

13 • Chemical Equilibria**PROBLEM SET # 1**

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 $[\text{SO}_3] = 1.25 \text{ M}$.

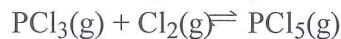
$$Q = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} = \frac{(1.25 \text{ M})^2}{(2.00 \text{ M})^2 (1.50 \text{ M})} = \boxed{0.260 \text{ M}^{-1}}$$

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

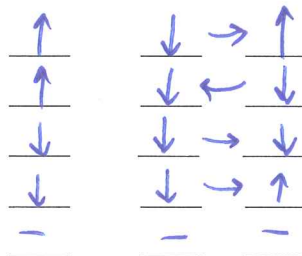
2. Study the discussion in your textbook about converting K_c and K_p . Write the K_p expression for the reaction in question 1 and calculate its value at 0°C . Remember, $R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$.

OMIT

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 PCl_3
b) removal of Cl_2
c) removal of PCl_5
d) decrease in the volume of the container
e) addition of He without change in volume

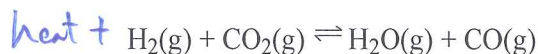


4. How will each of the changes in question 3 affect the K_{eq} ? (— = increase; — = decrease; $\frac{3}{4}$ = unchanged)

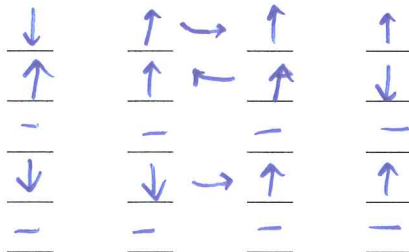
a — b — c — d — e —

Only Temp affects K

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 CO_2
b) addition of H_2O
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
- $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$
- | | | | | | |
|---|--------------|--------------|---------------|--------------|--|
| a) adding N_2O | \uparrow | \downarrow | \rightarrow | \uparrow | |
| b) removing O_2 | \uparrow | \downarrow | \leftarrow | \downarrow | |
| c) increasing the volume of the container | \downarrow | \downarrow | \rightarrow | \uparrow | |
| d) adding a catalyst | $-$ | $-$ | | $-$ | |

8. For the reaction, $4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$
 How will the concentration of each chemical be affected by
- | | | | | | |
|--|--------------|--------------|---------------|------------|-----|
| a) adding O_2 to the system | \downarrow | \uparrow | \rightarrow | \uparrow | $-$ |
| b) adding N_2 to the system | \uparrow | \uparrow | \leftarrow | \uparrow | $-$ |
| c) removing H_2O 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 N_2O	O ₂	4 NO
initial	0M	0M	3.00M
change	+1.00M	+0.50M	-2.00M
equilibrium	1.00M	0.50M	1.00M

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

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