CONCEPTUAL

CONNECTION 15.6

Q and K For the reaction $N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$, a reaction mixture at a certain temperature initially contains both N_2O_4 and NO_2 in their standard states (see the definition of standard state in Section 6.9). If $K_p = 0.15$, which statement is true of the reaction mixture before any reaction occurs?

(a) $Q = K$; the reaction is at equilibrium.

(b) $Q < K$; the reaction will proceed to the right.

(c) $Q > K$; the reaction will proceed to the left.

$Q = (P\ NO_2)^2/(P\ N_2O_4) = (1)^2 / 1 = 1$

$Q > K$, so $P\ NO_2$ needs to ↓

and $P\ N_2O_4$ needs to ↑

To reach equilibrium ($Q = K$)

Which is a shift to the LHS!

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Finding eq^m concs

- Given K_c (or K_p)
  - given concs/pressures.
- Solve for eq^m concs/pressures.

ex: $A(g) \rightleftharpoons 2B(g)$; $K_c = 0.33$

$[A]_0 = 1.00\,M$

$[B]_0 = 0.00\,M$

- use ICE chart
  - init | eq^m
  - change
- write K
  - solve

- what's $[A]_{eq}$, $[B]_{eq}$?

$$Q_c = \frac{[B]^2}{[A]_0} = \frac{0^2}{1.00} = 0$$

$Q_c < K_c$: Shift to RHS

	$A(g)$	$\rightleftharpoons 2B(g)$
Init	1.00	0.00
Change	$-x$	$+2x$
Eq^m	$(1.00-x)$	$(+2x)$

$$K_c = 0.33 \Rightarrow \frac{[B]^2}{[A]_{eq}} = \frac{(2x)^2}{(1.00-x)} = 0.33$$

$$\Rightarrow (2x)^2 = (1.00-x)\,0.33$$

$$\Rightarrow 4x^2 = 0.33 - 0.33x$$

$$\Rightarrow 4x^2 + 0.33x - 0.33 = 0$$

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

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

$$\Rightarrow x = \frac{-0.33 \pm \sqrt{0.33^2 - 4(4)(-0.33)}}{2(4)} = \frac{-0.33 \pm \sqrt{5.39}}{8} = +0.249 \text{ (or) } -0.331$$

✓ $+0.249$; -0.331 physically imposs.

$x = 0.249$

$[A]_{eq} = (1.00 - x) = 1.00 - 0.249 = 0.75\ M$

$[B]_{eq} = (2x) = 2(0.249) = 0.50\ M$

Check ?

$$K_c = 0.33 = \frac{[B]^2}{[A]_{eq}} = \frac{0.50^2}{0.75} = 0.33 \checkmark$$

ex: $I_2(g) + Cl_2(g) \rightleftharpoons 2ICl(g) \quad K_p = 81.9\ (25°C)$

if $P_{I_2} = P_{Cl_2} = 0.100\ atm = P_{ICl}$ (init)

Q: what will eq^m p's be ?

$$Q_p = \frac{(P_{ICl})^2}{(P_{I_2})(P_{Cl})} = \frac{0.100^2}{0.100 \times 0.100} = 1.00$$

	$I_2(g)$	$Cl_2(g)$	$\rightleftharpoons 2ICl(g)$
I	0.100	0.100	0.100
C	$-x$	$-x$	$+2x$
E	$(0.100-x)$	$(0.100-x)$	$(0.100+2x)$

Quadratic in x!

$$K_p = \frac{(P_{ICl})^2}{(P_{I_2})(P_{Cl_2})} \Rightarrow \sqrt{81.9} = \sqrt{\frac{(0.100+2x)^2}{(0.100-x)(0.100-x)}}$$

perfect square!

$$\sqrt{81.9} = \frac{(0.100+2x)}{(0.100-x)}$$

9.0499 → $\sqrt{81.9}$

$9.0499(0.100 - x) = (0.100 + 2x)$

$0.90499 - 9.0499x = 0.100 + 2x$

$11.0499x = 0.80499 \Rightarrow x = \frac{0.80499}{11.0499} = 0.07285$

@ eQ^m : $P_{I_2} = P_{Cl_2} = 0.100 - x$ = ~~0.03~~ 0.02715 atm

$x = 0.07285$

$P_{ICl} = 0.100 + 2x = 0.2457$ atm

$$K_p = 81.9 = \frac{(P_{ICl})^2}{(P_{I_2})(P_{Cl_2})} = 81.9 \checkmark$$

Approximations

let's say we have: $A(aq) \rightleftharpoons 2B(aq)$; $[A]_0 = 1.0\,M$

$[B]_0 = 0.0\,M$

Q: What are eQ^m [ ]'s ?

$K_c = 3.3 \times 10^{-5}$

@ eQ^m: mainly A
very little B.

	$A(aq)$	$\rightleftharpoons 2B(aq)$
I	1.0	0.0
C	$-x$	$+2x$
E	$(1.0-x)$	$(2x)$

$$K_c = \frac{[B]^2}{[A]_{eQ}} \Rightarrow 3.3 \times 10^{-5} = \frac{(2x)^2}{(1.0-x)}$$

Quadratic?