Equilibrium Worksheet #2

1. Chemists believe that chemical reactions occur because the molecules involved in the reaction _____.

   [A] exist only below a certain maximum temperature [B] are always unstable

   [C] are moving so fast that the chance of interaction is very small

   [D] spontaneously break apart then recombine

   [E] collide with each other with enough energy to break chemical bonds

2. Which of the following statements is(are) typically true for a catalyst?

   [A] The concentration of the catalyst will decrease as a reaction proceeds.

   [B] The catalyst speeds up the reaction.

   [C] The catalyst provides a new pathway for the reaction.

   [D] two of these [E] none of these

3. The rate of a chemical reaction is directly related to the number of collisions that occur between reactant molecules.

   [A] True [B] False

4. How many of the following are true?

   I. At equilibrium, the concentrations of all reactants and products are equal.
   II. At equilibrium, all products and reactants coexist.
   III. At equilibrium the change in concentration over time for all reactants and products is zero.
   IV. At equilibrium, the rates of the forward and reverse reactions are zero.

   [A] 4 [B] 0 [C] 1 [D] 3 [E] 2

5. Determine the equilibrium constant (units deleted) for the system $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ at 25°C. The equilibrium concentrations are shown here:

   $[N_2O_4] = 4.27 \times 10^{-2}\ M$ $[NO_2] = 1.41 \times 10^{-2}\ M$

   [A] 215 [B] 0.660 [C] 0.330 [D] 0.00466 [E] 3.03

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6. For the reaction of gaseous nitrogen with gaseous hydrogen to produce gaseous ammonia, the correct equilibrium expression is

[A] $\frac{[NH_3]}{[N_2][H_2]}$ [B] $\frac{[NH_3]}{[N][H]^3}$ [C] $\frac{[NH_3]^2}{[N]^3[H_2]}$

[D] $\frac{[NH_3]^2}{[N_2]\,[H_2]^3}$ [E] none of these

7. The correct equilibrium expression for the reaction of sulfur dioxide gas with oxygen gas to produce sulfur trioxide gas is

[A] $\frac{[SO_3]^2}{[SO_2]^2[O_2]}$ [B] $\frac{[O_2][SO_2]^2}{[SO_3]^2}$ [C] $\frac{[SO_3]}{[SO_2]^2[O_2]}$

[D] $\frac{[SO_3]}{[SO_3][O_2]}$ [E] none of these

8. For the reaction
$F_2(g) \rightarrow 2F(g)$
at a particular temperature, the concentrations at equilibrium were observed to be $[F_2] = 1.0 \times 10^{-2}$ mol/L and $[F] = 2.0 \times 10^{-4}$ mol/L. Calculate the value of the equilibrium constant from these data. (The units are deleted.)

[A] 2.5×10^5 [B] 2.0×10^{-2} [C] 4.0×10^{-6} [D] 2.0 [E] none of these

9. For the reaction
$2NO(g) + O2(g) \rightleftharpoons 2NO2(g)$
at a certain temperature, the equilibrium concentrations were found to be $[NO_2] = 3.0 \times 10^{-3}$ *M*, $[O_2] = 1.0 \times 10^{-2}$ *M*, and $[NO] = 2.0 \times 10^{-3}$ *M*. Calculate the value of the equilibrium constant from these data (delete units).

[A] 2.3×10^{-2} [B] 2.3×10^2 [C] 4.3×10^{-3} [D] 1.5×10^5 [E] none of these

10. The equilibrium expression for the following reaction is
$2A(s) + 3B(l) \rightleftharpoons C(aq) + 4D(aq)$

[A] $\frac{[C][D]^4}{[A]^2[B]^3}$ [B] $\frac{[A]^2[B]^3}{[C][D]^4}$ [C] $\frac{[C][4D]^4}{[2A]^2[3B]^3}$ [D] $[C][D]^4$ [E] none of these

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11. In the presence of ultraviolet light, the 'inert' gas xenon (Xe) will react with fluorine (F_2) gas to produce solid XeF_4. What is the equilibrium expression for this reaction?

[A] $\frac{1}{[Xe][F_2]}$ [B] $\frac{[XeF_4]}{[Xe][F_2]^2}$ [C] $\frac{1}{[Xe][F_2]^2}$ [D] $\frac{1}{[F_2]}$ [E] $\frac{[XeF_4]}{[Xe][F_2]}$

12. Consider the following equilibrium:
$H_2(g) + I_2(s) \rightleftharpoons 2HI(g)$
The equilibrium expression is

[A] $\frac{[H_2][I_2]}{[HI]^2}$ [B] $\frac{[HI]^2}{[H_2][I_2]}$ [C] $\frac{\sqrt{[H_2][I_2]}}{[HI]^2}$ [D] $\frac{[HI]^2}{[H_2]}$ [E] $\frac{[HI]}{\sqrt{[H_2]}}$

13. Consider a system of four gases. The equilibrium concentration of each product is 1.3 *M*. The equilibrium concentrations of the reactants are equal. The equilibrium is shown here:
$A + B \rightleftharpoons C + D \qquad K = 2.6$
What is the equilibrium concentration of gas A?

[A] 0.20 *M* [B] 1.6 *M* [C] 2.5 *M* [D] 0.80 *M* [E] 1.2 *M*

14. For the reaction
$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$
$K = 3.88$ at a certain temperature. If at this temperature in a certain experiment $[H_2] = 1.4$ *M*, $[CO_2] = 1.8$ *M*, and $[H_2O] = .26$ *M*, calculate [CO].

[A] 0.66 *M* [B] 2.5 *M* [C] 3.9 *M* [D] 0.40 *M* [E] none of these

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(1) E

(2) D (B & C)

(3) True

(4) II & III are true E

(5) $K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(1.41 \times 10^{-2})^2}{4.27 \times 10^{-2}} = \frac{1.9881 \times 10^{-4}}{4.27 \times 10^{-2}} = 4.66 \times 10^{-3}$ → D

(6) $N_2(g)$ = gaseous nitrogen; $H_2(g)$ = gaseous hydrogen; $NH_3(g)$ = gaseous ammonia

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(balanced)

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$ (D)

(7) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ ← balanced!

$K = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$ (A)

(8) $K = \frac{[F]^2}{[F_2]} = \frac{(2\times10^{-4})^2}{1\times10^{-2}} = \frac{4\times10^{-8}}{1\times10^{-2}} = 4\times\frac{10^{-8}}{10^{-2}} = 4\times10^{-6}$ (C)

(9) $K = \frac{[NO_2]^2}{[NO]^2[O_2]}$ the reaction should have been $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

I apologize for the typo errors,

$K = \frac{(3\times10^{-3})^2}{(2\times10^{-3})^2(1\times10^{-2})} = \frac{9\times10^{-6}}{(4\times10^{-6})(1\times10^{-2})} = \frac{9\times10^{-6}}{4\times10^{-8}} = 2.25\times10^2 = 225 = 230$ (B) ← 2 sig figs

(10) A is a solid and B is a liquid; liquids & solids do not go into K_{eq} expression,

$K = [C][D]^4$ (D)

(11) $Xe_{(g)} + 2F_{2(g)} \rightarrow XeF_{4(s)}$ ← balanced; ← does not go into K_{eq} expression

$K = \frac{1}{[Xe][F_2]^2}$ (C)

(12) D solids don't go into K_{eq} expression

(13) $[A]=[B]$, and $[C]=[D]=1.3M$ → let $x=[A]=[B]$

$K = \frac{[C][D]}{[A][B]} = \frac{1.3^2}{x^2} = 2.6$

$\frac{1.3^2}{2.6} = x^2$

$0.65 = x^2$

$0.806M = x$ (D)

(14) $K = \frac{[CO_2][H_2]}{[H_2O][CO]} = \frac{(1.8)(1.4)}{(.26)([CO])} = 3.88$

$[CO] = 2.5$ (B)