***Chemistry: The Central Science, 13e* (Brown et al.)**

**Chapter 15 Chemical Equilibrium**

15.3 Algorithmic Questions

1) Which of the following expressions is the correct equilibrium-constant expression for the equilibrium between dinitrogen tetroxide and nitrogen dioxide?

5N2O4(g)  10NO2 (g)

A) [NO2]10/[N2O4]5

B) [N2O4]10/[NO2]5

C) [NO2]5/[N2O4]10

D) [NO2]5/[N2O4]5

E) [N2O4]5/[NO2]5

Answer: A

Diff: 4 Var: 4 Page Ref: Sec. 15.1

LO: 15.1

GO: G2

2) Given the following reaction at equilibrium, if Kc = 5.84 x 105 at 230.0 °C, Kp = \_\_\_\_\_\_\_\_.

2NO (g) + O2 (g)  2NO2 (g)

A) 3.67 × 10-2

B) 1.41 × 104

C) 6.44 × 105

D) 2.40 × 106

E) 2.41 × 107

Answer: B

Diff: 3 Var: 10 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

3) Given the following reaction at equilibrium at 450.0 °C:

CaCO3 (s)  CaO (s) + CO2 (g)

If pCO2 = 0.0155 atm, Kc = \_\_\_\_\_\_\_\_.

A) 155

B) 0.0821

C) 0.920

D) 2.61 × 10-4

E) 9.20

Answer: D

Diff: 3 Var: 9 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

4) Given the following reaction at equilibrium, if Kp = 1.10 at 250.0 °C, Kc = \_\_\_\_\_\_\_\_.

PCl5 (g)  PCl3 (g) + Cl2 (g)

A) 3.90 × 10-6

B) 2.56 × 10-2

C) 1.10

D) 42.9

E) 47.2

Answer: B

Diff: 3 Var: 8 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

5) Given the following reaction at equilibrium at 300.0 K:

NH4HS (s)  NH3 (g) + H2S (g)

If pNH3 = pH2S = 0.105 atm, Kp = \_\_\_\_\_\_\_\_.

A) .0110

B) 4.99 × 10-4

C) .105

D) .0821

E) 5.66 × 10-3

Answer: A

Diff: 3 Var: 11 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

6) The value of Keq for the following reaction is 0.25:

SO2 (g) + NO2 (g)  SO3 (g) + NO (g)

The value of Keq at the same temperature for the reaction below is \_\_\_\_\_\_\_\_.

3SO2 (g) + 3NO2 (g)  3SO3 (g) + 3NO (g)

A) 1.6 × 10-2

B) 7.5 × 10-1

C) 8.3 × 10-2

D) 6.4 × 101

E) 0.25

Answer: A

Diff: 2 Var: 4 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

7) The Keq for the equilibrium below is 7.52 × 10-2 at 480.0 °C.

2Cl2 (g) + 2H2O (g)  4HCl (g) + O2 (g)

What is the value of Keq at this temperature for the following reaction?

8HCl (g) + 2O2 (g)  4Cl2 (g) + 4H2O (g)

A) 1.77 × 102

B) 5.66 × 10-3

C) 1.50 × 10-1

D) -7.52 × 10-2

E) 7.52 × 10-2

Answer: A

Diff: 2 Var: 4 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

8) The Keq for the equilibrium below is 5.4 × 1013 at 480.0 °C.

2NO (g) + O2 (g)  2NO2 (g)

What is the value of Keq at this temperature for the following reaction?

4NO (g) + 2O2 (g)  4NO2 (g)

A) 2.9 × 1027

B) 8.5 × 1054

C) 3.4 × 10-28

D) -1.1 × 1014

E) 5.4 × 1013

Answer: A

Diff: 2 Var: 6 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

9) The Keq for the equilibrium below is 0.112 at 700.0 °C.

SO2 (g) + O2 (g)  SO3 (g)

What is the value of Keq at this temperature for the following reaction?

2SO2 (g) + O2 (g)  2SO3 (g)

A) 1.25 × 10-2

B) 2.24 × 10-1

C) 7.97 × 101

D) 4.46

E) 0.112

Answer: A

Diff: 2 Var: 4 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

10) The value of Keq for the following reaction is 0.26:

A (g) + B (g)  C (g) + D (g)

The value of Keq at the same temperature for the reaction below is \_\_\_\_\_\_\_\_.

2A (g) + 2B (g)  2C (g) + 2D (g)

A) 0.068

B) 0.52

C) 1.2

D) 0.065

E) 0.26

Answer: A

Diff: 4 Var: 20 Page Ref: Sec. 15.2

LO: 14.2

GO: G4

11) The value of Keq for the following reaction is 0.16:

A (g) + B (g)  C (g) + D (g)

The value of Keq at the same temperature for the reaction below is \_\_\_\_\_\_\_\_.

3C (g) + 3D (g)  3A (g) + 3B (g)

A) 2.4 × 102

B) 2.1

C) 4.1 × 10-3

D) 5.3 × 10-2

E) 6.3

Answer: A

Diff: 4 Var: 21 Page Ref: Sec. 15.2

LO: 14.2

GO: G4

12) The value of Keq for the following reaction is 0.50:

A (g) + 2B (g)  C (g) + 4D (g)

The value of Keq at the same temperature for the reaction below is \_\_\_\_\_\_\_\_.

A (g) + B (g)  C (g) + 2D (g)

A) 7.1 × 10-1

B) 2.5 × 10-1

C) 0.25

D) 1.0

E) 0.50

Answer: A

Diff: 4 Var: 41 Page Ref: Sec. 15.2

LO: 14.2

GO: G4

13) The Keq for the equilibrium below is 7.16 × 10-2 at 440.0 °C.

2Cl2 (g) + 2H2O (g)  4HCl (g) + O2 (g)

What is the value of Keq at this temperature for the following reaction?

Cl2 (g) + H2O (g)  2HCl (g) + O2 (g)

A) 0.0716

B) 5.13 × 10-3

C) 0.268

D) 0.0376

E) 0.150

Answer: C

Diff: 2 Var: 8 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

14) At 1000.0 K, the equilibrium constant for the reaction

2NO (g) + Br2 (g)  2NOBr (g)

is Kp = 0.016. Calculate Kp for the reverse reaction,

2NOBr (g)  2NO (g) + Br2 (g).

A) 0.016

B) 1.6 × 10-4

C) 63

D) 0.99

E) 1.1

Answer: C

Diff: 2 Var: 9 Page Ref: Sec. 15.2

LO: 15.2

GO: G4

15) The expression of Keq for the following reaction will not include \_\_\_\_\_\_\_\_.

A(g) + B (g)  C (l) + D (g)

A) [C]

B) [A]

C) [B]

D) [D]

E) none of the above

Answer: A

Diff: 4 Var: 6 Page Ref: Sec. 15.4

LO: 15.4

GO: G2

16) Phosphorous trichloride and phosphorous pentachloride equilibrate in the presence of molecular chlorine according to the reaction:

PCl3 (g) + Cl2 (g) → PCl5 (g)

An equilibrium mixture at 450 K contains

PPCl3 = 0.224 atm,

PCl2 = 0.284 atm, and

PPCl5 = 4.24 atm. What is the value of Kp at this temperature?

A) 66.7

B) 1.50 × 10-2

C) 2.70 × 10-1

D) 3.74

E) 8.36

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

17) Consider the following chemical reaction:

H2 (g) + I2 (g)  2HI (g)

At equilibrium in a particular experiment, the concentrations of H2, I2, and HI were 0.20 M, 0.034 M, and 0.55 M, respectively. The value of Keq for this reaction is \_\_\_\_\_\_\_\_.

A) 23

B) 81

C) 0.0090

D) 5.1

E) 44

Answer: E

Diff: 3 Var: 8 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

18) Dinitrogen tetroxide partially decomposes according to the following equilibrium:

N2O4 (g) → 2NO2 (g)

A 1.000-L flask is charged with 9.20 × 10-3 mol of N2O4. At equilibrium, 5.98 × 10-3 mol of N2O4 remains. Keq for this reaction is \_\_\_\_\_\_\_\_.

A) 0.183

B) 0.197

C) 0.212

D) 6.94 × 10-3

E) 2.96 × 10-5

Answer: D

Diff: 3 Var: 10 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

19) The Kp for the reaction below is 1.49 × 108 at 100.0 °C:

CO (g) + Cl2 (g) → COCl2 (g)

In an equilibrium mixture of the three gases, PCO = PCl2 = 1.00 × 10-4 atm. The partial pressure of the product, phosgene (COCl2), is \_\_\_\_\_\_\_\_ atm.

A) 1.49

B) 1.49 × 1016

C) 6.71 × 10-17

D) 1.49 × 104

E) 1.49 × 1012

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

20) At 900.0 K, the equilibrium constant (Kp) for the following reaction is 0.345.

2SO2 + O2 (g) → 2SO3 (g)

At equilibrium, the partial pressure of SO2 is 36.9 atm and that of O2 is 16.8 atm. The partial pressure of SO3 is \_\_\_\_\_\_\_\_ atm.

A) 88.8

B) 3.89 × 10-3

C) 214

D) 5.57 × 10-4

E) 42.4

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

21) At elevated temperatures, molecular hydrogen and molecular bromine react to partially form hydrogen bromide:

H2 (g) + Br2 (g)  2HBr (g)

A mixture of 0.682 mol of H2 and 0.440 mol of Br2 is combined in a reaction vessel with a volume of   
2.00 L. At equilibrium at 700 K, there are 0.546 mol of H2 present. At equilibrium, there are \_\_\_\_\_\_\_\_ mol of Br2 present in the reaction vessel.

A) 0.000

B) 0.440

C) 0.546

D) 0.136

E) 0.304

Answer: E

Diff: 3 Var: 7 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

22) At 24° C, Kp = 0.080 for the equilibrium:

NH4HS (s)  NH3 (g) + H2S (g)

A sample of solid NH4HS is placed in a closed vessel and allowed to equilibrate. Calculate the equilibrium partial pressure (atm) of ammonia, assuming that some solid NH4HS remains.

A) 0.28

B) 0.080

C) 0.052

D) 0.0049

E) 3.8

Answer: A

Diff: 4 Var: 7 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

23) In the coal-gasification process, carbon monoxide is converted to carbon dioxide via the following reaction:

CO (g) + H2O (g)  CO2 (g) + H2 (g)

In an experiment, 0.35 mol of CO and 0.40 mol of H2O were placed in a 1.00-L reaction vessel. At equilibrium, there were 0.22 mol of CO remaining. Keq at the temperature of the experiment is \_\_\_\_\_\_\_\_.

A) 5.5

B) 0.75

C) 3.5

D) 0.28

E) 1.0

Answer: D

Diff: 4 Var: 9 Page Ref: Sec. 15.5

LO: 15.5

GO: G4

24) Kp = 0.0198 at 721 K for the reaction

2HI (g)  H2 (g) + I2 (g)

In a particular experiment, the partial pressures of H2 and I2 at equilibrium are 0.678 and 0.788 atm, respectively. The partial pressure of HI is \_\_\_\_\_\_\_\_ atm.

A) 7.87

B) 27.0

C) 5.19

D) 0.103

E) 0.0106

Answer: C

Diff: 3 Var: 8 Page Ref: Sec. 15.6

LO: 15.6

GO: G4

25) Nitrosyl bromide decomposes according to the following equation.

2NOBr (g)  2NO (g) + Br2 (g)

A sample of NOBr (0.64 mol) was placed in a 1.00-L flask containing no NO or Br2. At equilibrium the flask contained 0.16 mol of NOBr. How many moles of NO and Br2, respectively, are in the flask at equilibrium?

A) 0.48, 0.24

B) 0.48, 0.48

C) 0.16, 0.08

D) 0.16, 0.16

E) 0.24, 0.42

Answer: A

Diff: 4 Var: 8 Page Ref: Sec. 15.6

LO: 15.6

GO: G4

26) The reaction below is exothermic:

2SO2 (g) + O2 (g)  2SO3 (g)

Le Châtelier's Principle predicts that \_\_\_\_\_\_\_\_ will result in an increase in the number of moles of SO3 (g) in the reaction container.

A) increasing the amount of SO2

B) decreasing the pressure

C) increasing the temperature

D) removing some oxygen

E) increasing the volume of the container

Answer: A

Diff: 3 Var: 4 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

27) For the endothermic reaction

CaCO3 (s)  CaO (s) + CO2 (g)

Le Châtelier's principle predicts that \_\_\_\_\_\_\_\_ will result in an increase in the number of moles of CO2.

A) increasing the temperature

B) decreasing the temperature

C) increasing the pressure

D) removing some of the CaCO3(s)

E) none of the above

Answer: A

Diff: 3 Var: 6 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

28) Consider the following reaction at equilibrium:

2NH3 (g)  N2 (g) + 3H2 (g) ΔH° = +92.4 kJ

Le Châtelier's principle predicts that removing N2 (g) to the system at equilibrium will result in \_\_\_\_\_\_\_\_.

A) an increase in the concentration of H2

B) a decrease in the concentration of H2

C) removal of all of the H2

D) a lower partial pressure of H2

E) an increase in the value of the equilibrium constant

Answer: A

Diff: 3 Var: 4 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

29) Consider the following reaction at equilibrium:

2CO2 (g)  2CO (g) + O2 (g) ΔH° = -514 kJ

Le Châtelier's principle predicts that removing O2 (g) to the reaction container will \_\_\_\_\_\_\_\_.

A) increase the partial pressure of CO

B) decrease the partial pressure of CO

C) increase the partial pressure of CO2

D) increase the value of the equilibrium constant

E) decrease the value of the equilibrium constant

Answer: A

Diff: 3 Var: 4 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

30) Consider the following reaction at equilibrium:

C (s) + H2O (g)  CO (g) + H2 (g)

Which of the following conditions will decrease the partial pressure of CO?

A) decreasing the volume of the reaction vessel

B) increasing the volume of the reaction vessel

C) decreasing the amount of carbon in the system

D) decreasing the pressure of the reaction vessel

E) adding a catalyst to the reaction system

Answer: A

Diff: 5 Var: 6 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

31) Consider the following reaction at equilibrium:

2SO2 (g) + O2 (g)  2SO3 (g) ΔH° = -99 kJ

Le Châtelier's principle predicts that a(n) increase in temperature will result in \_\_\_\_\_\_\_\_.

A) an increase in the partial pressure of O2

B) a decrease in the partial pressure of O2

C) a decrease in the partial pressure of SO2

D) a(n) increase in Keq

E) no changes in equilibrium partial pressures

Answer: A

Diff: 3 Var: 6 Page Ref: Sec. 15.7

LO: 15.7

GO: G2

***Chemistry: The Central Science, 13e* (Brown et al.)**

**Chapter 16 Acid-Base Equilibria**

16.1 Multiple-Choice Questions

1) According to the Arrhenius concept, an acid is a substance that \_\_\_\_\_\_\_\_.

A) is capable of donating one or more H+

B) causes an increase in the concentration of H+ in aqueous solutions

C) can accept a pair of electrons to form a coordinate covalent bond

D) reacts with the solvent to form the cation formed by autoionization of that solvent

E) tastes bitter

Answer: B

Diff: 1 Var: 1 Page Ref: Sec. 16.1

LO: 16.1

GO: G2

2) A Br∅nsted-Lowry base is defined as a substance that \_\_\_\_\_\_\_\_.

A) increases [H+] when placed in H2O

B) decreases [H+] when placed in H2O

C) increases [OH-] when placed in H2O

D) acts as a proton acceptor

E) acts as a proton donor

Answer: D

Diff: 1 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

3) A Br∅nsted-Lowry acid is defined as a substance that \_\_\_\_\_\_\_\_.

A) increases Ka when placed in H2O

B) decreases [H+] when placed in H2O

C) increases [OH-] when placed in H2O

D) acts as a proton acceptor

E) acts as a proton donor

Answer: E

Diff: 1 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

4) Which one of the following is a Br∅nsted-Lowry acid?

A) (CH3)3NH+

B) CH3COOH

C) HF

D) HNO2

E) all of the above

Answer: E

Diff: 2 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

5) A substance that is capable of acting as both an acid and as a base is \_\_\_\_\_\_\_\_.

A) autosomal

B) conjugated

C) ambiprotic

D) saturated

E) miscible

Answer: C

Diff: 1 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

6) Which one of the following is a Br∅nsted-Lowry base?

A) (CH3)3N

B) CH3COOH

C) HF

D) HNO2

E) none of the above

Answer: A

Diff: 2 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

7) The molar concentration of hydronium ion in pure water at 25 °C is \_\_\_\_\_\_\_\_.

A) 0.00

B) 1.0 × 10-7

C) 1.0 × 10-14

D) 1.00

E) 7.00

Answer: B

Diff: 1 Var: 1 Page Ref: Sec. 16.3

LO: 16.3

GO: G2

8) Which one of the following statements regarding Kw is false?

A) pKw is 14.00 at 25 °C.

B) The value of Kw is always 1.0 × 10-14.

C) Kw changes with temperature.

D) The value of Kw shows that water is a weak acid.

E) Kw is known as the ion product of water.

Answer: B

Diff: 2 Var: 1 Page Ref: Sec. 16.4

LO: 16.4

GO: G2

9) The hydride ion, H-, is a stronger base than the hydroxide ion, OH-. The product(s) of the reaction of hydride ion with water is/are \_\_\_\_\_\_\_\_.

A) H3O+ (aq)

B) OH- (aq) + H2 (g)

C) OH- (aq) + 2H+ (aq)

D) no reaction occurs

E) H2O2 (aq)

Answer: B

Diff: 3 Var: 1 Page Ref: Sec. 16.5

LO: 16.5

GO: G2

10) HA is a weak acid. Which equilibrium corresponds to the equilibrium constant Kb for A-?

A) HA (aq) + H2O (l)  H2A+ (aq) + OH-(aq)

B) A- (aq) + H3O+ (aq)  HA (aq) + H2O (l)

C) HA (aq) + OH- (aq)  H2O (l) + H+ (aq)

D) A- (aq) + H2O (l)  HA (aq) + OH- (aq)

E) A- (aq) + OH- (aq)  HOA2- (aq)

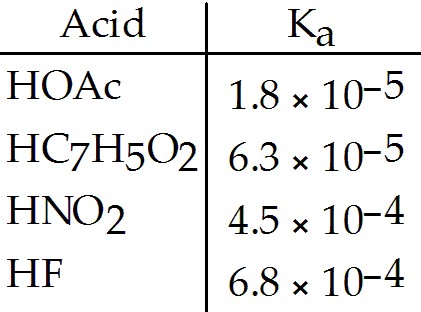
Answer: D

Diff: 3 Var: 1 Page Ref: Sec. 16.7

LO: 16.5

GO: G2

11) Using the data in the table, which of the conjugate bases below is the strongest base?



A) OAc-

B) C7H5O2-

C) NO2-

D) F-

E) OAc- and C7H5O2-

Answer: A

Diff: 3 Var: 1 Page Ref: Sec. 16.8

LO: 16.8

GO: G2

12) Which of the following ions will act as a weak base in water?

A) HS-

B) F-

C) NO2-

D) ClO-

E) All of the above will act as a weak base in water.

Answer: E

Diff: 3 Var: 1 Page Ref: Sec. 16.9

LO: 16.9

GO: G2

13) Of the following substances, an aqueous solution of \_\_\_\_\_\_\_\_ will form basic solutions.

NH4Cl Cu(NO3)2 K2CO3 NaF

A) NH4Cl, Cu(NO3)2

B) K2CO3, NH4Cl

C) NaF only

D) NaF, K2CO3

E) NH4Cl only

Answer: D

Diff: 3 Var: 1 Page Ref: Sec. 16.9

LO: 16.9

GO: G2

14) Of the compounds below, a 0.1 M aqueous solution of \_\_\_\_\_\_\_\_ will have the highest pH.

A) KCN, Ka of HCN = 4.0 × 10-10

B) NH4NO3, Kb of NH3 = 1.8 × 10-5

C) NaOAc, Ka of HOAc = 1.8 × 10-5

D) NaClO, Ka of HClO = 3.2 × 10-8

E) NaHS, Kb of HS- = 1.8 × 10-7

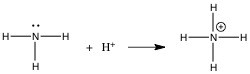
Answer: A

Diff: 5 Var: 1 Page Ref: Sec. 16.9

LO: 16.9

GO: G2

15) In the gas phase reaction below, NH3 is acting as a(n) \_\_\_\_\_\_\_\_ base but not as a(n) \_\_\_\_\_\_\_\_ base.



A) Arrhenius, Br∅nsted-Lowry

B) Br∅nsted-Lowry, Lewis

C) Lewis, Arrhenius

D) Lewis, Br∅nsted-Lowry

E) Arrhenius, Lewis

Answer: C

Diff: 3 Var: 1 Page Ref: Sec. 16.11

LO: 16.11

GO: G2

16) The conjugate base of H2PO4- is \_\_\_\_\_\_\_\_.

A) PO43-

B) H2PO4

C) H3PO4

D) HPO42-

E) none of the above

Answer: D

Diff: 2 Var: 1 Page Ref: Sec. 16.2

LO: 16.2

GO: G2

17) Calculate the pH of a solution at 25.0 °C that contains 1.94 × 10-10 M hydronium ions.

A) 1.94

B) 4.29

C) 7.00

D) 14.0

E) 9.71

Answer: E

Diff: 2 Var: 1 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

18) Calculate the concentration (in M) of hydroxide ions in a solution at 25.0 °C with a pOH of 4.223.

A) 5.98 × 10-5

B) 1.67 × 10-10

C) 1.67 × 104

D) 5.99 × 10-19

E) 1.00 × 10-7

Answer: A

Diff: 2 Var: 1 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

19) The pH of a 0.25 M aqueous solution of hydrofluoric acid, HF, at 25.0 °C is 2.03. What is the value of Ka for HF?

A) 2.0 × 10-9

B) 1.1 × 10-9

C) 6.0 × 10-5

D) 3.5 × 10-4

E) none of the above

Answer: D

Diff: 4 Var: 1 Page Ref: Sec. 16.6

LO: 16.6, 16.7

GO: G4

20) A 0.15 M aqueous solution of the weak acid HA at 25.0 °C has a pH of 5.35. The value of Ka for HA is \_\_\_\_\_\_\_\_.

A) 3.0 × 10-5

B) 1.8 × 10-5

C) 7.1 × 10-9

D) 1.3 × 10-10

E) 3.3 × 104

Answer: D

Diff: 4 Var: 1 Page Ref: Sec. 16.6

LO: 16.6, 16.7

GO: G4

21) The Ka of acetic acid (HC2H3O2) is 1.8 × 10-5. What is the pH at 25.0 °C of an aqueous solution that is 0.100 M in acetic acid?

A) +2.87

B) -2.87

C) -11.13

D) +11.13

E) +6.61

Answer: A

Diff: 4 Var: 1 Page Ref: Sec. 16.6

LO: 16.6, 16.7

GO: G4

22) The acid-dissociation constants of sulfurous acid (H2SO3) are Ka1 = 1.7 × 10-2 and Ka2 = 6.4 × 10-8 at 25.0 °C. Calculate the pH of a 0.163 M aqueous solution of sulfurous acid.

A) 4.53

B) 1.28

C) 1.86

D) 6.21

E) 1.93

Answer: B

Diff: 5 Var: 1 Page Ref: Sec. 16.6

LO: 16.6, 16.7

GO: G4

23) The pH of a 0.55 M aqueous solution ammonia, NH3, at 25.0 °C is 11.50. What is the value of Kb for NH3?

A) 2.0 × 10-9

B) 1.1 × 10-9

C) 6.0 × 10-5

D) 1.8 × 10-5

E) none of the above

Answer: D

Diff: 4 Var: 1 Page Ref: Sec. 16.7

LO: 16.6, 16.7

GO: G4

24) Ka for HCN is 4.9 × 10-10. What is the pH of a 0.068 M aqueous solution of sodium cyanide?

A) 0.74

B) 2.96

C) 11.07

D) 13.24

E) 7.00

Answer: C

Diff: 4 Var: 1 Page Ref: Sec. 16.9

LO: 16.9

GO: G4

25) Ka for HX is 7.5 × 10-12. What is the pH of a 0.15 M aqueous solution of NaX?

A) 7.97

B) 1.96

C) 6.00

D) 8.04

E) 12.10

Answer: E

Diff: 5 Var: 1 Page Ref: Sec. 16.9

LO: 16.9

GO: G4

26) An aqueous solution at 25.0°C contains [H+] = 0.085 M. What is the pH of the solution?

A) 1.07

B) -1.07

C) 13.0

D) 0.0850

E) 1.20 × 

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

27) The pH of an aqueous solution at 25.0 °C is 10.55. What is the molarity of H+ in this solution?

A) 2.8 × 10-11

B) 3.5 × 10-4

C) 3.45

D) 1.1 × 10-13

E) 3.5 × 1010

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

28) Calculate the molarity of hydroxide ion in an aqueous solution that has a pOH of 3.00.

A) 1.0 × 10-3

B) 11.00

C) 1.0 × 10-11

D) 3.0 × 10-14

E) 1.1 × 10-13

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

29) What is the pOH of an aqueous solution at 25.0 °C in which [H+] is 0.0050 M?

A) 8.70

B) 11.70

C) -11.70

D) -8.70

E) none of the above

Answer: B

Diff: 2 Var: 9 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

30) What is the pH of an aqueous solution at 25.0 °C in which [OH-] is 0.0030 M?

A) 5.81

B) -11.48

C) 2.52

D) -2.52

E) 11.48

Answer: E

Diff: 2 Var: 9 Page Ref: Sec. 16.4

LO: 16.4

GO: G4

***Chemistry: The Central Science, 13e* (Brown et al.)**

**Chapter 17 Additional Aspects of Aqueous Equilibria**

17.1 Multiple-Choice Questions

1) Which one of the following pairs cannot be mixed together to form a buffer solution?

A) NH3, NH4Cl

B) NaC2H3O2, HCl (C2H3O2- = acetate)

C) RbOH, HBr

D) KOH, HF

E) H3PO4, KH2PO4

Answer: C

Diff: 2 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G2

2) Of the following solutions, which has the greatest buffering capacity?

A) 0.543 M NH3 and 0.555 M NH*4*Cl

B) 0.087 M NH3 and 0.088 M NH4Cl

C) 0.234 M NH3 and 0.100 M NH4Cl

D) 0.100 M NH3 and 0.455 M NH4Cl

E) They are all buffer solutions and would all have the same capacity.

Answer: A

Diff: 3 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

3) Which one of the following will cause hemoglobin to release oxygen?

A) increase in pH

B) decrease in pH

C) decrease in temperature

D) decrease in CO2 concentration

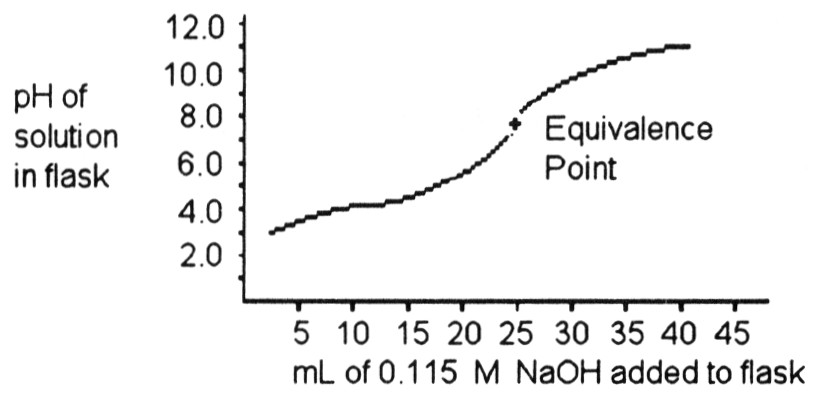
E) increase in O2 concentration

Answer: B

Diff: 3 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G2

**

4) A 25.0 mL sample of a solution of an unknown compound is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The unknown compound is \_\_\_\_\_\_\_\_.

A) a strong acid

B) a strong base

C) a weak acid

D) a weak base

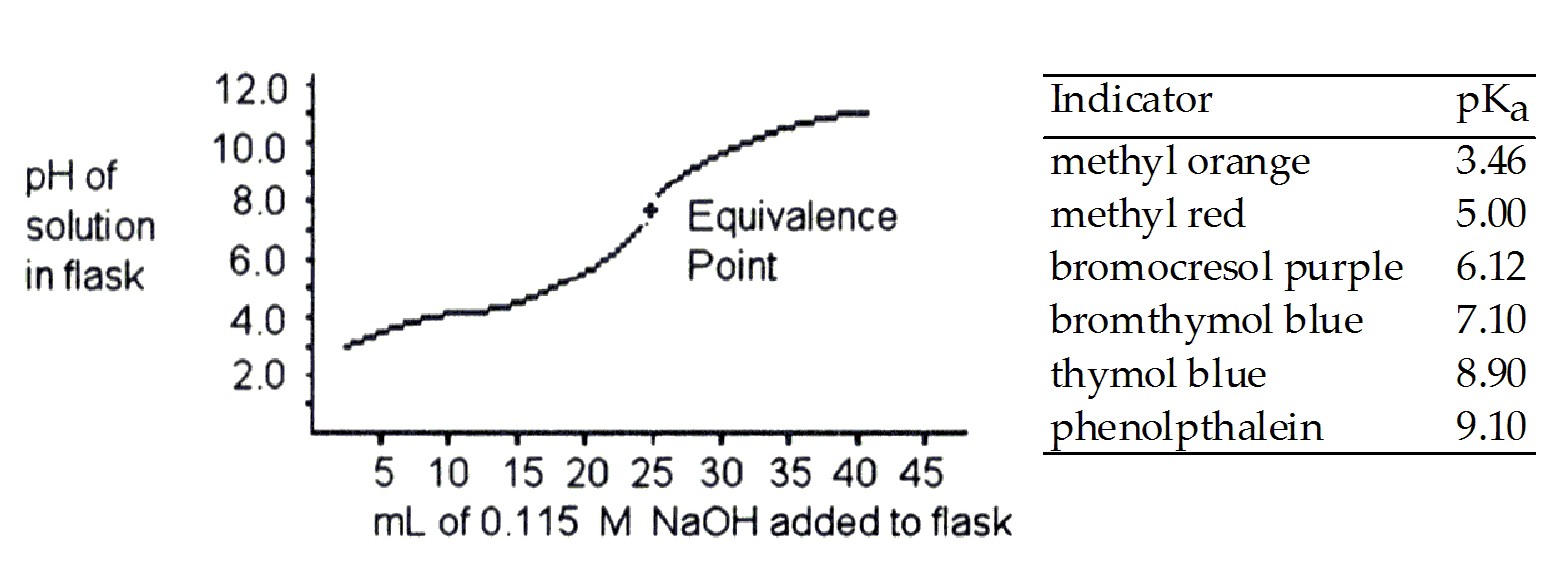
E) neither an acid nor a base

Answer: C

Diff: 3 Var: 1 Page Ref: Sec. 17.3

LO: 17.2

GO: G3



5) A 25.0 mL sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. Which of the following indicators would be best for this titration?

A) methyl red

B) bromthymol blue

C) thymol blue

D) phenolpthalein

E) bromocresol purple

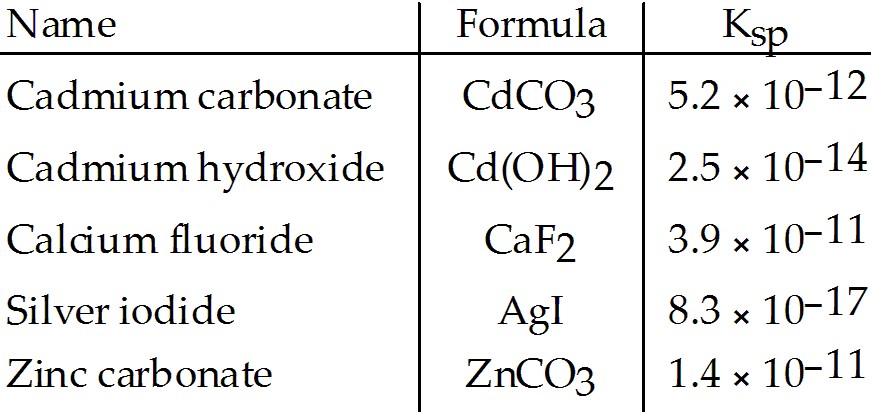
Answer: B

Diff: 2 Var: 1 Page Ref: Sec. 17.3

LO: 17.3

GO: G3

*Consider the following table of  values.*



6) Which compound listed below has the greatest molar solubility in water?

A) CdCO3

B) Cd(OH)2

C) AgI

D) CaF2

E) ZnCO3

Answer: D

Diff: 3 Var: 1 Page Ref: Sec. 17.4

LO: 17.4

GO: G3

7) Which compound listed below has the smallest molar solubility in water?

A) ZnCO3

B) Cd(OH)2

C) CdCO3

D) AgI

E) CaF2

Answer: D

Diff: 3 Var: 1 Page Ref: Sec. 17.4

LO: 17.4

GO: G3

8) The molar solubility of \_\_\_\_\_\_\_\_ is not affected by the pH of the solution.

A) Na3PO4

B) NaF

C) KNO3

D) AlCl3

E) MnS

Answer: C

Diff: 2 Var: 1 Page Ref: Sec. 17.5

LO: 17.4

GO: G3

9) In which one of the following solutions is silver chloride the most soluble?

A) 0.181 M HCl

B) 0.0176 M NH3

C) 0.744 M LiNO3

D) pure water

E) 0.181 M NaCl

Answer: B

Diff: 3 Var: 1 Page Ref: Sec. 17.5

LO: 17.4

GO: G2

10) Which one of the following is not amphoteric?

A) Al(OH)3

B) Ca(OH)2

C) Cr(OH)3

D) Zn(OH)2

E) Sn(OH)2

Answer: B

Diff: 2 Var: 1 Page Ref: Sec. 17.5

GO: G2

11) A result of the common-ion effect is \_\_\_\_\_\_\_\_.

A) that some ions, such as Na+ (aq), frequently appear in solutions but do not participate in solubility equilibria

B) that common ions, such as Na+ (aq), don't affect equilibrium constants

C) that the selective precipitation of a metal ion, such as Ag+, is promoted by the addition of an appropriate counterion (X-) that produces a compound (AgX) with a very low solubility

D) that ions such as K+ and Na+ are common ions, so that their values in equilibrium constant expressions are always 1.00

E) that common ions precipitate all counter-ions

Answer: C

Diff: 3 Var: 1 Page Ref: Sec. 17.6

LO: 17.1

GO: G2

12) The Ka of benzoic acid is 6.30 × 10-5. The pH of a buffer prepared by combining 50.0 mL of 1.00 M potassium benzoate and 50.0 mL of 1.00 M benzoic acid is \_\_\_\_\_\_\_\_.

A) 1.705

B) 0.851

C) 3.406

D) 4.201

E) 2.383

Answer: D

Diff: 3 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

13) Calculate the pH of a solution prepared by dissolving 0.150 mol of acetic acid and 0.300 mol of sodium acetate in water sufficient to yield 1.00 L of solution. The Ka of acetic acid is 1.76 × 10-5.

A) 2.516

B) 3.892

C) 4.502

D) 10.158

E) 5.056

Answer: E

Diff: 3 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

14) The pH of a solution prepared by dissolving 0.350 mol of solid dimethylamine hydrochloride ((CH3)2NH2Cl) in 1.00 L of 1.10 M dimethylamine ((CH3)2NH) is \_\_\_\_\_\_\_\_. The Kb for methylamine is 5.40 × 10-4. (Assume the final volume is 1.00 L.)

A) 1.66

B) 2.77

C) 11.23

D) 11.14

E) none of the above

Answer: C

Diff: 3 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

15) The pH of a solution prepared by mixing 50.0 mL of 0.125 M NaOH and 40.0 mL of 0.125 M HNO3 is \_\_\_\_\_\_\_\_.

A) 13.29

B) 7.00

C) 8.11

D) 11.00

E) 12.14

Answer: E

Diff: 3 Var: 1 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

16) A 50.0 mL sample of an aqueous H2SO4 solution is titrated with a 0.375 M NaOH solution. The equivalence point is reached with 62.5 mL of the base. The concentration of H2SO4 is \_\_\_\_\_\_\_\_ M.

A) 0.234

B) 0.469

C) 0.150

D) 0.300

E) 0.938

Answer: A

Diff: 3 Var: 1 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

17) The concentration of iodide ions in a saturated solution of lead (II) iodide is \_\_\_\_\_\_\_\_ M. The solubility product constant of PbI2 is 1.4 × 10-8.

A) 3.8 × 10-4

B) 3.0 × 10-3

C) 1.5 × 10-3

D) 3.5 × 10-9

E) 1.4 × 10-8

Answer: B

Diff: 3 Var: 1 Page Ref: Sec. 17.4

LO: 17.4

GO: G4

18) The concentration of iodide ions in a saturated solution of silver iodide is \_\_\_\_\_\_\_\_ M. The solubility product constant of AgI is 8.3 × 10-17.

A) 3.8 × 10-11

B) 3.0 × 10-10

C) 9.1 × 10-9

D) 3.5 × 10-9

E) 1.4 × 10-8

Answer: C

Diff: 2 Var: 1 Page Ref: Sec. 17.4

LO: 17.4

GO: G4

19) What are the principal organs that regulate the pH of the carbonic acid-bicarbonate buffer system in the blood?

A) kidneys, liver

B) lungs, kidneys

C) spleen, liver

D) lungs, skin

E) brain stem, heart

Answer: B

Diff: 2 Var: 1 Page Ref: Sec. 17.2

LO: 17.2

GO: G2

20) Calculate the percent ionization of formic acid (HCO2H) in a solution that is 0.322 M in formic acid and 0.178 M in sodium formate (NaHCO2). The Ka of formic acid is 1.77 × 10-4.

A) 35.6

B) 0.1011

C) 10.8

D) 1.03 × 10-3

E) 3.488

Answer: B

Diff: 4 Var: 10 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

21) Calculate the percent ionization of formic acid (HCO2H) in a solution that is 0.152 M in formic acid. The Ka of formic acid is 1.77 × 10-4.

A) 2.74 × 10-5

B) 0.0180

C) 3.44

D) 0.581

E) 8.44

Answer: C

Diff: 4 Var: 10 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

20) Calculate the percent ionization of nitrous acid in a solution that is 0.241 M in nitrous acid (HNO2) and 0.195 M in potassium nitrite (KNO2). The acid dissociation constant of nitrous acid is 4.50 × 10-4.

A) 44.7

B) 0.229

C) 13.5

D) 2.11 × 10-3

E) 3.258

Answer: B

Diff: 4 Var: 10 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

21) Of the following solutions, which has the greatest buffering capacity?

A) 1.15 M HF and 0.624 M NaF

B) 0.574 M HF and 0.312 M NaF

C) 0.287 M HF and 0.156 M NaF

D) 0.189 M HF and 0.103 M NaF

E) They are all buffer solutions and would all have the same capacity.

Answer: A

Diff: 3 Var: 50+ Page Ref: Sec. 17.2

LO: 17.2

GO: G2

22) The pH of a solution that contains 0.800 M acetic acid (Ka = 1.76 × 10-5) and 0.172 M sodium acetate is \_\_\_\_\_\_\_\_.

A) 4.087

B) 5.422

C) 8.578

D) 8.370

E) 9.913

Answer: A

Diff: 3 Var: 8 Page Ref: Sec. 17.2

LO: 17.2

GO: G4

23) A buffer solution with a pH of 4.40 is prepared with 0.78 M Na C2H3O2 and \_\_\_\_\_\_\_\_ M HC2H3O2. The Ka of HC2H3O2 is 1.8 × 10-5.

A) 1.7

B) 3.5

C) 4.1 × 104

D) 0.35

E) 0.86

Answer: A

Diff: 5 Var: 50+ Page Ref: Sec. 17.2

LO: 17.2

GO: G4

24) A buffer solution with a pH of 4.78 is prepared with \_\_\_\_\_\_\_\_ M formic acid and 0.90 M sodium formate. The Ka of formic acid is 1.8 × 10-4.

A) 0.083

B) 0.17

C) 3.3 × 103

D) 9.8

E) 0.041

Answer: A

Diff: 5 Var: 50+ Page Ref: Sec. 17.2

LO: 17.2

GO: G4

25) How many milliliters of 0.0839 M NaOH are required to titrate 25.0 mL of 0.0990 M HBr to the equivalence point?

A) 29.5

B) 0.332

C) 4.57

D) 0.208

E) 21.2

Answer: A

Diff: 3 Var: 10 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

26) A 25.0 mL sample of 0.150 M benzoic acid is titrated with a 0.150 M NaOH solution. What is the pH at the equivalence point? The Ka of benzoic acid is 4.50 × 10-4.

A) 11.20

B) 9.80

C) 4.20

D) 7.00

E) 8.54

Answer: E

Diff: 4 Var: 11 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

27) A 25.0 mL sample of 0.723 M HClO4 is titrated with a 0.273 M KOH solution. The H3O+ concentration after the addition of 0.00 mL of KOH is \_\_\_\_\_\_\_\_ M.

A) 0.0181

B) 0.430

C) 0.723

D) 0.273

E) none of the above

Answer: C

Diff: 3 Var: 7 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

28) The pH of a solution prepared by mixing 45.0 mL of 0.183 M KOH and 35.0 mL of 0.145 M HCl is \_\_\_\_\_\_\_\_.

A) 1.314

B) 1.403

C) 0.00824

D) 12.597

E) 12.923

Answer: D

Diff: 4 Var: 7 Page Ref: Sec. 17.3

LO: 17.3

GO: G4

29) What is the molar solubility of silver carbonate (Ag2CO3) in water? The solubility-product constant for Ag2CO3 is 8.1 × 10-12 at 25 °C.

A) 1.4 × 10-6

B) 2.0 × 10-4

C) 4.0 × 10-6

D) 1.3 × 10-4

E) 2.7 × 10-12

Answer: D

Diff: 4 Var: 4 Page Ref: Sec. 17.4

LO: 17.4

GO: G4

30) In which aqueous system is CaF2 least soluble?

A) H2O

B) 0.5 M HF

C) 0.2 M HF

D) 1.0 M HNO3

E) 0.8 M KF

Answer: E

Diff: 2 Var: 5 Page Ref: Sec. 17.5

LO: 17.1

GO: G2

SHOW YOUR WORK SECTION TYPE

QUESTIONS. TRY TO UNDERSTAND CALCULATIONS IN THE PREVIOUS MULTIPLE CHOICE QUESTIONS AS WELL

Chapter 15

1. The data below refer to the following reaction:

2NO(g) + Br2(g)  2NOBr(g)

|  |  |  |  |
| --- | --- | --- | --- |
| Concentration (M) | [NO] | [Br2] | [NOBr] |
| Initial | 2.5 | 5.0 | 1.0 |
| Equilibrium | 2.0 | \_\_\_\_ | \_\_\_\_ |  |

Find the concentration of Br2 when the system reaches equilibrium.

Ans: 4.75 M

2. The data below refer to the following reaction:

2NO(g) + Br2(g)  2NOBr(g)

|  |  |  |  |
| --- | --- | --- | --- |
| Concentration (M) | [NO] | [Br2] | [NOBr] |
| Initial | 2.5 | 5.0 | 1.0 |
| Equilibrium | 2.0 | \_\_\_\_ | \_\_\_\_ |  |

Calculate Kc.

Ans: 0.12

3. Consider the chemical reaction 2NH3(g)  N2(g) + 3H2(g). The equilibrium is to be established in a 1.0 L container at 1,000 K, where Kc = 4.0  10–2. Initially, 1,220 moles of NH3(g) are present. Estimate the equilibrium concentration of H2(g).

Ans: 20 M

4. Consider the chemical reaction 2NH3(g)  N2(g) + 3H2(g). The equilibrium is to be established in a 1.0 L container at 1,000 K, where Kc = 4.0  10–2. Initially, 1,220 moles of NH3(g) are present. Estimate the equilibrium concentration of N2(g).

Ans: 6.8 M

5. Consider the chemical reaction 2NH3(g)  N2(g) + 3H2(g). The equilibrium is to be established in a 1.0 L container at 1,000 K, where Kc = 4.0  10–2. Initially, 1,220 moles of NH3(g) are present. Calculate Kp for the reaction.

Ans: 270

6. Hydrogen iodide decomposes according to the equation:

2HI(g)  H2(g) + I2(g), Kc = 0.0156 at 400ºC

A 0.660 mol sample of HI was injected into a 2.00 L reaction vessel held at 400ºC.

Calculate the concentration of H2 equilibrium.

Ans: 0.033 M

7. The dissociation of solid silver chloride in water to produce silver ions and chloride ions has an equilibrium constant of 1.8  10–18. Based on the magnitude of the equilibrium constant, is silver chloride very soluble in water? Why?

Ans: Kc here will be [Ag+(aq)][Cl–(aq)]. If Keq is very small, then the concentrations of the dissolved ions must also be small, implying that AgCl is not very soluble.

8. Calcium carbonate decomposes at high temperatures to give calcium oxide and carbon dioxide.

CaCO3(*s*)  CaO(*s*) + CO2(*g*)

KP for this reaction is 1.16 at 800°C. A 5.00 L vessel containing 10.0 g of CaCO3(*s*) was evacuated to remove the air, sealed, and then heated to 800°C. Ignoring the volume occupied by the solid, what will be the mass of the solid in the vessel once equilibrium is reached?

Ans: 7.1 g of solid

9. Kc for the reaction CO2(g) + H2(g)  H2O(g) + CO(g) is 1.6 at about 990ºC. Calculate the number of moles of carbon dioxide in the final equilibrium system obtained by initially adding 1.00 mol of H2, 2.00 mol of CO2, 0.750 mol of H2O, and 1.00 mol of CO to a 5.00 L reactor at 990ºC.

Ans: 1.6 mol

10. Kc for the reaction CO2(g) + H2(g)  H2O(g) + CO(g) is 1.6 at about 990ºC. Calculate the number of moles of hydrogen gas in the final equilibrium system obtained by initially adding 1.00 mol of H2, 2.00 mol of CO2, 0.750 mol of H2O, and 1.00 mol of CO to a 5.00 L reactor at 990ºC.

Ans: 0.62 mol

11. Kc for the reaction CO2(g) + H2(g)  H2O(g) + CO(g) is 1.6 at about 990ºC. Calculate the number of moles of water in the final equilibrium system obtained by initially adding 1.00 mol of H2, 2.00 mol of CO2, 0.750 mol of H2O, and 1.00 mol of CO to a 5.00 L reactor at 990ºC.

Ans: 1.1 mol

12. Kc for the reaction CO2(g) + H2(g)  H2O(g) + CO(g) is 1.6 at about 990ºC.Calculate the number of moles of carbon monoxide in the final equilibrium system obtained by initially adding 1.00 mol of H2, 2.00 mol of CO2, 0.750 mol of H2O, and 1.00 mol of CO to a 5.00 L reactor at 990ºC.

Ans: 1.4 mol

Chapters 16& 17

1. Identify the conjugate acid-base pairs in the reaction HSO4– + HF  H2SO4 + F–

One conjugate acid-base pair is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; the other acid-base pair is \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Ans: HF–F–; H2SO4–HSO4–

2. Which of these acids is stronger, H3PO4 or H3AsO4?

Ans: H3PO4

3. Which of these acids is stronger, H3AsO3 or H3AsO4?

Ans: H3AsO4

4. Which of these acids is stronger, H2SO4 or HSO4–?

Ans: H2SO4

5. Calculate the pH of a solution containing 0.20 g of NaOH in 2,000. mL of solution.

Ans: 11.40

6. Calculate the pOH of a solution containing 0.25 g of HCl in 800. mL of solution.

Ans: 11.93

7. Calculate the H+ ion concentration in a solution with a pH of 3.85.

Ans: 1.4  10–4 M

8. If the pH of stomach acid is 1.0, what is the hydroxide ion concentration in this solution?

Ans: 1  10–13 M

9. If the pH of tomato juice is 4.0, what is the hydroxide ion concentration in this solution?

Ans: 1  10–10 M

10. If the pH of seawater is 8.0, what is the hydroxide ion concentration in seawater?

Ans: 1  10–6 M

11. The pH of a sample of river water is 6.0. A sample of effluent from a food processing plant has a pH of 4.0. What is the ratio of hydronium ion concentration in the effluent to the hydronium ion concentration in the river?

Ans: The hydronium ion concentration in the effluent is 100 times greater than the hydronium ion concentration in the river.

12. What concentration of potassium hydroxide will result from the reaction of 0.170 g of potassium with 100. mL of water?

Ans: 4.35  10–2 M

13. What volume of hydrogen, at STP, will be formed by the reaction of 0.170 g of potassium with 100. mL of water?

Ans: 4.87  10–2 L

14. An unknown substance was added to a solution and the pH decreases. What type of substance was added?

Ans: An acid

15. The pH of a 0.02 M solution of an unknown weak base is 8.1. What is the pKb of the unknown base?

Ans: 10.1

16. A solution containing NH3(aq) and NH4Cl(aq) has a pH of 9.5. What is the [NH3]/[NH4+] ratio in this solution? (For ammonia, Kb = 1.8  10–5.)

Ans: 1.8

17. When 2.0  10–2 mole of nicotinic acid (a monoprotic acid) is dissolved in 350. mL of water, the pH is 3.05. What is the Ka of nicotinic acid?

Ans: 1.4  10–5

18. A 8.0 M solution of formic acid (HCOOH) is 0.47% ionized. What is the Ka of formic acid?

Ans: 1.77  10–4

19. The pH of a 0.6 M solution of a weak acid is 4.0. What percent of the acid has ionized?

Ans: 0.02 %

20. Write the EQUATION AND THE chemical formula for the acid formed when Cl2O7 is dissolved in water.

Ans: HClO4