs in the following:

 \alpha A + \beta B \rightleftharpoons \sigma S + \tau T \alpha A + \beta B \rightleftharpoons \sigma S + \tau TNH+(aq) + OH-(aq) NH3(aq) + H2O(l) CO32-(aq) + H2O(l) HCO3-(aq) + OH-(aq)

***A B CB CA B A CA CB***

1. A weak acid’s conjugate base will be weak/**strong**. A strong acid’s conjugate base will be **weak**/strong.
2. In water, strong acids and bases will ***completely dissociate***

In water, weak acids and bases will ***partially dissociate***

***Strong acids are better conductors***

1. In relation to conductivity (conducting electricity), how do strong and weak acids/bases differ?

**19.3: pH**

1. pH measures **acidity**/basicity by measuring **[H+]** or [OH-] ion concentration.

pOH measures acidity/**basicity** by measuring [H+] or **[OH-]** ion concentration.

1. Draw and label a pH scale using arrows, numbers, and the following words: neutral, acidic, and basic.

***0 acidic 7 neutral 14 basic***

1. The lower pH, the more **acidic**/basic a solution is. If you decrease [H+] concentration, pH increases/**decreases**
2. What are two methods used to measure pH? **pH meters, indicators**
3. Calculate the pH and pOH of the following:
   1. [OH­-] = 6.5x10-4 *M* b.[H+] = 0.025 *M*

***pOH = -log[OH-]; pOH = 3.18 pH = -log[H+]; pH = 1.6***

***pH + pOH = 14; pH = 10.81 pH + pOH = 14; pOH = 12.40***

1. Calculate the pH of each of the following solutions:
   1. .050 mol/L HNO3 b. 2.4x10-5 *M* Mg(OH)2

***[H+] = .050 M [OH-] = 2(2.4x10-5) M = 4.8x10-5 M***

***pH = -log[H+]; pH = 1.3 pOH=-log[OH-]=4.62; pH+pOH=14; pH=9.38***

1. Calculate [H+] and [OH­-] from the following pHs:
   1. pH = 6.50 b. pH = 11.05

***[H+] = 10-pH; [OH-]= 3.2x10-7 M [H+] = 10-pH; [H+] = 8.9x10-12 M***

***pH+pOH=14; pOH = 7.5 pH+pOH=14; pOH = 7.5***

***[OH-]=10-pOH; [OH-] = 2.3x10-12 M [OH-]=10-pOH; [OH-] = 1.1x10-3 M***

**19.4: Neutralization**

1. Define neutralization. ***A reaction between an acid and a base***
2. Strong acid + strong base → ***salt*** + ***water***
3. What is a titration? ***An acid-base reaction used to find the molarity of an acid or base.***
4. What is a buffer? ***A solution that resists changes in pH when small amounts of acids or bases are added***
5. A titration took 25 mL of 5 *M* NaOH to neutralize 1000 mL of HCl. What was the concentration HCl?

**Mbase Vbase = Macid Vacid (5*M*) (25mL) = (M) ( 1000 mL) M =.125 M HCl**