Unit Test

1. Chemical systems reach equilibrium when
   A. no reaction is occurring
   B. the mass of products equals the mass of reactants
   C. the rates of forward and reverse reactions become equal
   D. the number of moles of products equals the number of moles of reactants

2. Which of the following reactions involve a homogeneous equilibrium?
   A. $CO_{2(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$
   B. $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$
   C. $3Fe_{(s)} + 4H_2O_{(g)} \rightleftharpoons Fe_3O_{4(s)} + 4H_{2(g)}$
   D. $H_{2(g)} + CO_{(g)} + H_2O_{(g)} \rightleftharpoons 2H_{2(g)} + CO_{2(g)}$

3. When heated, the given equilibrium is established.
   $PCl_{5(s)} \rightleftharpoons PCl_{3(l)} + Cl_{2(g)}$

   The mass of chlorine gas produced will be maximized when temperature __*i*__ and the volume of the flask __*ii*__.

   Which of the following tables completes the given sentence?

   A.

i	ii
increases	increases

   B.

i	ii
increases	decreases

   C.

i	ii
decreases	increases

   D.

i	ii
decreases	decreases

4. Hydrogen fluoride is produced by reacting hydrogen with fluorine.
   $H_{2(g)} + F_{2(g)} \rightleftharpoons 2HF_{(g)} \Delta H = -542.2$ kJ

   A stress that would shift the equilibrium toward the products would be to
   A. add $HF_{(g)}$
   B. remove $H_{2(g)}$
   C. decrease the volume of the reaction vessel
   D. decrease the temperature of the reaction vessel

5. This equilibrium is established after placing 0.734 mol of $NO_{2(g)}$ in a 2.00 L flask at 25°C.
   $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

   a) The initial concentration of the $NO_{2(g)}$ was
   A. 0.184 mol/L **B.** 0.367 mol/L
   C. 0.734 mol/L **D.** 1.47 mol/L

   b) The equilibrium concentration of $N_2O_{4(g)}$ is 0.125 mol/L. The equilibrium constant, K_c, for the reaction is $a.bc \times 10^d$ mol/L. What are the values of a, b, c, and d?

   a____
   b____
   c____
   d____

6. Two cleaning solutions were accidentally mixed. A strong smell of ammonia alerted a technician to the accident. After checking the labels of the cleaners and discovering that one container held $NH_4Cl_{(aq)}$ and the other $KOH_{(aq)}$, the technician determined that the smell came from the following reaction:

$NH^+_{4(aq)} + OH^-_{(aq)} \rightleftharpoons NH_{3(aq)} + H_2O_{(l)}$

In this equilibrium, the Brønsted–Lowry acids are

A. $NH_{3(aq)}$ and $H_2O_{(l)}$

B. $NH^+_{4(aq)}$ and $H_2O_{(l)}$

C. $NH_{3(aq)}$ and $OH^-_{(aq)}$

D. $NH^+_{4(aq)}$ and $OH^-_{(aq)}$

7. Most plants grow best in soil with a pH between 6 and 7. Higher or lower pH values prevent them from absorbing essential nutrients. Plants can absorb phosphorus in the form of $H_2PO^-_{4(aq)}$.

In basic soil, $H_2PO^-_{4(aq)}$ could be converted to

A. $P_{4(s)}$

B. $PO^{3-}_{4(aq)}$

C. $H_3PO_{4(aq)}$

D. $HPO^{2-}_{4(aq)}$

8. $\underset{1}{HSO^-_{4(aq)}} + \underset{2}{HCOO^-_{(aq)}} \rightleftharpoons \underset{3}{HCOOH_{(aq)}} + \underset{4}{SO^{2-}_{4(aq)}}$

Match each acid or base in the forward reaction, as numbered above, with the corresponding term given below.

Acid ____
Conjugate base ____
Base ____
Conjugate acid ____

9. In which of the following reactions does equilibrium favour the products?

A. $HSO^-_{4(aq)} + F^-_{(aq)} \rightleftharpoons HF_{(aq)} + SO^{2-}_{4(aq)}$

B. $NO^-_{2(aq)} + NH^+_{4(aq)} \rightleftharpoons HNO_{2(aq)} + NH_{3(aq)}$

C. $SO^{2-}_{4(aq)} + HCN_{(aq)} \rightleftharpoons HSO^-_{4(aq)} + CN^-_{(aq)}$

D. $HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}$

10. The conjugate base of $N_2H^+_{5(aq)}$ is

A. $HOH_{(l)}$

B. $OH^-_{(aq)}$

C. $N_2H_{4(aq)}$

D. $N_2H^{2+}_{6(aq)}$

11. The main buffer solution of plasma and tissue fluid found in our bodies is $H_2CO_{3(aq)}/HCO^-_{3(aq)}$. When excess hydronium ions enter our blood, the equation that represents the reaction that occurs is

A. $H_3O^+_{(aq)} + OH^-_{(aq)} \rightleftharpoons 2H_2O_{(l)}$

B. $CO^{2-}_{3(aq)} + H_3O^+_{(aq)} \rightleftharpoons HCO^-_{3(aq)} + H_2O_{(l)}$

C. $H_2CO_{3(aq)} + H_3O^+_{(aq)} \rightleftharpoons H_3CO^+_{3(aq)} + H_2O_{(l)}$

D. $H_3O^+_{(aq)} + HCO^-_{3(aq)} \rightleftharpoons H_2CO_{3(aq)} + H_2O_{(l)}$

12. A solution was tested and found to have a pOH of 3.2. This solution would **most likely**

A. be a proton donor

B. react violently with zinc

C. cause thymolphthalein to be blue

D. cause bromocresol green to be yellow

13. The $OH^-_{(aq)}$ of a solution with a pH = 3.45 is

A. 1.9×10^{-14} mol/L

B. 2.8×10^{-11} mol/L

C. 3.6×10^{-4} mol/L

D. 0.54 mol/L

14. Sodium azide, which is found in automobile air bags, reacts readily with acids to form the highly toxic and explosive hydroazoic acid $HN_{3(aq)}$. The K_a for hydroazoic acid is 1.9×10^{-5}.

The pH of a 0.28 mol/L $HN_{3(aq)}$ solution is ____.

15. Sodium azide, which is found in automobile air bags, reacts readily with acids to form the highly toxic and explosive hydroazoic acid $HN_{3(aq)}$. The K_a for hydroazoic acid is 1.9×10^{-5}.

The K_a expression for hydroazoic acid is

A. $K_a = \dfrac{[HN_{3(aq)}]}{[H_3O^+_{(aq)}][N^-_{3(aq)}]}$

B. $K_a = \dfrac{[H_3O^+_{(aq)}][N^-_{3(aq)}]}{[HN_{3(aq)}]}$

C. $K_a = \dfrac{[HN_{3(aq)}]}{[H_3O^+_{(aq)}][N^-_{3(aq)}]^3}$

D. $K_a = \dfrac{[H_3O^+_{(aq)}][N^-_{3(aq)}]^3}{[HN_{3(aq)}]^3}$

16. The K_b of $F^-_{(aq)}$ is

A. 1.5×10^{17} **B.** 6.3×10^{-4}

C. 1.6×10^{-11} **D.** 1.0×10^{-14}

17. Initially, equal amounts of $H_2O_{(g)}$ and $CO_{(g)}$ are placed in a reaction vessel. The reaction comes to equilibrium as shown.

$H_2O_{(g)} + CO_{(g)} \rightleftharpoons H_{2(g)} + CO_{2(g)}$

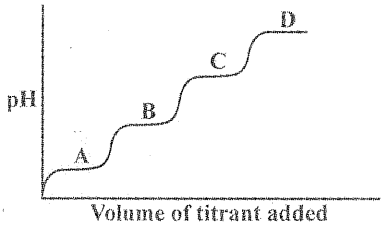
$K_c = 44.0$ at 200°C

At equilibrium, the concentration of $H_{2(g)}$ was found to be 5.70 mol/L.

What were the initial concentrations of $H_2O_{(g)}$ and $CO_{(g)}$? ___ mol/L

18. $H_3PO_{4(aq)}$ titrated with sodium hydroxide solution.

$H_3PO_{4(aq)}$ Titrated with Sodium Hydroxide Solution



The region of the titration curve that represents the buffer $H_2PO^-_{4(aq)}/HPO^{2-}_{4(aq)}$ is

A. Region A **B.** Region B

C. Region C **D.** Region D

19. A student predicts that the K_a value of a weak acid may be affected by the temperature of the acid solution. Given an acid of known concentration, design an experiment to test this prediction using commonly available laboratory apparatus. Your response should include

- a procedure
- identification of controlled, manipulated, and responding variables
- indication of the calculations necessary to solve for K_a

Answers and Solutions – Unit-Test

1. C	5. a) B	8. 1 4 2 3	12. C	16. C
2. D	b) 9 1 3 0	9. A	13. B	17. 6.56
3. A	6. B	10. C	14. 2.64	18. B
4. D	7. D	11. D	15. B	19. WR