Equilibrium Multiple Choice Questions

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1. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H < 0$

Which change(s) will increase the quantity of $SO_3(g)$ at equilibrium?

I.	increasing the temperature
II.	reducing the volume of the container
III.	adding He to increase the pressure

(A) I only (B) II only

(C) I and III only (D) II and III only

2. What is the equilibrium expression for the reaction:
$2ZnS(s) + 3O_2(g) \rightleftharpoons 2ZnO(s) + 2SO_2(g)$

(A) $K = \dfrac{2[SO_2]}{3[O_2]}$ (B) $K = \dfrac{[SO_2]^2}{[O_2]^3}$

(C) $K = \dfrac{2[ZnO][SO_2]}{3[ZnS][O_2]}$ (D) $K = \dfrac{[ZnO]^2[SO_2]^2}{[ZnS]^2[O_2]^3}$

3. What is the K_{eq} expression for the reaction,
$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$?

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

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

4. The equilibrium system $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ has $K_p = 11$ and $\Delta H^\circ = 57\ kJ{\cdot}mol^{-1}$ at 25 °C. Which action will not cause a change in the position of the equilibrium?

(A) increasing the temperature

(B) adding $NO_2(g)$

(C) adding xenon gas to increase the pressure

(D) increasing the container volume

5. What is the relationship of the equilibrium constants for the following two reactions?

$2NO_2(g) \leftrightarrow N_2O_4(g) \qquad K_1$

$N_2O_4(g) \leftrightarrow 2NO_2(g) \qquad K_2$

a. $K_1 = K_2$
b. $K_1 = -K_2$
c. $K_1 = K_2^{1/2}$
d. $K_1 = K_2^{2}$
e. $K_1 = 1/K_2$

6. For which reaction at equilibrium does a decrease in volume of the container cause a decrease in product(s) at constant temperature?

(A) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

(B) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(C) $HCl(g) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Cl^-(aq)$

(D) $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$

7. Which statement is true for a reaction at equilibrium?

(A) All reaction ceases.

(B) The reaction has gone to completion.

(C) The rates of the forward and reverse reactions are equal.

(D) The amount of product equals the amount of reactant.

8. $2NO_2(g) + 7H_2(g) \rightleftharpoons 2NH_3(g) + 4H_2O(l)$

What is the correct equilibrium expression for this reaction?

(A) $K_c = \dfrac{[NH_3]^2}{[NO_2]^2[H_2]^7}$ (B) $K_c = \dfrac{[NO_2]^2[H_2]^7}{[NH_3]^2}$

(C) $K_c = \dfrac{[NH_3]^2[H_2O]^4}{[NO_2]^2[H_2]^7}$ (D) $K_c = \dfrac{[NH_3]^2[H_2O]^4}{[NO_2]^2}$

9. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

The equilibrium reaction shown is endothermic as written. Which change will increase the amount of NO_2 at equilibrium?

(A) adding a catalyst

(B) decreasing the temperature

(C) increasing the volume of the container

(D) adding an inert gas to increase the pressure

10. **$H_2(g) + I_2(g) \leftrightarrow 2HI(g) \quad \Delta H = -29\ kJ$**

For the reaction listed above, $K_c = 12.3$. If the initial concentrations of each species in the equilibrium are 1.0 M, which of the following statements is true?

a. The concentration of HI will rise as the system approaches equilibrium.
b. The system is at equilibrium, no change.
c. The concentrations of H_2 and I_2 will increase as the system approaches equilibrium.
d. The temperature of the system will decrease as it approaches equilibrium.

11. Consider the system at equilibrium:

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g) \quad \Delta H > 0$$

Factors which favor the formation of more $H_2S(g)$ include which of the following?

I adding a small amount of $NH_4HS(s)$ at constant volume

II increasing the pressure at constant temperature

III increasing the temperature at constant pressure

(A) I only (B) III only

(C) I and II only (D) I and III only

12. A 2.0 L container is charged with a mixture of 6.0 moles of $CO(g)$ and 6.0 moles of $H_2O(g)$ and the following reaction takes place:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

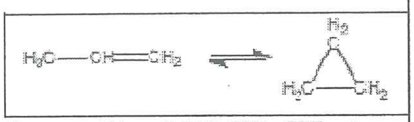
When equilibrium is reached the $[CO_2] = 2.4$ M. What is the value of K_c for the reaction?

(A) 16 (B) 4.0 (C) 0.25 (D) 0.063

13. When 2.00 mol each of $H_2(g)$ and $I_2(g)$ are reacted in a 1.00 L container at a certain temperature, 3.50 mol of HI is present at equilibrium. Calculate the value of the equilibrium constant, K_c.

(A) 3.7 (B) 14 (C) 56 (D) 2.0×10^2

14. The gas phase reaction shown is endothermic as written. Which change(s) will increase the quantity of $CH_3CH{=}CH_2$ at equilibrium?



I. increasing the temperature
II. increasing the pressure

(A) I only (B) II only

(C) Both I and II (D) Neither I nor II

Key: 1-B, 2-B, 3-C, 4-C, 5-E, 6-A, 7-C, 8-A, 9-C, 10-A, 11-B, 12-A, 13-D, 14-D 15. a) 0.34 b) Kc = 5.04 c) $K_c = K_p = 5.04$ d) K = 0.87 e) [CO] = 0.12 M

15. $CO_2(g) + H_2(g) \leftrightarrow H_2O(g) + CO(g)$

When $H_2(g)$ is mixed with $CO_2(g)$ at 2,000 K, equilibrium is achieved according to the equation above. In one experiment, the following equilibrium concentrations were measured.

$$[H_2] = 0.20 \text{ mol/L}$$
$$[CO_2] = 0.30 \text{ mol/L}$$
$$[H_2O] = [CO] = 0.55 \text{ mol/L}$$

(a) What is the mole fraction of $CO(g)$ in the equilibrium mixture?

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(b) Using the equilibrium concentrations given above, calculate the value of K_c, the equilibrium constant for the reaction.

(c) Determine K_p in terms of K_c for this system.

(d) When the system is cooled from 2,000 K to a lower temperature, 30.0 percent of the $CO(g)$ is converted back to $CO_2(g)$. Calculate the value of K_c at this lower temperature.

(e) In a different experiment, 0.50 mole of $H_2(g)$ is mixed with 0.50 mole of $CO_2(g)$ in a 3.0-liter reaction vessel at 2,000 K. Calculate the equilibrium concentration, in moles per liter, of $CO(g)$ at this temperature.

12) $K_c = \frac{[CO_2][H_2]}{[CO][H_2O]} =$

$CO + H_2O \rightleftharpoons CO_2 + H_2$

	CO	H_2O	CO_2	H_2
I	3.0M	3.0M	0	0
C	−2.4	−2.4	+2.4	+2.4
E	0.60M	0.60M	2.4M	2.4M

$\frac{(2.4)^2}{(.60)^2} = \boxed{16}$

13) $H_2 + I_2 \longrightarrow 2HI$

	H_2	I_2	$2HI$
I	2.00M	2.00M	0
C	−1.75	−1.75	+3.50
E	.250M	.250M	3.50M

$\frac{(3.50)^2}{(.250)^2} = \cancel{196} \boxed{2.0 \times 10^2}$

15) a)

0.20 $[H_2]$
$+0.30$ $[CO_2]$
$+0.55 \times 2$ $[H_2O]=[CO]$
1.6

$\frac{.55}{1.6} = \boxed{0.34}$

b)

$K_c = \frac{[.55][.55]}{[0.30][.20]} = \quad K_c = \boxed{5.04}$

c) $K_p = K_c(RT)^{\Delta n} \quad K_p = K_c = \boxed{5.04}$

d) $CO_2 + H_2 \rightleftharpoons H_2O + CO$

	CO_2	H_2	H_2O	CO
I	.30	.20	.55	.55
C	+.165	+.165	−.165	−.165
E	.465	.365	.385	.385

$= \frac{[.385]^2}{(.465)(.365)} = \boxed{0.87}$