CHEM 206 section 01

LECTURE #18 Wed. March 12, 2008

LECTURE TOPICS:

TODAY'S CLASS: 16.3-16.5

NEXT CLASS: finish Ch.16 & start Ch.17

(1)

3.) Determining what your eqm mixture will look like …16.4-5 Solving Equilibrium Problems…

1. Write the balanced equation for the reaction. ALWAYS!
2. Write the equilibrium expression using the law of mass action. + find/calculate *K*
3. List the initial concentrations.
4. Calculate *Q*, and determine the direction of the shift to equilibrium. Not REQUIRED… but ensures you've THOUGHT about your answer!
5. Define the 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*.

SUMMARY: YOUR "TO DO" LIST

- Balance rxn equation
- "ICE" table: initial, change & eqm [ ]'s
- Eqm expression (*K* = …)
- THINK…

(2)

Finding eqm concentrations… (or partial pressures)
…knowing initial conditions and K

At 1000K, this rxn involved in making steel has K_p = 0.259 :

$$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$$

What are the eqm partial pressures of CO and CO_2 if initially have P_{CO} = 1.000 atm & P_{CO_2} = 0.500 atm?

…assume both solids are present at the end (or else won't be at equilibrium!)

1. Rxn equation
2. "ICE" table
3. Eqm expression
4. THINK…

Same example as seen earlier…
…now in a more typical problem setting.

Recall: we already showed that this rxn will proceed LEFT (Q > K) as it approaches equilibrium…

(3)

$$FeO(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g) \qquad K_p = 0.259$$

Assuming some FeO & Fe remain, what are P_{eqm} CO & P_{eqm} CO_2 if initially P_{CO} = 1.000 atm & P_{CO_2} = 0.500 atm?

	FeO(s) +	CO(g) ⇌	Fe(s) +	$CO_2(g)$
Initial	present	1.000 atm	present	0.500 atm
Change		+ x		- x
Eqm	present	1.000 + x	present	0.500 - x

$$K = \frac{P_{CO_2}}{P_{CO}} \Rightarrow 0.259 = \frac{0.500 - x}{1.000 + x}$$

$$0.259 + 0.259x = 0.500 - x$$

$$1.259x = 0.241$$

$$x = 0.191 \text{ atm}$$

So, at eqm: P_{CO} = 1.000 + 0.191 = 1.191 atm

P_{CO_2} = 0.500 – 0.191 = 0.309 atm

Note: you don't NEED to find Q 1st! Can put "-x" for reactants and "+x" for products & the algebra takes care of the signs. Try it for yourself….

(4)

A trickier example of finding $[\ ]_{eqm}$'s…

At 1000 K, I_2 molecules dissociate, with $K_c = 3.76\times10^{-5}$:

$$I_2(g) \rightleftharpoons 2I(g)$$

(i) If we introduce 1.00 mol of iodine into a 2.00 L flask, what will $[I_2]$ and $[I]$ be when the system reaches eqm?

(ii) What percentage of the iodine molecules have dissociated at eqm (*i.e.*, what is % dissociation of I_2?)

Work through both: two ways to approach it!
- A.) "brute force" using quadratic equation
- B.) using an approximation…only allowed since K is small

(5)

Solving for x using the quadratic formula

$$I_2(g) \rightleftharpoons 2I(g)$$

…always works…

Initial	0.500 M	0
Change	-x	+2x
Eqm	0.500-x	2x

$$K = \frac{[I]^2}{[I_2]} = 3.76\times10^{-5}$$

$$3.76\times10^{-5} = \frac{[2x]^2}{[0.500-x]}$$

$$4x^2 = (0.500-x)(3.76\times10^{-5})$$

$$0 = 4x^2 + 3.76\times10^{-5}\,x - 1.88\times10^{-5}$$

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

$\Rightarrow$ $x = 2.16\times10^{-3}$ *OR* -2.16×10^{-3} M

both are mathematically correct but only one has physical meaning…

At eqm: $[I_2] = 0.500 - 2.16\times10^{-3} = 0.498$ M

and $[I] = 2(2.16\text{x}10\text{-}3) = 0.00432$ M

(6)

Using an approximation...*ok* when K is SMALL

$$I_2(g) \rightleftharpoons 2I(g)$$

Initial	0.500 M	0
Change	-x	+2x
Eqm	0.500-x	2x

APPROXIMATION:

let $x \ll [\ ]_{initial}$

VALID if K is "small"

$$K = \frac{[I]^2}{[I_2]} \Rightarrow 3.76\times10^{-5} = \frac{[2x]^2}{[0.500-x]} \approx \frac{4x^2}{0.500}$$

$\Rightarrow 4x^2 = (0.500)(3.76\times10^{-5})$

$\Rightarrow x = 2.17\times10^{-3}$ M

WARNING - Must verify that approximation was reasonable:

- Use 5% rule: VALID if find $x < 0.05[\ ]_{initial}$
- Guess 1st : approximation works if $K < 1000\times[\ ]_{initial}$

Check:

$$\frac{x}{[I_2]_{initial}} = \frac{0.00217}{0.500} = 0.0043$$

Way less than 5% ∴ ok

(7)

ASSIGNED READINGS:

BEFORE NEXT CLASS:

Read: Ch.19.7,
Ch.16

+ WORK ON Problems from Ch.19, Ch.16

(don't wait until assigned for tutorial homework!)