Problem Set 9

Practice problems:

Do these to learn the material. Check your answers against those in the back of the book or against your friends’ answers, or bring questions to office hours.

19-2, 19-4, 19-12, 19-16, 19-25, 19-32

Discussion problems:

We will discuss these in class (3:30) on Wednesday the 4th. Be prepared to present answers to and to discuss any of these up at the blackboard.

1. 2-butene has cis and trans isomers:

The equilibrium constant for this reaction is 1.65 at 500 K.

(a) What proportions of cis and trans species would you expect to find at equilibrium?

(b) Would you expect these proportions to change with pressure or temperature?

(c) You can purchase ≥99% pure samples of either cis or trans 2-butene. Why doesn’t the cis turn to trans (or trans to cis) in these samples? How do you get a pure sample of one or another in the first place?

2. Iodine serves as a catalyst for cis-trans isomerization. Consider the following reactions:

\[ C_4H_8(\text{cis}) + I_2 \rightleftharpoons C_4H_8I(\text{syn}) + I \]
\[
\begin{align*}
C_4H_8I(\text{syn}) & \rightleftharpoons C_4H_8I(\text{anti}) \\
C_4H_8I(\text{anti}) + I & \rightleftharpoons C_4H_8(\text{trans}) + I_2
\end{align*}
\]

The presence of a catalyst, however, **does not affect the position of equilibrium.** Show this explicitly by expressing \( K \) for the reaction

\[
C_4H_8(\text{cis}) \rightleftharpoons C_4H_8(\text{trans})
\]

in terms of the equilibrium constants for the three reactions above.

**Graded problem:**

This should be written up and handed in before class begins on Wednesday the 4th. This problem may also be discussed in class.

1. For the following reaction

\[
I_2(s) + Cl_2(g) \rightleftharpoons 2ICl(g)
\]

the equilibrium constant is \( 1.05 \times 10^{-2} \text{ atm} \) at 25 \(^\circ\)C. The equilibrium constant at 25 \(^\circ\)C for

\[
I_2(s) \rightleftharpoons I_2(g)
\]

is \( 5.4 \times 10^{-4} \text{ atm} \).

(a) If a 1 L closed reaction vessel at 25 \(^\circ\)C contains 0.1 atm Cl\(_2\)(g) and 0.2 g solid iodine and is then allowed to come to equilibrium, what are the partial pressures of ICl, Cl\(_2\), and I\(_2\)(g), and how much I\(_2\)(s) remains in the container?

(b) After equilibrium is reached, the vessel remains sealed but its volume is increased to 5 L. What are the partial pressures of ICl, Cl\(_2\), and I\(_2\)(g), and how much I\(_2\)(s) remains in the container?

Don’t worry about condensation of ICl(g), and assume that the I\(_2\)(s) takes up no volume in the container.