Woksheet: Equilibrium & Keq NAME:_____

1. Given the reaction at equilibrium:

   $CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g)$

   What is the correct equilibrium expression for this reaction?

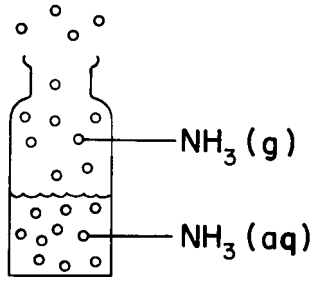
2. Which is the correct equilibrium expression for the reaction below?

   $4NH_3(g) + 7O_2(g) \leftrightarrow 4NO_2(g) + 6H_2O(g)$

   (A) $K = \frac{[NO_2][H_2O]}{[NH_3][O_2]}$ (C) $K = \frac{[NH_3][O_2]}{[NO_2][H_2O]}$

   (B) $K = \frac{[NO_2]^4[H_2O]^6}{[NH_3]^4[O_2]^7}$ (D) $K = \frac{[NH_3]^4[O_2]^7}{[NO_2]^4[H_2O]^6}$

3. The diagram below shows a bottle containing $NH_3(g)$ dissolved in water.



   How can the equilibrium,

   $NH_3(g) \leftrightarrow NH_3(aq)$, be reached?

   (A) Add more $NH_3(g)$.
   (B) Stopper the bottle.
   (C) Cool the contents.
   (D) Add more water.

4. Calculate the value of the equilibrium constant, K, for the reaction below:

   $4NH_3(g) + 7O_2(g) <=====> 4NO_2(g) + 6H_2O(g)$

   $[NH_3] = 1.2$ M
   $[O_2] = 0.2$ M
   $[NO_2] = 1.0$ M
   $[H_2O] = 0.5$ M

5. Calculate the value of the equilibrium constant for this reaction:

   $2\,CO(g) + O_2(g) \leftrightarrow 2\,CO_2(g)$

   $[CO] = 0.5$ M
   $[O_2] = 0.5$ M
   $[CO_2] = 0.5$ M

6. Which reaction has the equilibrium expression $K = \frac{[A][B]^2}{[AB_2]}$?

   (A) $A(g) + B_2(g) \leftrightarrow 2\,AB(g)$
   (B) $A(g) + 2\,B(g) \leftrightarrow AB_2(g)$
   (C) $2\,AB(g) \leftrightarrow A(g) + B_2(g)$
   (D) $AB_2(g) \leftrightarrow A(g) + 2\,B(g)$

7. Which is the correct equilibrium expression for the reaction

   $4\,NH_3(g) + 5\,O_2(g) \leftrightarrow 4\,NO(g) + 6\,H_2O(g)$?

   (A) $K_{eq} = \frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$

   (B) $K_{eq} = \frac{[4NO] + [6H_2O]}{[4NH_3] + [5O_2]}$

   (C) $K_{eq} = \frac{[NO]^4 + [H_2O]^6}{[NH_3]^4 + [O_2]^5}$

   (D) $K_{eq} = \frac{[4NO][6H_2O]}{[4NH_3][5O_2]}$

8. In an experiment, radioactive $Pb^*(NO_3)_2(aq)$ was added to the following equilibrium system:
   [* indicates radioactive Pb^{2+} ions]

   $PbCl_2(s) \leftrightarrow Pb^{2+}(aq) + 2Cl^-(aq)$

   When equilibrium was reestablished, some of the $PbCl_2(s)$ was recovered from the system and dried. Testing showed the $PbCl_2(s)$ was radioactive. Which statement is best supported by this result?

   (A) At equilibrium, the rates of chemical change are unequal.
   (B) At equilibrium, the rates of chemical change are equal.
   (C) The process of dynamic equilibrium is demonstrated.
   (D) The process of dynamic equilibrium is not demonstrated.

9. Which is the correct equilibrium expression for the reaction

   $2\,A(g) + 3\,B(g) \leftrightarrow C(g) + 3\,D(g)$?

   (A) $K = \frac{[A]^2[B]^3}{[C][D]^3}$ (C) $K = \frac{[2A] + [3B]}{[C] + [3D]}$

   (B) $K = \frac{[C] + [3D]}{[2A] + [3B]}$ (D) $K = \frac{[C][D]^3}{[A]^2[B]^3}$

10. Which factors must be equal in a reversible chemical reaction at equilibrium?
    (A) the rates of the forward and reverse reactions
    (B) the concentrations of the reactants and products
    (C) the activation energies of the forward and reverse reactions
    (D) the potential energies of the reactants and products
11. Given the reaction at equilibrium:

    $2\ CO(g) + O_2(g) \leftrightarrow 2\ CO_2(g)$

    What is the correct equilibrium expression for this reaction?

    (A) $K_{eq} = \dfrac{[2CO_2]}{[2CO]\,[O_2]}$

    (C) $K_{eq} = \dfrac{[2CO]\,[O_2]}{[2CO_2]}$

    (B) $K_{eq} = \dfrac{[CO_2]^2}{[CO]^2[O_2]}$

    (D) $K_{eq} = \dfrac{[CO]^2\,[O_2]}{[CO_2]^2}$

12. Given the reaction at equilibrium:

    $PCl_5\ (s) \leftrightarrow PCl_3\ (l)\ +\ Cl_2\ (g)$

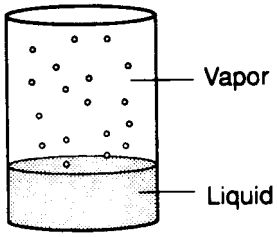
    What is the correct equilibrium expression for this reaction?

13. Given the reaction at equilibrium:

    $PCl_3\ (l)\ +\ Cl_2\ (g) \leftrightarrow\ PCl_5\ (s)$

    What is the correct equilibrium expression for this reaction?

14. A closed system is shown in the diagram below.

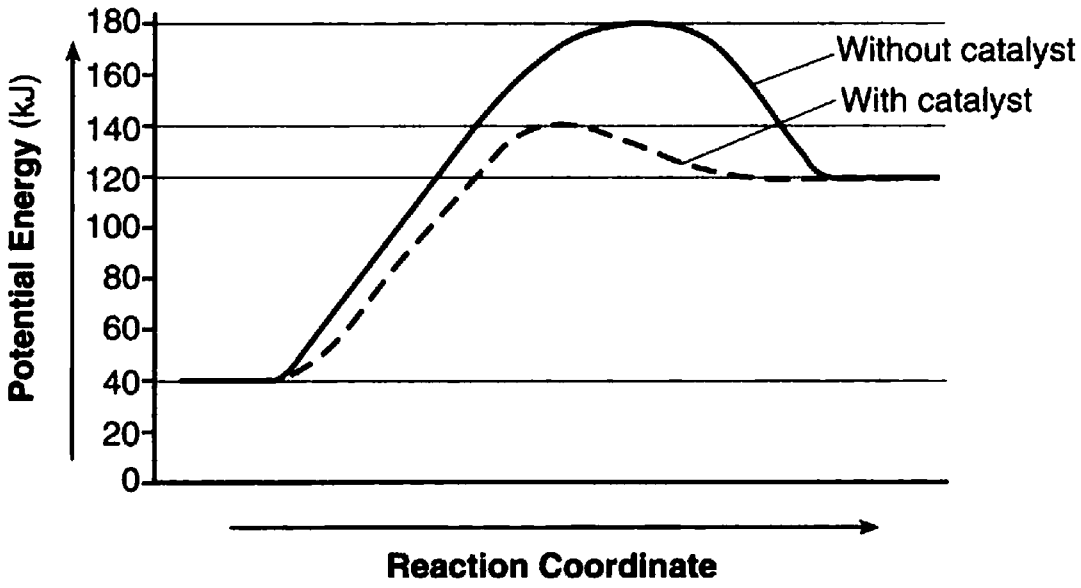


    The rate of vapor formation at equilibrium is
    (A) less than the rate of liquid formation
    (B) greater than the rate of liquid formation
    (C) equal to the rate of liquid formation
15. A chemical reaction has reached equilibrium when
    (A) the reverse reaction begins
    (B) the forward reaction ceases
    (C) the concentrations of the reactants and products become equal
    (D) the concentrations of the reactants and products become constant
16. A chemical reaction is at equilibrium. Compared to the rate of the forward reaction, the rate of the reverse reaction is
    (A) the same and the reaction continues in both directions
    (B) faster and more product is produced
    (C) the same and the reaction has stopped
    (D) faster and more reactant is produced
17. Given the reaction at equilibrium:

    $2\ H_2O\ (liquid) \leftrightarrow H_3O^+\ (aq)\ +\ OH^-\ (aq)$

    What is the correct equilibrium expression for this reaction?

Base your answers to questions **18** through **20** on the potential energy diagram below.



18. What is the activation energy for the forward reaction with the catalyst?

19. Explain, in terms of the function of a catalyst, why the curves on the potential energy diagram for the catalyzed and uncatalyzed reactions are different.

20. What is the heat of reaction for the forward reaction?