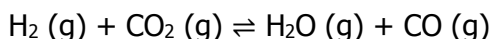


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Equilibrium Summary Problems

1. In an experiment for this reaction at 2000 K:



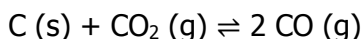
The equilibrium values of each substance are as follows:

$$[\text{H}_2] = 0.20 \text{ M}$$

$$[\text{CO}_2] = 0.30 \text{ M}$$

$$[\text{H}_2\text{O}] = [\text{CO}] = 0.55 \text{ M}$$

- Calculate the value of K_c for the reaction at 2000 K.
 - Determine K_p for this system.
 - When the system is cooled from 2000 K to a lower temperature, 30% of the CO is converted back to CO_2 . Determine K_c at this temperature. Is this reaction endothermic or exothermic?
 - In a different experiment, 0.50 mol of H_2 is mixed with 0.50 mole of CO_2 in a 3.0 L reaction vessel at 2000 K. Calculate the equilibrium concentration of CO at this temperature.
2. For the reaction:



Solid carbon and carbon dioxide gas at 1160 K were placed in a rigid 2.00 L container, and the reaction shown above occurred. As the reaction proceeded, the total pressure in the container was monitored. When equilibrium was reached, there was still some carbon remaining in the container. Results are:

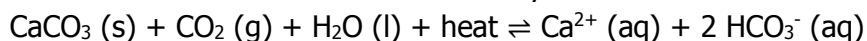
| Time (hours) | Total Pressure of Gases (atm) |
|--------------|-------------------------------|
| 0.0 | 5.00 |
| 2.0 | 6.26 |
| 4.0 | 7.09 |
| 6.0 | 7.75 |
| 8.0 | 8.37 |
| 10.0 | 8.37 |

- Write the K_p expression.
- Use ideal gas law to determine the initial number of moles of CO_2 placed in the vessel.
- If the value of K_p is 27.87, determine the partial pressure of each gas in the system at equilibrium.
- 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 1160 K. Determine whether the partial pressure of CO_2 will increase, decrease or remain the same as the system approaches equilibrium.

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3. Determine the effect of each stress on the reaction system:



- | | |
|--|----------------------------------|
| a. Adding $\text{CaCO}_3 (\text{s})$ | e. Adding $\text{Ne} (\text{g})$ |
| b. Removing $\text{Ca}^{2+} (\text{aq})$ | f. Increasing temperature |
| c. Removing $\text{CO}_2 (\text{g})$ | g. Decreasing volume |
| d. Adding $\text{NaHCO}_3 (\text{s})$ | h. Adding a catalyst |

4. A saturated solution is prepared by adding excess $\text{PbI}_2 (\text{s})$ to distilled water to form 1.0 L of solution at 25°C . The concentration of $\text{Pb}^{2+} (\text{aq})$ in the saturated solution is found to be $1.3 \times 10^{-3} \text{ M}$.

- Write the dissociation equation for lead(II) iodide.
- Write the equilibrium constant expression for the equation.
- Calculate the molar concentration of $\text{I}^- (\text{aq})$ in the solution.
- Calculate the value of the equilibrium constant, K_{sp} .
- If 2.0 L of a saturated solution is prepared at 25°C , what would be the molar concentrations of $\text{Pb}^{2+} (\text{aq})$ and $\text{I}^- (\text{aq})$?
- Solid NaI is added to the saturated solution of PbI_2 . Assuming the volume is constant, will the concentration of Pb^{2+} increase, decrease or stay the same?

5. The value of K_{sp} for BaCrO_4 is 1.2×10^{-10} . Determine if a precipitate will form when a 0.500 L sample of $8.2 \times 10^{-6} \text{ M}$ of $\text{Ba}(\text{NO}_3)_2$ is added to 0.500 mL of $8.2 \times 10^{-6} \text{ M}$ $\text{Na}_2\text{CrO}_4 (\text{aq})$.6. A solution is made so that $[\text{Zn}^{2+}] = 0.00250 \text{ M}$ and $[\text{Ag}^+] = 0.0570 \text{ M}$. K_{sp} for ZnF_2 is 4.8×10^{-7} and for AgF is 7.6×10^{-8} .

- Which will precipitate first? At which $[\text{F}^-]$ will it begin to precipitate?
- What is the maximum $[\text{F}^-]$ that can be made to precipitate almost all of one and none of the other?
- What is the concentration of the less soluble ion under the conditions specified in b.?

Solutions

- | | | | |
|---|---------------|---|---|
| 1a. 5.0 | 3a. no change | 4a. $\text{PbI}_2 (\text{s}) \rightleftharpoons \text{Pb}^{2+} (\text{aq}) + 2\text{I}^- (\text{aq})$ | 5. no |
| 1b. 5.0 | 3b. right | 4b. $K_{\text{sp}} = [\text{Pb}^{2+}][\text{I}^-]^2$ | 6a. AgF ; $1.3 \times 10^{-6} \text{ M}$ |
| 1c. 0.87; endothermic | 3c. left | 4c. $2.6 \times 10^{-3} \text{ M}$ | 6b. $1.4 \times 10^{-2} \text{ M}$ |
| 1d. 0.12 M | 3d. left | 4d. 8.8×10^{-9} | 6c. $5.5 \times 10^{-6} \text{ M}$ |
| 2a. $K_p = P_{\text{CO}}^2/P_{\text{CO}_2}$ | 3e. no change | 4e. the same ($1.3 \times 10^{-3} \text{ M}$ and $2.6 \times 10^{-3} \text{ M}$) | |
| 2b. 0.105 mol | 3f. right | 4f. decrease (adding I^-) | |
| 2c. $P_{\text{CO}_2} = 1.63 \text{ atm}$ | 3g. right | | |
| 2d. decrease | 3h. no change | | |