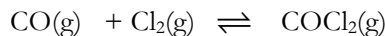**CHEM-1212**
Spring 2015
First Examination
Form A

Multiple Choice - Choose the BEST Answer

1. A system is described by the following reaction:

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

The system is at equilibrium, at a given temperature and when the $P_{CO} = 0.30$ bar, $P_{Cl2} = 0.10$ bar and $P_{COCl2} = 0.60$ bar. An additional 0.40 bar of $Cl_2(g)$ is added to the system. What is the pressure, in bar, of CO when the system returns to equilibrium?
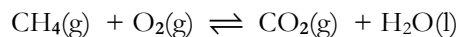
   A) 0.12 bar
   B) 5.0 bar
   C) 0.18 bar
   D) 0.20 bar
   E) The P_{CO} will still equal 0.30 bar. That is the partial pressure of CO at equilibrium.

2. Balance the reaction between CH_4 and O_2 to give CO_2 and H_2O, and then which of the following is the appropriate equilibrium constant?

$$CH_4(g) + O_2(g) \rightleftharpoons CO_2(g) + H_2O(l)$$

A) $K = \left(\dfrac{(P_{CO_2})(P_{O_2})}{(P_{CH_4})(P_{H_2O})} \right)$

B) $K = \left(\dfrac{(P_{CO_2})(P_{H_2O})^2}{(P_{CH_4})(P_{O_2})^2} \right)$

C) $K = \left(\dfrac{(P_{CO_2})(P_{H_2O})}{(P_{CH_4})(P_{O_2})} \right)$

D) $K = \left(\dfrac{(P_{CH_4})(P_{O_2})^2}{(P_{CO_2})} \right)$

E) $K = \left(\dfrac{(P_{CO_2})}{(P_{CH_4})(P_{O_2})^2} \right)$

3. Which of the following statements is false about chemical equilibrium?

   A) When a system is at equilibrium, neither the forward nor reverse reaction stops.
   B) A large equilibrium constant indicates that the forward reaction (as written) is favored.
   C) In an equilibrium reaction, the reverse reaction begins only when all reactants have been converted to products.
   D) If the Gibbs free energy of reaction is negative, the reaction proceeds forward to reach equilibrium.
   E) More than one of the above statements is false.

4. What is the standard Gibbs free energy of reaction, $\Delta G°_{rxn}$, in kJ/mol that occurs in a closed vessel with constant volume and total pressure, a temperature of 500. K and $K = 3.6 \times 10^{-2}$ for the reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
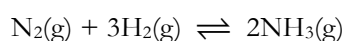
   A) 14 kJ/mol
   B) 4.7 kJ/mol
   C) 140 kJ/mol
   D) 4.5 kJ/mol
   E) 68 kJ/mol

5. If $K_c = 1.0$ for the equilibrium $C(g) \rightleftharpoons 2D(g)$, what is the relationship between [C] and [D] at equilibrium?

   A) The concentration of C will be twice as much as the concentration of D.
   B) The concentration of C equals the concentration of D, but the concentration of neither is equal to 1.00.
   C) The concentration of C will be equal to the concentration of D to the 2nd power.
   D) The concentration of C will be equal to the square root of the concentration of D.
   E) There is not enough information to compare the concentrations of C and D at equilibrium.

6. The following K_c values were attained at body temperature:

$$Hb(aq) + O_2(aq) \rightleftharpoons HbO_2(aq) \qquad K_c = 1.8$$

$$Hb(aq) + CO(aq) \rightleftharpoons HbCO(aq) \qquad K_c = 306$$

Calculate the equilibrium constant for: $HbO_2(aq) + CO(aq) \rightleftharpoons HbCO(aq) + O_2(aq)$ at body temperature.

   A) $K_c = 304$
   B) $K_c = 170$
   C) $K_c = 5.9 \times 10^{-3}$
   D) $K_c = 551$
   E) $K_c = 1.8 \times 10^{-3}$

7. A reaction mixture is prepared by mixing 0.100 mol SO_2 0.200 mol NO_2, 0.100 mol NO and 0.150 mol SO_3 in a 5.00-L reaction vessel. The reaction $SO_2(g) + NO_2(g) \rightleftharpoons NO(g) + SO_3(g)$ is allowed to reach equilibrium at 46°C; K_c = 85.0. Which of the following statement(s) is(are) true about the system?

   A) The reaction would shift to the left (toward reactants, as written).
   B) The amount of SO_2 (g) would decrease comparatively to the initial amount, because Q < K.
   C) The amount of $SO_3(g)$ would decrease comparatively to the initial amount, because Q < K.
   D) The reaction would shift to the right (toward products, as written).
   E) Both B and D

8. A fertilizer company produces ammonia on a large scale at a temperature of 450° C. The balanced equation below represents the reaction that takes place in a sealed container.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H(-)$$
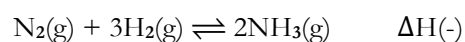
To meet an increased demand for fertilizer, the management of the company instructs their engineer to make the necessary adjustments to increase the yield of ammonia.

In a trial run on a small scale in the laboratory, the engineer makes adjustments to the Temperature, Pressure and Concentration of the equilibrium mixture. The graphs below represent the results obtained. Which of the following statement(s) is(are) true about the system?
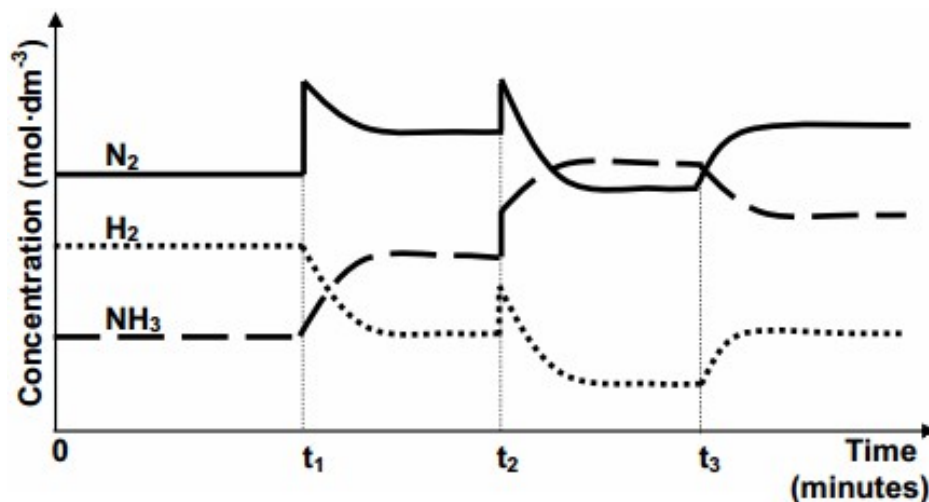

   A) At t_1, the concentration of N_2 was increased.
   B) At t_2, the temperature was increased.
   C) At t_2, the pressure was increased.
   D) Both A and C
   E) None of the above.

9. Which of the following statement(s) is(are) true about removing heat from the following reaction at equilibrium:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \quad \Delta H(+)$$

A) The system is immediately stressed and at that moment, $Q < K$
B) The reaction will shift to the right to reestablish equilibrium, and the reaction will have a greater value of K.
C) The reaction will shift to the left to reestablish equilibrium, and the reaction will have a lower value of K.
D) The reaction will shift to the right to reestablish equilibrium, and for $Q = K$.
E) Both A and D.

10. What is the value of K_c at 297 K for the following reaction at equilibrium when the value of $K = 9.4 \times 10^{-2}$ at 297 K?

$$2\ NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$$
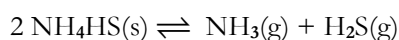
A) 1.5×10^{-4}
B) 9.4×10^{-2}
C) 5.5×10^{-1}
D) 1.6×10^{-8}
E) 5.4×10^{-5}

11. Which of these is true when the amount of CO_2 in a tissue is increased?

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$
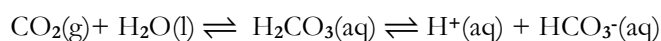
A) It reacts with water to produce H^+ ions, increasing the blood pH
B) It reacts with H^+ in the blood and has no effect on pH
C) It reacts with water to produce H^+ ions, lowering the blood pH
D) It reacts with H_2CO_3, lowering the blood pH
E) It reacts with water, with no effect on the pH

12. The figure below is a step taken from the mechanism of a serine protease enzyme, where species A is the enzyme. Which of the following statements is true about this step shown below?

      A   B   C   D
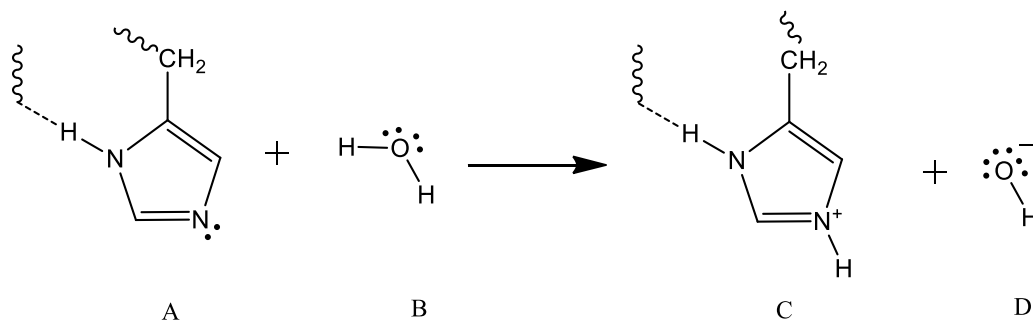
    I. Species A acts as an Arrhenius base
    II. Species A acts as a Lewis base
    III. Species A acts as a Lewis acid
    IV. Species A acts as an Arrhenius acid
    V. Species C has a coordinate covalent bond

  A) I only
  B) Both III and IV
  C) Both I and II
  D) Both II and V
  E) None of the above are true

13. SO_4^{2-}(aq) is a weak base. Which of the following equations demonstrates the proton transfer equilibrium of the conjugate acid of SO_4^{2-}(aq) in water?

  A) SO_4^{2-}(aq) + H_2O(l) $\rightleftharpoons$ HSO_4^- (aq) + H_3O^+(aq)
  B) SO_4^{2-}(aq) + $2H_2O$(l) $\rightleftharpoons$ H_2SO_4(aq) + $2OH^-$(aq)
  C) H_2SO_4(aq) + H_2O(l) $\rightleftharpoons$ H_3O^+(aq) + SO_4^{2-}(aq)
  D) HSO_4^-(aq) + H_3O^+(aq) $\rightarrow$ H_2SO_4(aq) + H_2O(l)
  E) HSO_4^-(aq) + H_2O(l) $\rightleftharpoons$ SO_4^{2-}(aq) + H_3O^+(aq)

14. What is the pH of a 0.200 M HNO_2(aq) solution? The K_a of nitrous acid is 4.3 x 10^{-4}.

  A) pH = 2.04
  B) pH = 9.60
  C) pH = 0.70
  D) pH = 3.37
  E) Not enough information is given.

15. You have an aqueous solution of a weak base, in water, which of the following are present?

        I. the weak base
        II. OH⁻
        III. H_3O^+
        IV. the conjugate acid
        V. H_2O

A) I and IV
B) II and IV
C) I, II, III and IV
D) I, II and IV
E) I, II, III, IV and V

16. Using the following information, which of the following is the weakest base?

Formula	K_a
$HCHO_2$	1.8 x 10⁻⁴
HCN	4.9 x 10⁻¹⁰
$HClO_2$	1.1 x 10⁻²

A) $HClO_2$
B) HCN
C) CN⁻
D) ClO_2^-
E) $HCHO_2$

17. What is the pOH of 0.045 M solution of HBr ?

A) pOH = 1.05
B) pOH = 1.35
C) pOH = 12.95
D) pOH = 12.65
E) Not enough information is given; I need to know the K_a or the K_b value.

18. Which of the following statements is true in regards to relative strengths of acids?

A) HF is a weaker acid than HBr due to the great electronegative of the fluorine atom in compared to bromine.
B) HF is a weaker acid than HI because fluorine has a small radius in compared to iodine, causing the H-F bond to be stronger than the HI bond.
C) The bond between hydrogen and fluorine is too weak to make HF a strong acid.
D) H_2S is a weaker acid than H_2O because the H-S bond is weaker than the H-O bond because the radius of the sulfur atom is smaller than that of oxygen.
E) HCl is a stronger acid than HF because the electronegativity difference is greater between HF than HCl.

19. What is the pK_b of a weak base if the pOH of a 0.25 M solution is 2.68?

    A) 4.75
    B) 11.32
    C) 2.08
    D) 11.92
    E) 9.24

20. Which of the following reactions, best illustrates the protonation of water and the deprotonation of acetic acid?

    A) $CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COOH_2(aq) + OH^- (aq)$
    B) $CH_3COO^-(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + OH^- (aq)$
    C) $CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$
    D) $CH_3COOH(aq) + H_2O(l) \rightarrow CH_3COO^-(aq) + H_3O^+ (aq)$
    E) $CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

21. Which form of the exam do you have?

    A) A
    B) B