# Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_

# AP Chemistry: *15HW*

***Directions: Complete the following problems.***

Write the equilibrium-constant expression (Kc) for each of the following reactions.

1A. N2(g) + O2(g) 🡨🡪 2 NO(g) 1B. N2O4(g) 🡨🡪 2 NO2(g)

SiH4(g) + 2 Cl2(g) 🡨🡪 SiCl4(g) + 2 H2(g) 2 PBr3(g) + 3 Cl2(g) 🡨🡪 2 PCl3(g) + 3 Br2(g)

2 NH3(g) + CO2(g) 🡨🡪 N2CH4O(s) + H2O(g) 2 NBr3(s) 🡨🡪 N2(g) + 3 Br2(g)

2 KClO3(s) 🡨🡪 2 KCl(s) + 3 O2(g) CuO(s) + H2(g) 🡨🡪 Cu(l) + H2O(g)

At a given temperature, Kc = 0.043 for the Haber process N2 + 3 H2 🡨🡪 2 NH3

At the same temperature, determine values of Kc for each gaseous reaction below.

2A. 1/2 N2 + 3/2 H2 🡨🡪 NH3 2C. NH3 🡨🡪 1/2 N2 + 3/2 H2

2B. 2 NH3 🡨🡪 N2 + 3 H2 2D. 2 N2 + 6 H2 🡨🡪 4 NH3

3A. At a particular temperature, for the reaction SiH4(g) + 2 Cl2(g) 🡨🡪 SiCl4(g) + 2 H2(g), it is found that the equilibrium concentrations are as follows: [SiH4] = 0.133 M, [Cl2] = 0.251 M, [SiCl4] = 0.087 M, and [H2] = 0.058 M. Calculate the value of the equilibrium constant at that temperature.

ANSWERS: 2A. 0.21 2B. 23 2C. 4.8 2D. 1.8 x 10–3 3A. 0.035

3B. At an elevated temperature, for the gaseous reaction N2 + 3 Br2 🡨🡪 2 NBr3 it is found that the equilibrium concentrations are as follows: [NBr3] = 0.722 M, [N2] = 0.0215 M, and [Br2] = 0.0047 M. Find the value of the equilibrium constant at that temperature.

3C. 2 NOBr(g) 🡨🡪 2 NO(g) + Br2(g) At a particular temperature at equilibrium, a 3.5-L flask contains

2.18 mol Br2, 1.35 mol NOBr, and 0.175 mol NO. Calculate Kc at this temperature.

3D. 2 SO2(g) + O2(g) 🡨🡪 2 SO3(g) At some temperature at equilibrium, a 3.00-L flask contains

0.0108 mol SO2, 0.0114 mol O2, and 0.0235 mol SO3. Find Kc at this temp. and state if

[SO2] = 0.0505 M, [SO3] = 0.280 M, and [O2] = 0.0245 M represents equilibrium at this temp.

Given the following information, calculate the pressure-equilibrium constant.

4A. 2 N2O (g) 🡨🡪 2 N2(g) + O2(g) P(N2O) = 0.31 atm, P(N2) = 0.00012 atm, P(O2) = 0.00053 atm

4B. N2(g) + 3 Cl2(g) 🡨🡪 2 NCl3(g) P(NCl3) = 0.154 atm, P(N2) = 0.623 atm, P(Cl2) = 0.074 atm

At a certain temperature, Kc = Kp = 2800 for the reaction 2 HI(g) 🡨🡪 H2(g) + I2(g)

Decide if each system is at equilibrium. If NOT, state the direction in which the system will shift.

5A. A 1.25-L flask contains 0.043 mol HI, 3.3 mol H2, and 2.1 mol I2.

5B. P(HI) = 0.018 atm, P(H2) = 0.14 atm, and P(I2) = 0.85 atm.

ANSWERS: 3B. 2.3 x 108 3C. 0.010 3D. 1250 4A. 7.9 x 10–11 4B. 94

5C. A 5.0-L flask contains 0.054 mol HI, 1.7 mol H2, and 4.8 mol I2.

5D. P(HI) = 0.0058 atm, P(H2) = 0.46 atm, and P(I2) = 0.76 atm.

At a certain temperature, Kp = 0.86 for the reaction CaCO3(s) 🡨🡪 CaO(s) + CO2(g). For each of the following mixtures, state whether the amount of calcium oxide will increase, decrease, or remain the same.

6A. 515 g CaCO3, 85 g CaO, P(CO2) = 2.25 atm

6B. 58.3 g CaCO3, 8.4 g CaO, P(CO2) = 0.86 atm

6C. 0.36 g CaCO3, 421 g CaO, P(CO2) = 0.86 atm

6D. 738 g CaCO3, 764 g CaO, P(CO2) = 0.23 atm

7A. For the reaction 2 N2O(g) 🡨🡪 2 N2(g) + O2(g) Kc = 0.0043 at a given temperature. At equilibrium, it is found that [N2O] = 0.14 M and [N2] = 0.038 M. Find the concentration of oxygen under these conditions.

7B. For the reaction 2 NO(g) + Cl2(g) 🡨🡪 2 NOCl(g) Kp = 134 at some temp. If the equilibrium partial pressure of Cl2 is 0.021 atm and that of NOCl is 0.087 atm, find the equilibrium partial pressure of NO.

ANSWERS: 7A. 0.058 M 7B. 0.052 atm

8A. A 2.25-L flask is filled with 3.00 mol of gaseous SO2 and 4.00 mol of gaseous NO2. After equilibrium was reached, 1.60 mol of NO was present. With reference to the equation given, calculate Kc under the conditions of the experiment. SO2(g) + NO2(g) 🡨 🡪 SO3(g) + NO(g)

8B. A sample of G6(g) is placed in an otherwise empty rigid container at a certain temperature and an initial

pressure of 2.00 atm, where it decomposes according to the reaction: G6(g) 🡨 🡪 3 G2(g) At equilibrium, the partial pressure of G6 is 0.75 atm. Determine Kp for the reaction at this temperature.

9A. For the exothermic reaction: H2O(g) + CO(g) 🡨🡪 CO2(g) + H2(g)

State how the equilibrium will be affected (“shift left,” “shift right,” or “no shift”) if…

i. …carbon dioxide is removed

ii. …water vapor is added

iii. …the pressure is increased by adding neon

iv. …the pressure is increased by decreasing the container’s effective volume

v. …the temperature is increased. Also, what happens to K, in this case?

9B. Given the reaction: 2 SO3(g) 🡨 🡪 2 SO2(g) + O2(g) Ho = +197 kJ

State what will happen to the number of moles of sulfur trioxide if…

i. …oxygen is added

ii. …sulfur dioxide is removed

iii. …the pressure is increased by adding helium

iv. … the pressure is increased by decreasing the volume

v. …the temperature is increased. Also, what happens to K, in this case?

ANSWERS: 8A. 0.762 8B. 70.

9C. For the reaction, N2(g) + 3 H2(g) 🡨 🡪 2 NH3(g), Kp varies with temperature as follows:

300oC, Kp = 4.3 x 10–3 500oC, Kp = 1.5 x 10–5 600oC, Kp = 2.3 x 10–6

Determine if the reaction exothermic or endothermic. Explain.

For each of the following reactions, identify the acid, the base, the conjugate acid, and the conjugate base.

10A. H3O+ + HCO3– 🡨 🡪 H2O + H2CO3 10B. H3O+ + Al(H2O)5(OH)2+ 🡨 🡪 Al(H2O)63+ + H2O

C5H5N + H3O+ 🡨 🡪 C5H5NH+ + H2O HONH2 + H3O+ 🡨 🡪 H2O + HONH3+

C5H5N + H2CO3 🡨 🡪 HCO3– + C5H5NH+ OCl– + C6H5NH3+ 🡨 🡪 HOCl + C6H5NH2

11A. Kw changes with temperature as shown in the table.

Temp. (oC) Kw

0 1.1 x 10–15

25 1.0 x 10–14

35 2.1 x 10–14

40. 2.9 x 10–14

50. 5.5 x 10–14

i. Is the autoionization of water exothermic or endothermic? Explain.

ii. Determine the concentrations of the hydrogen and hydroxide ions in a neutral, 50.oC solution.

11B. Use the table above to answer the following questions.

i. Determine the concentrations of the hydrogen and hydroxide ions in pure water at 40.oC.

ii. Determine the pH of pure water at 40.oC.

iii. Determine the pH in a 40.oC solution if the hydroxide ion concentration is 0.15 M.

ANSWERS: 11Aii. 2.3 x 10–7 M 11Bi. 1.7 x 10–7 M 11Bii. 6.77 11Biii. 12.71

12. Complete the following table. Assume each solution is at 25oC.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **pH** | **pOH** | **[H+]** | **[OH–]** | **Acid, base, or neutral?** |
| **Solution A** | 5.22 |  |  |  |  |
| **Solution B** |  |  |  | 6.3 x 10–12 M |  |
| **Solution C** |  | 3.77 |  |  |  |
| **Solution D** |  |  | 1.0 x 10–7 M |  |  |

13. Calculate [H+], [OH–], pH, and pOH for a solution with 180 g of potassium hydroxide in 18.5 L of solution.

14A. What mass of sodium hydroxide is needed to prepare 975 mL of a solution with pH = 12.26?

14B. How many milligrams of chloric acid are in 380 mL of a solution having a pH of 3.28?

ANSWERS: 13. [H+] = 5.9 x 10–14 M, [OH–] = 0.17 M, pH = 13.23, pOH = 0.77 14A. 0.71 g 14B. 17 mg

15. Calculate the concentration of an aqueous calcium hydroxide solution having a pH of 9.82.

16A. A mixture contains 40.0 mL of 0.0600 M hydrochloric acid and 160.0 mL of 0.0800 M nitric acid. Determine the concentrations of all ions in this solution.

16B. A solution is prepared by mixing 150 mL of 4.5 M hydroiodic acid and 250 mL of 8.5 M perchloric acid. The solution is then diluted to a final volume of 12.0 L. Calculate [H+], [OH–], and the pH for this solution.

17. Describe how to prepare 650 mL of a pH = 0.85 solution using concentrated (i.e., 8.9 M) hydrobromic acid.

ANSWERS: 15. 3.3 x 10–5 M 16A. [H+] = 0.0760 M, [Cl–] = 0.0120 M, [NO3–] = 0.0640 M. [OH–] = 1.32 x 10–13 M

16B. [H+] = 0.23 M, [OH–] = 4.3 x 10–14 M, pH = 0.63