



CONCEPTUAL
CONNECTION 15.6

Q and K For the reaction $\text{N}_2\text{O}_4(g) \rightleftharpoons 2 \text{NO}_2(g)$, 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?

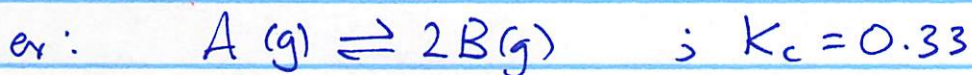
- (a) $Q = K$; the reaction is at equilibrium.
- (b) $Q < K$; the reaction will proceed to the right.
- (c) $Q > K$; the reaction will proceed to the left.**

$Q = (P \text{NO}_2)^2 / (P \text{N}_2\text{O}_4) = (1)^2 / 1 = 1$
 $Q > K$, so $P \text{NO}_2$ needs to \downarrow
and $P \text{N}_2\text{O}_4$ needs to \uparrow
To reach equilibrium ($Q = K$)
Which is a shift to the LHS!

3/18/2019

Finding eqm concs

- Given K_c (or K_p)
 - given concs/pressures.
- Solve for eqm concs/pressures.



$$[A]_0 = 1.00 M$$

$$[B]_0 = 0.00 M$$

- use ICE chart

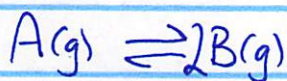
init | eqm
change

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

- write K

- solve

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



Init 1.00 0.00

Change $-x$ $+2x$

Eqm $(1.00-x)$ $(+2x)$

$Q_c < K_c$: Shift
to RHS

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

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

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

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

$ax^2 + bx + c = 0$

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

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

8 physically
imposs. -0.331

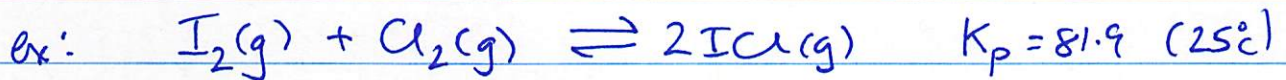
$$x = 0.249$$

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

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

Check?

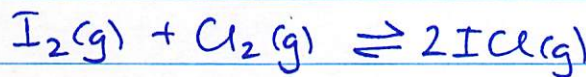
$$K_c = 0.33 = \frac{[B]^2}{[A]_{eq}} = \frac{0.50^2}{0.75} = 0.33 \quad \checkmark$$



if $P_{\text{I}_2} = P_{\text{Cl}_2} = 0.100 \text{ atm} = P_{\text{ICl}}$ (init)

Q: what will eqm p's be?

$$Q_p = \frac{(P_{\text{ICl}})^2}{(P_{\text{I}_2})(P_{\text{Cl}_2})} = \frac{0.100^2}{0.100 \times 0.100} = 1.00$$



I 0.100 0.100 0.100

C -x -x +2x

E (0.100-x) (0.100-x) (0.100+2x)

$$K_p = \frac{(P_{\text{ICl}})^2}{(P_{\text{I}_2})(P_{\text{Cl}_2})}$$

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

Quadratic in x!

perfect square!

$$9.0499 \rightarrow \frac{\sqrt{81.9}}{(0.100 - x)} = (0.100 + 2x)$$

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

$$0.90499 - 9.0499x = 0.100 + 2x$$

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

@ eqm : $P_{I_2} = P_{Cl_2} = 0.100 - x = \cancel{0.03} 0.02715 \text{ atm}$
 $x = 0.07285$

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

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

Approximations

let's say we have: $A(g) \rightleftharpoons 2B(g)$; $[A]_0 = 1.0 M$
 $[B]_0 = 0.0 M$

Q: What are eqm []'s ?

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

\nearrow
 @ eqm : mainly A
 very little B.

	$A(g) \rightleftharpoons 2B(g)$	
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?