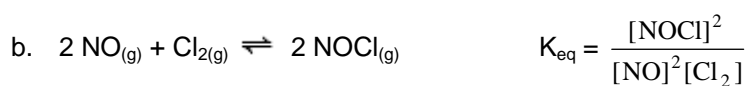


**I. Multiple Choice****15**

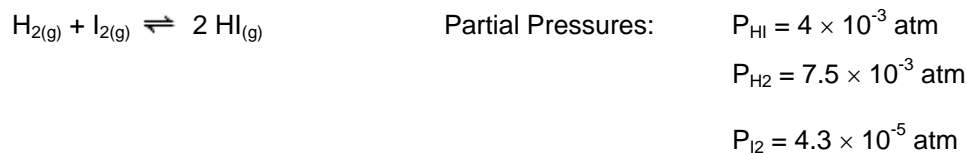
- |      |       |       |
|------|-------|-------|
| 1. B | 6. B  | 11. C |
| 2. D | 7. B  | 12. B |
| 3. C | 8. B  | 13. C |
| 4. A | 9. A  | 14. C |
| 5. A | 10. A | 15. A |

**II. Short Answer****35**

1. Write the equilibrium constant expression for the following equilibrium. Be sure to pay attention to the physical state.



2. For systems involving gases, the equilibrium constant is often determined by using partial pressure instead of concentration. Given the following reaction at equilibrium at the partial pressures of the participants,



- a. Calculate  $K_{\text{eq}}$  for this reaction, carried out at a constant temperature. Begin by writing the equilibrium constant expression for the reaction. Show your work. 3

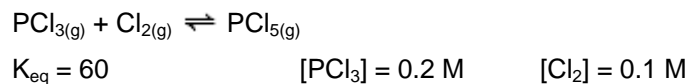
$$K_{\text{eq}} = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{(4 \times 10^{-3})^2}{(7.5 \times 10^{-3})(4.3 \times 10^{-5})} = 49.6$$

- b. Are the reactants ( $\text{H}_2$  and  $\text{I}_2$ ) or products ( $\text{HI}$ ) favored at equilibrium at this temperature? 2

How do you know?

**Products are favored;  $K_{\text{eq}} > 1$**

3. For the equilibrium system at a certain temperature, described by the equation



- a. Calculate the equilibrium concentration of  $\text{PCl}_5$ . 3

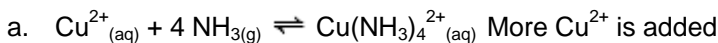
$$K_{\text{eq}} = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]} \quad 60 = \frac{x}{(0.2)(0.1)} \quad x = [\text{PCl}_5] = 1.2 \text{ M}$$

- b. Are reactants or products favored at equilibrium for this system? 1

**products are favored;  $K_{\text{eq}} = 60$  is greater than 1**

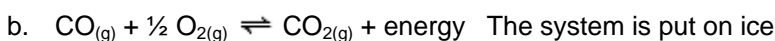
4. Each of the following systems has come to equilibrium. The systems are then subjected to the changes indicated.

Tell how the concentrations of the following substances will change as a result of the stress – will their concentrations **increase**, **decrease**, or undergo **no change** when the indicated change is made: **5**



$[\text{NH}_3]$  will **decrease**

$[\text{Cu}(\text{NH}_3)_4^{2+}]$  will **increase**



$[\text{CO}]$  will **decrease**

$[\text{O}_2]$  will **decrease**

$[\text{CO}_2]$  will **increase**

5. For the reaction  $\text{PBr}_3(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons \text{PBr}_5(\text{g}) + \text{heat}$  **3**

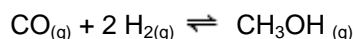
How will the reaction shift (**forward**; **reverse**; **no change**) if:

a. the pressure is increased **forward**

b. concentration of  $\text{Br}_2$  is decreased **reverse**

c. temperature is increased **reverse**

6. The following system is allowed to reach equilibrium:



At a given temperature,  $K_{\text{eq}}$  for the reaction = 12, and the following concentrations are noted:

$$[\text{CO}] = 0.02 \text{ M}$$

$$[\text{H}_2] = 0.35 \text{ M}$$

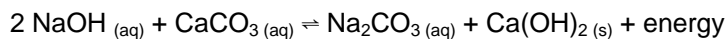
$$[\text{CH}_3\text{OH}] = ???$$

Calculate the concentration of  $\text{CH}_3\text{OH}$  at equilibrium. Begin by writing the equilibrium constant expression.

$$K_{\text{eq}} = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}][\text{H}_2]^2} \quad 12 = \frac{x}{(0.02)(0.35)^2} \quad x = [\text{CH}_3\text{OH}] = 2.94 \times 10^{-2} \text{ M}$$

**3**

7. Consider the following system at equilibrium:



a. Write the equilibrium constant expression for this reaction. 1

$$K_{eq} = \frac{[\text{Na}_2\text{CO}_3]}{[\text{NaOH}]^2 [\text{CaCO}_3]}$$

b. Predict the effect of increasing the concentration of NaOH to the system: 4

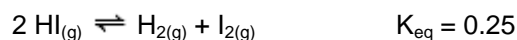
Select the appropriate answer in each case

The reaction will shift to the (right / left)	<b>right</b>
[CaCO <sub>3</sub> ] will (increase / decrease / no change)	<b>decrease</b>
[Na <sub>2</sub> CO <sub>3</sub> ] will (increase / decrease / no change)	<b>increase</b>
The value of K <sub>eq</sub> will (increase / decrease / not change)	<b>not change</b>

c. What will happen to the system if the temperature of the system is increased and the volume is kept constant? 4

The reaction will shift to the (right / left)	<b>left</b>
[CaCO <sub>3</sub> ] will (increase / decrease / no change)	<b>increase</b>
[Na <sub>2</sub> CO <sub>3</sub> ] will (increase / decrease / no change)	<b>decrease</b>
The value of K <sub>eq</sub> will (increase / decrease / no change)	<b>decrease</b>

8. A flask is filled with some HI<sub>(g)</sub> and allowed to reach equilibrium.



At equilibrium the concentration of [HI] = 0.80 M. What is the concentration of H<sub>2</sub> at equilibrium?

[Hint: you will also be finding [I<sub>2</sub>] – consider how [H<sub>2</sub>] and [I<sub>2</sub>] compare to each other] 3

$$K_{eq} = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]}$$

$$0.25 = \frac{x^2}{(0.8)^2} = \frac{x^2}{0.64}$$

$$x^2 = 0.16$$

$$x = [\text{H}_2] = 0.4 \text{ M}$$