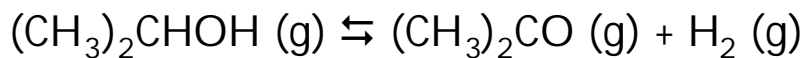


02/25/02

- Questions for today's Problem Session?
- Demo Wednesday!
- Quiz Friday!

1

The **ICE** Method



I initial:	0.3086 atm	-	-
C hange:	<u>-x</u>	<u>+x</u>	<u>+x</u>
E quilibrium:	0.3086 - x	x	x

Plug values into equilibrium constant expression:

$$K = (\text{P}_{\text{acet}})(\text{P}_{\text{H}_2})/(\text{P}_{\text{isopro}})$$

2

Solving for x

$$K = \frac{(x)(x)}{0.3086 - x} = 0.444$$

$$x^2 = 0.13702 - 0.444x$$

It's a quadratic!

$$x^2 + 0.444x - 0.13702 = 0$$

$$x = \frac{-b \pm (b^2 - 4ac)^{1/2}}{2a}$$

a **b** **c**

3

Solving for x (continued)

➤ Substituting into the quadratic equation:

$$x = \frac{-0.444 \pm [(0.444)^2 - 4(1)(-0.13702)]^{1/2}}{2(1)}$$

➤ Rearranging and solving:

$$x = \frac{-0.444 \pm 0.863259}{2} = 0.20963$$

Negative root has no physical meaning

Relating x to pressures

- Substitute x back into equilibrium pressure expressions:

$$P_{\text{acetone}} = P_{\text{H}_2} = x = \underline{\mathbf{0.210 \text{ atm}}}$$

$$P_{\text{isopropanol}} = 0.3086 - x = \underline{\mathbf{0.099 \text{ atm}}}$$

➤ What is the %-dissociation of isopropanol?

$$\% \text{-dissoc} = (P_{\text{reacted}}/P_{\text{initial}}) \times 100$$

$$= (x/0.3086) \times 100$$

$$= (0.20963/0.3086) \times 100 = \underline{\mathbf{67.9\%}}$$

5

Disturbing Equilibrium

What happens when we *disturb* a system at equilibrium?

Le Chatelier's Principle:

Reaction will proceed so as to *counteract* the effects of the disturbance

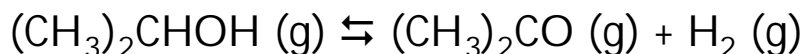
Let's look at the effects of changing:

- Amount of a product or reactant
- Volume
- Pressure

6

Changing Amounts of Reactant or Product

Back to our example reaction:



➤ Remove a product: rxn shifts to the **right**

➤ Add a reactant: rxn shifts to the **right**

➤ Remove a reactant : rxn shifts to the **left**

➤ Add a product : rxn shifts to the **left**

Now, Quantitatively

■ We start at our established point of equilibrium:

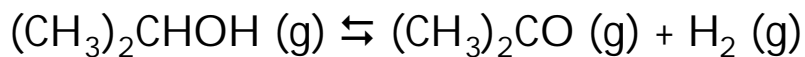
$$P_{\text{acetone}} = P_{\text{H}_2} = \underline{\underline{0.210 \text{ atm}}}$$

$$P_{\text{isopropanol}} = \underline{\underline{0.099 \text{ atm}}}$$

➤ What will the equilibrium pressures become if we add H_2 so that:

$$P_{\text{H}_2} = 0.300 \text{ atm?}$$

***ICE* Again**



← **Shift**

I ntial:	0.0990 atm	0.210	0.300
C hange:	<u>+X</u>	<u>-X</u>	<u>-X</u>
E quilibrium:	$0.0990 + x$	$0.210 - x$	$0.300 - x$

9

Solve for x

$$K = \frac{(0.210 - x)(0.300 - x)}{0.0990 + x} = 0.444$$

From the quadratic formula, we get:

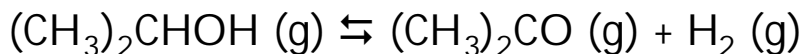
$$\mathbf{x = 0.0204}$$

Substituting into *ICE* equilibrium expressions, gives:

$P_{\text{isopropanol}}$	$= 0.0990 + x$	$= \mathbf{0.119 atm}$	$= P_{\text{isopropanol}}$
P_{acetone}	$= 0.210 - x$	$= \mathbf{0.190 atm}$	$= P_{\text{acetone}}$
P_{H_2}	$= 0.300 - x$	$= \mathbf{0.280 atm}$	$= P_{\text{H}_2}$

Changing Volume

➤ Let's see what happens if we *halve* the volume of our reaction vessel:



At equilibrium:

0.119 atm 0.210 atm 0.280 atm

Halving the volume will **double** the pressures:

0.238 atm 0.420 atm 0.560 atm

What happened to Q?

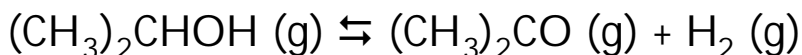
11

Equilibrium Check!

$$Q = \frac{(0.420)(0.560)}{0.238} = 0.988$$

$$Q = 0.988 > 0.444 = K$$

Too much product, so reaction shifts:



← Shift

12

Volume Change: I n General

- Changing the *volume* will change the partial pressures of all gases
 - ✓ If the ***number of moles of gas*** products or reactants is not the same, then the change in pressure will be different for the products and reactants (and $Q \neq K$)
 - ✓ Equilibrium shifts to *decrease* the overall pressure and the reaction shifts to the side with the fewest number of moles of gas (until $Q = K$).
 - ✓ What ***if $Dn_{\text{gas}} = 0$? No Shift!*** ($Q = K$).

13