Unit Test: Equilibrium

SCH4UE 2012 – 2013_V1 Name: __________

Multiple Choice (18)

1. A chemical equilibrium is described as "dynamic" because:

A. maximum randomness has been achieved

B. Pressure and temperature do not change

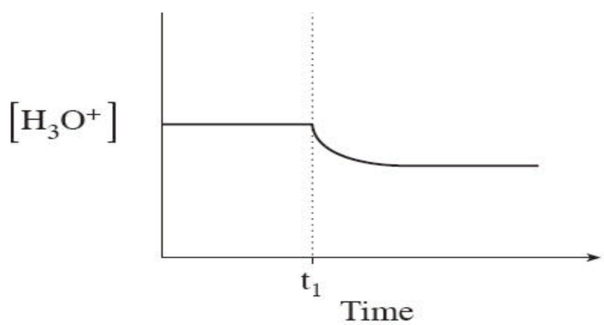
C. The rate of the forward and rate of the reverse reaction are constant.

D. The concentrations of the reactants is the same as the concentration of the products.

2. Consider the following equilibrium:

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CHCOO^{-1}_{(aq)} + H_3O^{+1}_{(aq)} + \text{heat}$$

A stress was applied at time t_1 and the data was plotted on the following graph:



The stress that was imposed at time t_1 is the result of:

A. Addition of $HCl_{(aq)}$

B. Decreasing the temperature

C. increasing the volume of the container

D. Addition of $CH_3COOH_{(aq)}$

3. Consider the following potential energy diagram for an equilibrium system:

When the temperature of the system is increased, the equilibrium shifts to the:

A. left and K_c increases

B. left and K_c decreases

C. Right and K_c increases

D. Right and K_c decreases

4. Consider the following equilibrium:

$$2\ O_{3(g)} \rightleftharpoons 3\ O_{2\ (g)} \qquad K_c = 65$$

Initially 0.10 mol of $O_{3(g)}$ and 0.10 mol of $O_{2(g)}$ are place in a 1.0 L container. Which of the following describes the changes as the reaction proceeds towards equilibrium?

	$[O_{3(g)}]$	$[O_{2(g)}]$
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

5. Consider the following equilibrium system:

$$2\ CrO_4^{-2}{}_{(aq)} + 2\ H_3O^{+1}{}_{(aq)} \rightleftharpoons Cr_2O_7^{-2}{}_{(aq)} + 3\ H_2O_{(l)}$$

yellow Orange

An unknown solution is added to an orange equilibrium sample until the sample turns yellow. The unknown solution could be:

A. NaOH B. KNO_3 C. NH_4NO_3 D. CH_3COOH

6. Ammonia is produced by the following reaction:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2\ NH_{3(g)} + \text{Heat}$$

Which of the following would result in the highest concentration of ammonia at equilibrium?

A. Increasing the temperature and increasing the pressure
B. Decreasing the temperature and increasing the pressure
C. Increasing the temperature and decreasing the pressure
D. Decreasing the temperature and decreasing the pressure

7. Consider the following equilibrium:

$$C_{(s)} + 2H_{2(g)} \rightleftharpoons CH_{4(g)} \qquad ?H = -74.8\ kJ$$

Which of the following will cause an increase in the value of K_c ?

A. increasing $[H_2]$
B. Decreasing the volume
C. Finely powdering the $C_{(s)}$
D. Decreasing the temperature

8. Consider the following equilibrium system:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

At equilibrium $[H_2] = 0.00220$ mol L^{-1}, $[I_2] = 0.00220$ mol L^{-1}, and $[HI] = 0.0156$ mol L^{-1}. The value of K_c is:

A. 3.10×10^{-4} B. 1.99×10^{-2} C. 5.03×10^{1} D. 3.22×10^{3}

9. Products are favoured in an equilibrium reaction when the:

A. Reaction is endothermic
B. Macroscopic properties are constant
C. Activation energy for the forward reaction is high

D. Equilibrium constant is large.

10. Consider the following equilibrium system at 900 ^{O}C:

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

Initially 5.0 mols of $H_2O_{(g)}$ and 4.00 mols of $CO_{(g)}$ were reacted. At equilibrium, 2.0 mols of $H_{2(g)}$ were present. How many mols of $H_2O_{(g)}$ remain in the mixture?

A. 1.0 mol B. 2.0 mol C. 3.0 mol D. 4.0 mol

11. Consider the following equilibrium system at 25 ^{O}C:

$$2SO_{2(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3(g)}$$

At equilibrium $[SO_{2(g)}] = 4.00 \times 10^{-3}$, $[O_{2(g)}] = 4.00 \times 10^{-3}$ and the $[SO_{3(g)}] = 2.33 \times 10^{-3}$. From this data, the value of K_c at this temperature is:

A. 6.85×10^{-3} B. 1.18×10^{-2} C. 84.8 D. 146

12. Consider the following equilibrium system at 500 ^{O}C:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)} \qquad K_c = 50.0$$

What is the value of K_c for the following reaction:

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$$

A. 0.0200 B. —50.0 C. 25.0 D. 50.0

13. What is the effect of an increase in temperature on the rate constant of the forward reaction, k, and on the equilibrium constant, K_c, of an exothermic reversible reaction?

	Rate constant of the forward reaction, k	**Equilibrium constant, K_c**
A	decreases	increases
B	increases	decreases
C	decreases	decreases
D	increases	increases

14. A liquid and its vapour are at equilibrium in a sealed container. Which of the following increase as the container is heated?

I. The mass of the liquid
II. The vapour pressure of the liquid
III. The rate of vaporization of the liquid.

A. I and II only B. I and III only C. II and III only D. I, II and III

15. All equilibrium systems have:

I. Rates that are constantly changing
II. An equilibrium expression.
III. Equal concentrations of products and reactants.

A. II only B. III only C. I and II only D. I and III

16. Starting with equal moles of reactants, which of the following equilibrium system most favours the reactants?

A. $SO_{3(g)} \rightleftharpoons SO_{2(g)} + \frac{1}{2} O_{2(g)}$ $K_c = 3.4$

B. $2\ NOBr_{(g)} \rightleftharpoons 2\ NO_{(g)} + Br_{2(g)}$ $K_c = 31.4$

C. $4\ HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(l)} + 2\ Cl_{2(g)}$ $K_c = 10$

D. $Br_2 + Cl_2 \rightleftharpoons 2BrCl$ $K_c = 1.0 \times 10^{-31}$

17. Consider the following equilibrium:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)} \qquad K_c = 0.45 \text{ at } 227\ ^{O}C$$

Initially, a 1.00 L flask is filled with 0.100 mol $PCl_{3(g)}$, 0.100 mol $Cl_{2(g)}$ and 0.100 mol of $PCl_{5(g)}$ at 227 ^{O}C. Calculate the reaction quotient, Q, and use it to predict the change in $[Cl_{2(g)}]$ as equilibrium is established.

	reaction quotient, Q	**$[Cl_{2(g)}]$**
A	$Q > K_c$	increase
B	$Q < K_c$	decreases
C	$Q > K_c$	decreases
D	$Q < K_c$	increases

18. 2.4 mol of $PCl_{5(g)}$ are injected into a 2.0 L container and the following equilibrium becomes established.

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

If at equilibrium 1.0 mol of $PCl_5(g)$ is still in the container the Kc must be which of the following?

A. 2.0 B. 1.4 C. 0.71 D. 0.98

Multiple Choice Answers

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**

Problems ( )

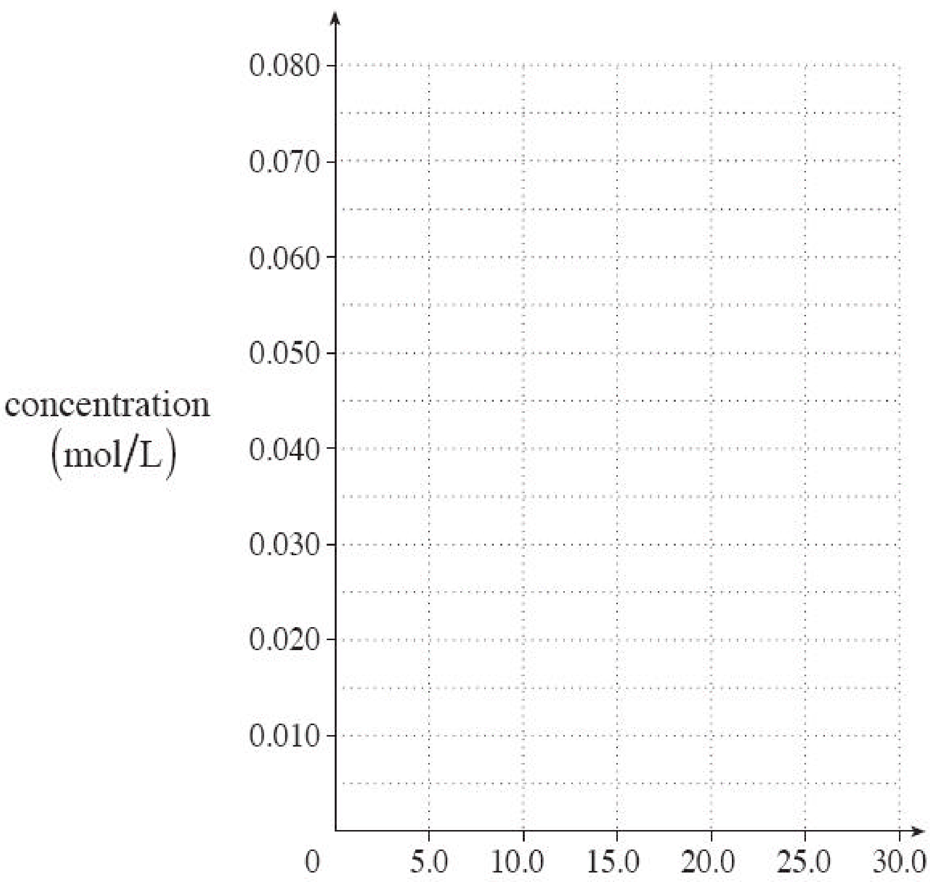
Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

A 2.0 L container is filled with 0.070 mol of $H_{2(g)}$ and 0.060 mol of $I_{2(g)}$. Equilibrium is established after 15.0 minutes at which time there is 0.060 mol of $HI_{(g)}$ present.

a. Calculate the concentrations of $H_{2(g)}$ and $I_{2(g)}$ present at equilibrium. 3

b. Sketch and label the graphs for the changes in concentration of $H_{2(g)}$, $I_{2(g)}$ and $HI_{(g)}$ for the period of 0 to 30 minutes. 3



2. Methanol, CH_3OH, is produced industrially by the following process:

$$CO_{(g)} + 2H_{2\,(g)} \rightleftharpoons CH_3OH_{(g)} + \text{heat}$$

a. State and explain the conditions of temperature and pressure that would be employed to shift the equilibrium to the right. 5

(i) Temperature

Statement: _____

Explanation:

(ii) Pressure:

Statement: _____

Explanation:

b. In terms of rates, explain why these conditions cause the equilibrium to shift to the right. 2

Temperature

Pressure:

3. Consider the following equilibrium system at 200 ^{O}C:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} \qquad K_c = 626$$

At equilibrium $[N_{2(g)}] = 1.06$ mol L^{-1}, $[H_{2(g)}] = 0.456$ mol L^{-1}, calculate the $[NH_{3\,(g)}]$ at equilibrium. 2

4. Consider the following equilibrium system at 500 ^{O}C:

$$3I_{2(g)} + 3F_{2(g)} \rightleftharpoons 2\,IF_{2(g)} + I_4F_{2\,(g)}$$

a. Initially 2.00 x 10^{-1} mol of $I_{2(g)}$ and 3.00 x 10^{-1} mol of $F_{2(g)}$ are placed in a 10.0 L flask. At equilibrium 2.00 x 10^{-3} mol L^{-1} of $I_4F_{2(g)}$ was present. Calculate K_c for this reaction. 4

b. Explain what may be deduced about this reaction, from the numerical value of K_c calculated by you in (a) above. 2

5. Consider the following reaction:

$$Fe^{3+}_{(aq)} + SCN^{1-}_{(aq)} \rightleftharpoons [FeSCN]^{+2}_{(aq)}$$

orange colourless blood-red

When a few drops of 6.0 mol L^{-1} $NaOH_{(aq)}$ is added to 25.0 cm^3 of the above system, a precipitate of $Fe(OH)_3$ forms and the solution turns pale yellow.

a. Explain this colour change in terms of Le Chatelier's Principle. 2

b. Describe the effect on the rate of the reverse reaction as the colour change occurs. 1