

150

# 13 • Chemical Equilibria

## QUIZ

1. Consider the equilibrium:  $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g})$   $K_c = 4.36 \text{ M}^{-1}$   
 Calculate the value of "Q" for a situation in which the concentrations are  $[\text{SO}_2] = 2.00 \text{ M}$ ,  $[\text{O}_2] = 1.50 \text{ M}$ , and  $[\text{SO}_3] = 1.25 \text{ M}$ .

$$Q = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} = \frac{(1.25)^2}{(2.00)^2 (1.50)} = \boxed{0.266 \text{ M}^{-1}}$$

3pts

Does this mixture shift toward the reactants or products to reach equilibrium? toward products

$$Q < K$$

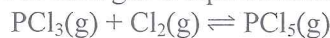
1pt

2. Study the discussion in your textbook about converting  $K_c$  and  $K_p$ . Write the  $K_p$  expression for the reaction in question 1 and calculate its value at  $0^\circ\text{C}$ . Remember,  $R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$ .

$$K_p = K_c (RT)^{\Delta n} = (4.36)(0.0821 \times 273)^{-1} = \boxed{0.195}$$

3pts

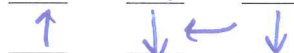
3. Consider the equilibrium  $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$ .  
 How would the following changes affect the partial pressures of each gas at equilibrium?



a) addition of  $\text{PCl}_3$



b) removal of  $\text{Cl}_2$



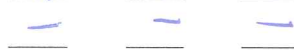
c) removal of  $\text{PCl}_5$



d) decrease in the volume of the container



e) addition of He without change in volume



1pt each blank

4. How will each of the changes in question 3 affect the  $K_{eq}$ ? (↑=increase; ↓=decrease; — = unchanged)

a — b — c — d — e —

5. Indicate how each of the following changes affects the amount of each gas in the system below, for which  $\Delta H_{\text{reaction}} = +9.9 \text{ kcal}$ .



a) addition of  $\text{CO}_2$



b) addition of  $\text{H}_2\text{O}$



c) addition of a catalyst



d) increase in temperature



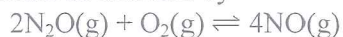
e) decrease in the volume of the container



6. How will each of the changes in question 5 affect the equilibrium constant?

a — b — c — d ↑ e —

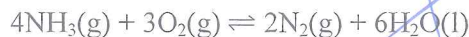
7. Consider the equilibrium:  $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$   
 How will the amount of chemicals at equilibrium be affected by



- |   |              |              |               |              |
|---|--------------|--------------|---------------|--------------|
| a) adding $\text{N}_2\text{O}$            | $\uparrow$   | $\downarrow$ | $\rightarrow$ | $\uparrow$   |
| b) removing $\text{O}_2$                  | $\uparrow$   | $\downarrow$ | $\leftarrow$  | $\downarrow$ |
| c) increasing the volume of the container | $\downarrow$ | $\downarrow$ | $\rightarrow$ | $\uparrow$   |
| d) adding a catalyst                      | $-$          | $-$          | $-$           | $-$          |

1 pt each  
blank

8. For the reaction,  
 How will the concentration of each chemical be affected by



- |  |              |              |               |            |     |
|--|--------------|--------------|---------------|------------|-----|
| a) adding $\text{O}_2$ to the system             | $\downarrow$ | $\uparrow$   | $\rightarrow$ | $\uparrow$ | $-$ |
| b) adding $\text{N}_2$ to the system             | $\uparrow$   | $\uparrow$   | $\leftarrow$  | $\uparrow$ | $-$ |
| c) removing $\text{H}_2\text{O}$ from the system | $-$          | $-$          | $-$           | $-$        | $-$ |
| d) decreasing the volume of the container        | $\downarrow$ | $\downarrow$ | $\rightarrow$ | $\uparrow$ | $-$ |

9. Consider the equilibrium:  $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$

3.00 moles of  $\text{NO}(\text{g})$  are introduced into a 1.00-Liter evacuated flask. When the system comes to equilibrium, 1.00 mole of  $\text{N}_2\text{O}(\text{g})$  has formed. Determine the equilibrium concentrations of each substance. Calculate the  $K_c$  for the reaction based on these data.

	2 $\text{N}_2\text{O}$	$\text{O}_2$	4 $\text{NO}$
initial	0 M	0 M	3.00 M
change	+ 1.00 M	+ 0.50 M	- 2.00 M
equilibrium	1.00 M	0.50 M	1.00 M

Remember: The "ice" box may be used with moles, molarity, or Liters (for gaseous equilibria)... never grams.

$$K_c = \frac{[\text{NO}]^4}{[\text{N}_2\text{O}]^2[\text{O}_2]} = \frac{(1.00)^4}{(1.00)^2(0.50)} = \boxed{2.0 \text{ M}}$$

Go VIKINGS!

3pts