13.6 - Equilibrium Calculations using the RICE Method

Picture of Vanilla Ice

"RICE RICE Baby!"

Problem Solving Strategy

Equilibrium problems generally follow the following process, stopping when the desired data is obtained:

1. Write the balanced equation.
2. Write the equilibrium expression using the Law Of Mass Action.
3. List initial concentrations.
4. Calculate *Q*, and determine the direction of shift to equilibrium.
5. Define change needed to reach equilibrium, and define the equilibrium concentrations by applying the change to the initial concentrations.
6. Substitute the equilibrium concentrations into the equilibrium expression and solve for the unknown.
7. Check your calculated equilibrium concentrations by making sure they give the correct value of *K*.

Introducing the RICE Model!

Previous problems have allowed for easy algebraic calculations of reactant/product concentrations. These problems become more difficult with increased numbers of species, and their coefficients.

One strategy to effectively solve them involves good data tables, which is the RICE model:

R = Balance and display the chemical **R**eaction.

I = List **I**nitial concentrations.

C = Determine **C**hange needed to reach equlibrium.

E = Determine **E**quilibrium concentrations.

Quadratic Formula

Some of these problems will require the use of the quadratic formula, used to solve mathematical expressions up to the second power: quadratic equations in the form:

$$ax^2 + bx + c = 0$$

a, b, and c are constants, and x will be the concentration.

Graphing a quadratic equation yields a parabola, and in chemistry this will be an upward opening one with two roots - *one of which will not be viable.*

The quadratic formula is:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

RICE Model Guided Practice

Hydrogen and fluorine react in a 3.00 L flask. Initially, it contains 3.00 mol of hydrogen, and 6.00 moles of fluorine, and no product. If the equilibrium constant for the reaction is 115, what is the equilibrium concentration for each component?

1. Write a balanced reaction:

$$H_{2(g)} + N_{2(g)} \rightleftharpoons 2\,HF_{(g)}$$

2. What is the equilibrium expression?

$$K = 115 = \frac{[HF]^2}{[H_2][F_2]}$$

RICE Model Guided Practice Cont'

3. What are the initial concentrations:

$$[H_2]_0 = \frac{3.00\,mol}{3.00\,L} = 1.00M$$

$$[F_2]_0 = \frac{6.00\,mol}{3.00\,L} = 2.00M$$

$$[HF]_0 = 0$$

4. What is Q?

No need to compute this: we know initially that there is no HF, thus the reaction must shift to the right.

RICE Model Guided Practice Cont'

5. What is change required to reach equilibrium?

Let *x* represent the number of moles per liter of H_2 consumed to reach equilibrium. We can then represent the equilibrium concentrations as follows, using the RICE Model:

Reaction	H_2 +	F_2 <-->	2 HF
Initial	1.00	1.00	0
Change	-x	-x	+ 2x
Equilibrium	1.00 - x	1.00 - x	2 x

RICE Model Guided Practice Cont'

6. What is the value of *K*?

Substituting concentrations at equilibrium in to the equilibrium expression yields:

$$K = 115 = \frac{[HF]^2}{[H_2][F_2]} = \frac{(2x)^2}{(1.00-x)(2.00-x)}$$

Since the right side is not a perfect square, we've gotta use the quadratic formula process:

$$115(1.00-x)(2.00-x) = (2x)^2 = 4x^2$$

$$115(x^2 - 3x + 2) = 4x^2$$

$$115x^2 - 345x + 230 = 4x^2$$

$$111x^2 - 345x + 230 = 0$$

RICE Model Guided Practice Cont'

Which can then be applied to the quadratic formula, where a = 111, b = -345, and c = 230:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-345) \pm \sqrt{(-345)^2 - 4 \cdot 111 \cdot 230}}{2 \cdot 111}$$

Solving yields two values for $[H_2]$:

2.14 M and 0.968 M.

Both cannot be valid, so we must apply them both to the hydrogen relation:

$[H_2] = 1.00\ M - x$

Doing so invalidates 2.14 M, since $[H_2]$ cannot be negative.

RICE Model Guided Practice Cont'

Equilibrium concentrations can now be determined:

Reaction	H_2 +	F_2 <-->	2 HF
Equilibrium	1.00 - x	1.00 - x	2 x

$$H_2 = 1.00\,M - 0.968\,M = 3.2E-2\,M$$

$$F_2 = 2.00\,M - 0.968\,M = 1.032\,M$$

$$HF = 2 \cdot 0.968\,M = 1.936\,M$$

RICE Model Guided Practice Cont'

7. Check your numbers against *K*:

$$K = \frac{[HF]^2}{[H_2][F_2]} = \frac{1.936^2}{3.2E-2 \cdot 1.032} = 113$$

Pitted against the originally posted value of 115, this is less than 2% off, and is within error.

Homework

Preview 12.7

13.6 Problems in your Booklet
Due: Next Class