A.P. Chemistry

Equilibrium Test

Multiple Choice

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

1. After the equilibrium represented above is established, some pure $O_{2(g)}$ is injected into the reaction vessel at constant temperature. After equilibrium is reestablished, which of the following has a lower value compared to its value at the original equilibrium?

   (A) K_{eq} for the reaction

   (B) The total pressure in the reaction vessel

   (C) The amount of $SO_{3(g)}$ in the reaction vessel

   (D) The amount of $O_{2(g)}$ in the reaction vessel

   (E) The amount of $SO_{2(g)}$ in the reaction vessel

$$W_{(g)} + X_{(g)} \rightarrow Y_{(g)} + Z_{(g)}$$

2. Gases W and X react in a closed, rigid vessel to form gases Y and Z according to the equation above. The initial pressure of $W_{(g)}$ is 1.20 atm and that of $X_{(g)}$ is 1.60 atm. No $Y_{(g)}$ or $Z_{(g)}$ is initially present. The experiment is carried out at constant temperature. What is the partial pressure of $Z_{(g)}$ when the partial pressure of $W_{(g)}$ has decreased to 1 .0 atm?

   (A) 0.20 atm (B) 0.40 atm (C) 1.0 atm (D) 1.2 atm (E) 1.4 atm

$$2\ NO_{(g)} + O_{2(g)} \leftrightarrow 2\ NO_{2(g)} \quad \Delta H < 0$$

3. Which of the following changes alone would cause a decrease in the value of K_{eq} for the reaction represented above?

   (A) Decreasing the temperature

   (B) Increasing the temperature

   (C) Decreasing the volume of the reaction vessel

   (D) Increasing the volume of the reaction vessel

   (E) Adding a catalyst

$HCO_3^-(aq) + OH^-(aq) \leftrightarrow H_2O(l) + CO_3^{2-}(aq) \qquad \Delta H = -41.4$ kJ

4. When the reaction represented by the equation above is at equilibrium at 1 atm and 25°C, the ratio $\frac{[CO_3^{2-}]}{[HCO_3^-]}$ can be increased by doing which of the following?

(A) Decreasing the temperature
(B) Adding acid
(C) Adding a catalyst
(D) diluting the solution with distilled water
(E) Bubbling neon gas through the solution

$H_2(g) + Br_2(g) \leftrightarrow 2\ HBr(g)$

5. At a certain temperature, the value of the equilibrium constant, K, for the reaction represented above is 2.0×10^5. What is the value of K for the reverse reaction at the same temperature?

(A) -2.0 × 10–5 (B) 5.0 × 10-6 (C) 2.0 × 10-5 (D) 5.0 × 10-5 (E) 5.0 × 10-4

6. In which of the following systems would the number of moles of the substances present at equilibrium NOT be shifted by a change in the volume of the system at constant temperature?

a. $CO(g) + NO(g) \leftrightarrow CO_2(g) + \frac{1}{2}N_2(g)$
b. $N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$
c. $N_2(g) + 2\ O_2(g) \leftrightarrow 2\ NO_2(g)$
d. $N_2O_4(g) \leftrightarrow 2\ NO_2(g)$
e. $NO(g) + O_3(g) \leftrightarrow NO_2(g) + O_2(g)$

$H_2O(l) + CO_3^{2-}(aq) \leftrightarrow HCO_3^-(aq) + OH^-(aq)$

7. Which of the following is the correct equilibrium expression for the hydrolysis of CO_3^{2-}?

a. $K = \frac{[HCO_3^-]}{[CO_3^{2-}][H_3O^+]}$

c. $K = \frac{[CO_3^{2-}][OH^-]}{[HCO_3^-]}$

e. $K = \frac{[CO_3^{2-}][H_3O^+]}{[HCO_3^-]}$

b. $K = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$

d. $K = \frac{[CO_3^{2-}]}{[CO_2][OH^-]^2}$

8. Consider a reaction

$3A(g) + B(s) \leftrightarrow 2C(g)$

If 2.0 mol A, 3.0 mol B, and 2.0 mol C are present in a 1.0 L flask at equilibrium, what is the value of K_c?

a. 4.0 b. 1.0 c. 2.0 d. 0.25 e. 0.50

Free Response:

$$2H_2S_{(g)} \leftrightarrows 2H_{2(g)} + S_{2(g)}$$

1 . When heated, hydrogen sulfide gas decomposes according to the equation above. A 3.40 g sample of $H_2S_{(g)}$ is introduced into an evacuated rigid 1.25 L container. The sealed container is heated to 483 K, and 3.72×10^{-2} mol of $S_{2(g)}$ is present in equilibrium.

(a) Write the expression for the equilibrium constant, K_c, for the decomposition reaction represented above.

(b) Calculate the equilibrium concentration, in mol L^{-1}, of the following gases in the container at 483 K.

(i) $H_{2(g)}$

(ii) $H_2S_{(g)}$

(c) Calculate the value of the equilibrium constant, K_c, for the decomposition reaction at 483 K.

(d) Calculate the partial pressure of $S_{2(g)}$ in the container at equilibrium at 483K.

(e) For the reaction $H_{2(g)} + \frac{1}{2} S_{2(g)} \leftrightarrows H_2S_{(g)}$ at 483 K, calculate the value of the equilibrium constant, K_c.

CHEMISTRY

Section II

(Total time—95 minutes)

Part A

Time—55 minutes

YOU MAY USE YOUR CALCULATOR FOR PART A.

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the pink cover. Do NOT write your answers on the green insert.

Answer Questions 1, 2, and 3. The Section II score weighting for each question is 20 percent.

$$C(s) + CO_2(g) \rightleftarrows 2\,CO(g)$$

1. Solid carbon and carbon dioxide gas at 1,160 K were placed in a rigid 2.00 L container, and the reaction represented above occurred. As the reaction proceeded, the total pressure in the container was monitored. When equilibrium was reached, there was still some $C(s)$ remaining in the container. Results are recorded in the table below.

Time (hours)	Total Pressure of Gases in Container at 1,160 K (atm)
0.0	5.00
2.0	6.26
4.0	7.09
6.0	7.75
8.0	8.37
10.0	8.37

(a) Write the expression for the equilibrium constant, K_p, for the reaction.

(b) Calculate the number of moles of $CO_2(g)$ initially placed in the container. (Assume that the volume of the solid carbon is negligible.)

GO ON TO THE NEXT PAGE.

(c) For the reaction mixture at equilibrium at 1,160 K, the partial pressure of the $CO_2(g)$ is 1.63 atm. Calculate

(i) the partial pressure of $CO(g)$, and

(ii) the value of the equilibrium constant, K_p.

(d) If a suitable solid catalyst were placed in the reaction vessel, would the final total pressure of the gases at equilibrium be greater than, less than, or equal to the final total pressure of the gases at equilibrium without the catalyst? Justify your answer. (Assume that the volume of the solid catalyst is negligible.)

In another experiment involving the same reaction, a rigid 2.00 L container initially contains 10.0 g of $C(s)$, plus $CO(g)$ and $CO_2(g)$, each at a partial pressure of 2.00 atm at 1,160 K.

(e) Predict whether the partial pressure of $CO_2(g)$ will increase, decrease, or remain the same as this system approaches equilibrium. Justify your prediction with a calculation.
