

Equilibrium Problems

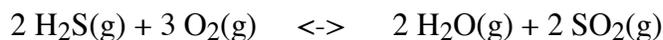
15.17 For the system



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?

Answers $\text{PCl}_3 = .1 \text{ M}$ $\text{Cl}_2 = .1 \text{ M}$ $\text{PCl}_5 = .2 \text{ M}$

15.21 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

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

Answers a = left b = right c = left d. = right

15.40 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 $\text{SO}_2\text{Cl}_2(\text{g}) \rightleftharpoons \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$

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

Answers a. The system is not at equilibrium because Q is not equal to K_c .
b. The reaction will proceed to the left on the way to equilibrium because Q is greater than K_c and the product concentration needs to get smaller while the reactant concentration needs to get larger. Q was .048 – greater than .011

15.41 The commercial preparation of methanol, CH_3OH , is done at elevated temperatures with the reaction $\text{CO}(\text{g}) + 2 \text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g})$. 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

- 0.80 M CO and 1.5 M H_2 ?
- 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?

Answers a. $Q = 0$, so the reaction will proceed to the right in order to make more products and increase the ratio.
b. $Q = 88.8$ which is greater than 7.3, so the reaction will proceed to the left in order to decrease the ratio of products to reactants.

15.43 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?

Answer 1.02 M

15.44 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 .

Answer .025 M

15.45 For the equilibrium in Problem 15.44, 1.00 mol HI is placed in a 4.00-L flask at 800 K. What are the equilibrium concentrations of H_2 , I_2 , and HI?

Answer $\text{HI} = .2 \text{ M}$ $\text{H}_2 = .025 \text{ M}$ $\text{I}_2 = .025 \text{ M}$

15.46 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

Answers
a. .0068 M, .0068 M, and .136 M
b. IBr = .136 M, iodine = .007 M and bromine = .007 M
c. IBr = .205 M, iodine = .01 M and bromine = .01 M

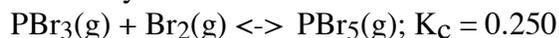
15.47 For the system



$K_C = 3.0$. If 1.5 mol CO and 1.0 mol Cl_2 are put in a 5.0-L container, what are the equilibrium concentrations of all species?

Answers $\text{CO}(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{COCl}_2(\text{g})$
.22 M .12 M .08 M

15.48 For the system



A starting mixture of 1.00 mol PBr_3 and 3.00 mol Br_2 is used in a 1.00-L container. What are the concentrations of all species at equilibrium?

Answers $\text{PBr}_3(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons \text{PBr}_5(\text{g})$
.6 M 2.6 M .4 M

15.51 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

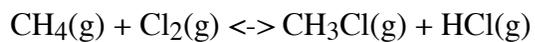
Answers a = left b = left c = left d = no effect

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

- a. $\text{SbCl}_5(\text{g}) \rightleftharpoons \text{SbCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
- b. $\text{Ni}(\text{s}) + 4 \text{CO}(\text{g}) \rightleftharpoons \text{Ni}(\text{CO})_4(\text{g})$
- c. $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$

Answers a = right b = left c = no change

15.53 For the system



$\Delta H = -99 \text{ kJ}$ 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.

Answer -- K_C should decrease.