

Equilibrium Problems

1 K_c is 2.6×10^8 at 825 K for the reaction $2 \text{H}_2(\text{g}) + \text{S}_2(\text{g}) \rightleftharpoons 2 \text{H}_2\text{S}(\text{g})$

What is the equilibrium concentration of H_2S if those of H_2 and S_2 are 0.0020M and 0.0010M, respectively?

Ans: 1.02

2 For the system $2 \text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$

$K_c = 0.016$ at 800 K. If, at 800 K $[\text{HI}] = 0.20 \text{ M}$ and $[\text{H}_2] = [\text{I}_2]$, calculate the equilibrium concentration of H_2 .

Ans: .025

3 For the system



If 0.30 mol PCl_5 is placed in a 1.0-L container at this temperature, what are the equilibrium concentrations of all species?

Ans: .2, .1, .1

4 For the equilibrium in Problem 2, 1.00 mol HI is placed in a 4.00-L flask at 800 K. What are the equilibrium concentrations of H₂, I₂, and HI?

Ans: .2, .2, .025

5 For the system
 $\text{CO(g)} + \text{Cl}_2\text{(g)} \rightleftharpoons \text{COCl}_2\text{(g)} \quad K_c = 3.0$. If 1.5 mol CO and 1.0 mol Cl₂ are put in a 5.0-L container, what are the equilibrium concentrations of all species?

Ans: .22, .12, .08

6 For the system
 $\text{PBr}_3\text{(g)} + \text{Br}_2\text{(g)} \rightleftharpoons \text{PBr}_5\text{(g)}; K_c = 0.250$
A starting mixture of 1.00 mol PBr₃ and 3.00 mol Br₂ is used in a 1.00-L container. What are the concentrations of all species at equilibrium?

Ans: .6, 2.6, .4

7 For the reaction



K_C is 2.5×10^{-3} at 25°C . Calculate the equilibrium concentration of each species in a 4.0-L vessel starting with

- a. 0.60 mol IBr b. 0.30 mol I_2 , 0.30 mol Br_2 c. 0.30 mol I_2 , 0.30 mol Br_2 , 0.30 mol IBr
Ans: .136, .0068, .0068 Ans: .136, .007, .007 Ans: .205, .01, .01

8 A gaseous reaction mixture contains 0.30 mol SO_2 , 0.16 mol Cl_2 , and 0.50 mol SO_2Cl_2 in a 2.0-L container; $K_C = 0.011$ for $\text{SO}_2\text{Cl}_2\text{(g)} \rightleftharpoons \text{SO}_2\text{(g)} + \text{Cl}_2\text{(g)}$

- a. Is the system at equilibrium? Explain.
b. If it is not at equilibrium, in which direction will the system move to reach equilibrium?

9 The commercial preparation of methanol, CH_3OH , is done at elevated temperatures with the reaction $\text{CO(g)} + 2 \text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)}$ At a certain temperature, the K_C value is 7.3. In which direction will the system move to achieve equilibrium when the starting mixture contains

- a. 0.80 M CO and 1.5 M H_2 ?
b. a gaseous mixture of 0.90 mol CH_3OH , 0.45 mol CO, and 0.45 mol H_2 in a 3.0-L container?

10 For the system



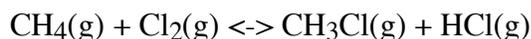
ΔH is +39.7 kJ. Predict what effect each of the following changes will have on the position of the equilibrium:

- decreasing the container size at constant temperature
- adding NO
- lowering the temperature
- adding helium gas

11 Predict the direction in which each of the following equilibria will shift if the pressure on the system is reduced by expansion:

- $\text{SbCl}_5(\text{g}) \rightleftharpoons \text{SbCl}_2(\text{g}) + \text{Cl}_2(\text{g})$
- $\text{Ni}(\text{s}) + 4 \text{CO}(\text{g}) \rightleftharpoons \text{Ni}(\text{CO})_4(\text{g})$
- $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$

12 For the system



$\Delta H = -99$ kJ for the forward reaction; K_c is 1×10^{18} at 25°C . Would you expect K_c to increase or decrease when the temperature rises? Explain.

13 Consider the system



ΔH for the forward reaction is -1036 kJ. Predict whether the forward or reverse reaction will occur when the equilibrium is disturbed by

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|----------------------------------------------------|------------------------------|
| a. expanding the container at constant temperature | b. removing SO_2 |
| c. raising the temperature | d. absorbing the water vapor |