**SCH 4UI Exam Review Answers Unit #3 - Equilibrium**

1. **What does it mean when a system is in equilibrium?**

A system is in equilibrium when the rate of the forward reaction is the same as the reverse reaction

1. **The equilibrium system shown below was analyzed and the concentration of NH3(g),N2(g) and H2(g) were found to be 4.4 mol/L, 3.2 mol/L and 1.5 mol/L respectively. Determine the equilibrium constant.**

**N2(g) + 3H2(g) ⇄ 2NH3(g)**

|  |  |  |
| --- | --- | --- |
| Keq =  | [NH3(g)]2 |  |
| [N2][ H2]3 |  |
|  |  |  |
| Keq = | [4.4]2 |  |
| [3.2][ 1.5]3 |  |
|  |  |  |
| Keq = | 1.79 |  |

1. **Consider the following reaction: CO(g) + Cl2(g) ⇄COCl2(g) ∆H = -108.28 kJ**

**Explain the effect the following changes would have on the equilibrium**

* 1. **increasing the temperature**

think of the energy as a product (-∆H is exothermic), the reaction would shift towards the reactants in order to use up the extra energy

* 1. **decreasing the volume**

the reaction would shift towards the products as there are fewer moles of gas on this side and this will help to reduce the pressure

* 1. **adding chlorine gas**

the reaction would shift towards the products in order to use up the extra reactant

* 1. **removing COCl2**

the reaction would shift towards the products to replace the missing product

1. **2.0 mol of HI(g) are injected into a 2.5L container and the following equilibrium was established**

**H2(g) + I2(g) ⇄ 2HI(g) + 65 kJ**

**If the Keq = 50, determine the concentration of HI in the container at equilibrium**

|  |  |  |  |
| --- | --- | --- | --- |
|  | H2(g) | I2(g) | 2HI(g) |
| initial | 0 | 0 | 2.0mol/2.5L = 0.8 mol/L |
| change | +x | +x | -2x |
| equilibrium | 0 + x | 0 + x | 0.8-2x |

|  |  |  |  |
| --- | --- | --- | --- |
| Keq =  | [HI(g)]2 |  | [HI(g)] = 0.8 – 2(0.882) |
| [H2][ I2] |  | [HI(g)] = 0.624 mol/L |
|  |  |  |  |
| 50 = | [0.8-2x]2 |  |  |
| [x][x] |  |  |
|  |  |  |  |
| 7.07 = | [0.8-2x] |  |  |
| x |  |  |
|  |  |  |  |
| x = | 0.0882 |  |  |

1. **Calculate the molar solubility of Zn(IO3)2 if the Ksp is 3.9 x 10-5**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Zn(IO3)2(s) | Zn2+(aq) | 2 IO31- (aq) |
| initial | --- | 0 | 0 |
| change | --- | +x | +2x |
| equilibrium | --- | x | 2x |

Ksp = [Zn] [IO3]2 The molar solubility of Zn(IO3)2(s) is 2.1 x 10-2 mol/L

3.9 x 10-5 = [x] [2x]2

3.9 x 10-5 = 4x3

x = 2.1 x 10-2

1. **The Ksp for PbCrO4(s) is 2.3 x 10-13. Determine the solubility of PbCrO4(s) in a 0.010 mol/L solution of Na2CrO4.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | PbCrO4(s) | Pb2+(aq) | CrO4(s) (aq) |
| initial | --- | 0 | 0.010 |
| change | --- | +x | +x |
| equilibrium | --- | x | 0.010 + x |

Ksp = [Pb] [CrO4]The molar solubility of PbCrO4(s) in 0.010 mol/L Na2CrO4(s) is 2.1 x 10-11 mol/L

2.3 x 10-13= [x] [0.010 + x]

2.3 x 10-13= 0.010x + x2

x = 2.1 x 10-11

1. **HSO41- is amphoteric. Write chemical equations to show how HSO41- can behave as both an acid and a base.**
	1. **as an acid:** HSO41-(aq) + H2O(l) ⇄ SO42-(aq) + H3O+(aq)
	2. **as a base:** HSO41-(aq) + H2O(l) ⇄ H2SO4(aq) + OH-(aq)
2. **Determine the pH of the following solutions**
	1. **0.1 mol/L HCl**

\*note – HCl is a strong acid it will all react to form H3O+(aq)

pH = -log[H3O+]

pH = -log[0.1]

pH = 1

* 1. **0.01 mol/L NaOH**

NaOH(aq) 🡪 Na+(aq) + OH-(aq)

pOH = -log[OH-] pH + pOH = 14

pOH = -log[0.01] pH = 14 - 2

pOH = -2 pH = 12

* 1. **1.5 mol/L CH3COOH**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | CH3COOH (aq) | H2O(l) | CH3COO -(aq) | H3O+(aq) |
| initial | 1.5 | --- | 0 | 0 |
| change | -x | --- | +x | +x |
| Equilibrium | 1.5-x | --- | x | x |

|  |  |  |  |
| --- | --- | --- | --- |
| Ka =  | [CH3COO -][ H3O+] |  | \* Ka found on page 803 of textbook |
| [CH3COOH] |  |  |
|  |  |  |  |
| 1.8 x 10-5 = | [x][x] |  | 1.5/Ka > 1000 x is small wrt to 1.5 |
| [1.5] |  |  |
|  |  |  |  |
|  |  |  |  |
| x = | 0.0052 | x can’t be –ve |  |

pH = -log[H3O+]

pH = -log[0.0052]

pH = 2.3

1. What is the Kb for the citrate ion (H2C6H5O7-)

Kw = Ka x Kb

1.0 x 10-14 = (7.4 x 10-4) x Kb

Kb = 1.35 x 10-11

1. **Determine the pH of**
	1. **a 50 mL of 0.25 mol/L methanoic acid**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | HCOOH (aq) | H2O(l) | HCOO -(aq) | H3O+(aq) |
| initial | 0.25 | --- | 0 | 0 |
| change | -x | --- | +x | +x |
| Equilibrium | 0.25-x | --- | x | x |

|  |  |  |  |
| --- | --- | --- | --- |
| Ka =  | [HCOO -][ H3O+] |  | \* Ka found on page 803 of textbook |
| [HCOOH] |  |  |
|  |  |  |  |
| 1.8 x 10-4 = | [x][x] |  |  |
| [0.25] |  | \* 0.25/Ka > 1000 x is small wrt to 0.25 |
|  |  |  |  |
|  |  |  |  |
| x = | 0.0067 | x can’t be –ve |  |

pH = -log[H3O+]

pH = -log[0.0067]

pH = 2.2

* 1. this has been removed
1. **50 mL of NH3 was titrated with 0.1 mol/L HCl. The titration curve is shown below.**



* 1. **Determine the concentration of NH3**

The equivalence point occurs when 25mL of HCl has been added

NH3(aq) + HCl(aq) ⇄ NH4+ (aq) + Cl-(aq)

nHCl = (0.1 mol/L HCl) ( 0.025L) = 0.0025mol HCl

nHCl = nNH3

c = 0.0025mol/0.050L = 0.50 mol/L NH3

* 1. **Explain the difference between the equivalence point and the end point of a titration**

Equivalence point is when the number of moles of acid is equal to the number of moles of base

Endpoint is the pH at which the indicator changes colour

Ideally these two points will the same

* 1. **Which of the following would be the best indicator for this titration? Explain your choice.**

|  |  |
| --- | --- |
| **Indicator** | **pH range** |
| thymol blue | 1.2-2.8 |
| phenolphthalein | 8.2-10.0 |
| methyl red | 4.8-6.0 |

 The best indicator for this titration would be methyl red as the pH of the equivalence point is around pH 5