warm-up. 1.00 mol $PCl_5(g)$ is placed in a 10.0 L vessel at 525 K. After equilibrium is reached, $[PCl_5]_E = 0.0529$ M. What is Kc? **February 12th**

M	$PCl_5(g)$ ⇌	$PCl_3(g)$ +	$Cl_2(g)$
I	0.100	0	0
C	− x	+ x	+ x
E	0.0529	0.0471	0.0471

$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{0.0471^2}{0.0529}$

$= 0.0419$

*pressure

$K_p = \frac{P_{PCl_3} * P_{PCl_2}}{P_{PCl_5}}$

P $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

I

C

E

$PV = nRT$

$P_A = \frac{n_A}{V} RT$

→ $P_A = [A]RT$

$K_p = \frac{[PCl_3]RT[PCl_2]RT}{[PCl_5]RT}$

$K_p = K_c(RT)$

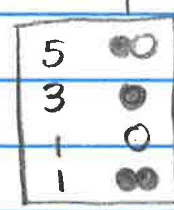
→ $R = 0.0821$ L·atm/mol·K

BUT... $A \rightleftharpoons B$ $K_p = \frac{P_B}{P_A}$ $\frac{[B]RT}{[A]RT} = K_c$

*In general: $K_p = K_c(RT)^{\Delta n gas}$ → Δ in moles of gas!

	Δngas	
$A \rightleftharpoons B$	0	$K_p = K_c$
$A \rightleftharpoons 2B$	+1	$K_p = K_c \cdot RT$
$2A \rightleftharpoons B$	−1	$K_p = K_c(RT)^{-1}$
$A \rightleftharpoons 3B$	+ 2	

warm-up #2: $A_2 + B \rightleftharpoons A + AB$ $K_c = 2.0$



$Q_c = \frac{3 \times 5}{1 \times 1} = 15$ $Q_c > K_c$ → shift L

M	A_2 +	B ⇌	A +	AB
I	1	1	3	5
C	+x	+x	−x	−x
E				

already @ equilibrium → E

M	A_2 +	B ⇌	A +	AB
I (E)	2	2	2	4
C				
E				

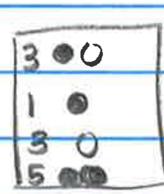
$K_c = 2.0$

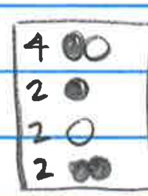
$Q_c = \frac{2 \times 4}{2 \times 2} = 2.0$ $Q_c = K_c$ ✓

M	A_2 +	B ⇌	A +	AB
I	3	3	1	3
C				
E				

$Q_c = \frac{1 \times 3}{3 \times 3} = 0.33$

$Q_c < K_c$ → shift R





1. Which are at equilibrium?
2. If not, which way must they shift?

3. What happens if some A_2 is added to system @ equilibrium?

February 12th

lechatlier description #1: Add/remove a substance

M $A_2 + B \rightleftharpoons A + AB$ $K_c = 2$

E 2 2 2 4

* suppose we add A_2 so there are 3

I 3 2 2 4 $Q_c = \frac{2\times4}{3\times2} = 1.3$ too small ∴ shift R

C −x −x +x +x

E

M $2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$ $K_c^{1000} = 5.1$

I 0.10 0 0

C −2x +x +x

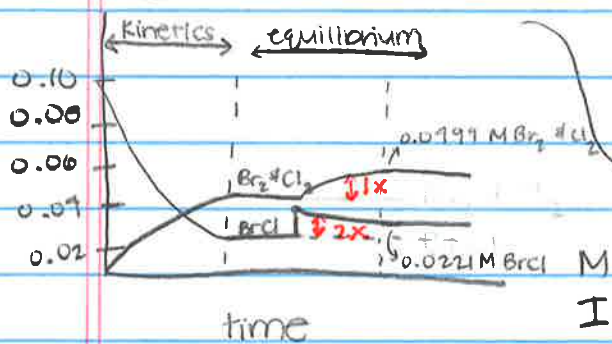
E $0.10 - 2x =$ 0.0181 $x =$ 0.0409 $x =$ 0.0409

$K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2} \overset{?}{=} \frac{0.0409^2}{0.0181^2} = 5.1$ ✓ ☺

↳ $\frac{x^2}{(0.10-2x)^2}$

$\frac{x}{0.10-2x} = \sqrt{5.1} = 2.258$

↳ solve for x: 0.0409



* suppose some BrCl is added so that [BrCl] = 0.040 M.

M $2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$

I 0.0400 0.0409 0.0409

C −2x +x +x

E $0.04 - 2x$ $0.0409 + x$ $0.0409 + x$

↳ $x = 0.00896$

lechatlier #2: ↳ If the vol. is changed, so is the [ ]

$(V\downarrow, \uparrow n)$

$(V\uparrow, \downarrow n)$

$N_2O_4 \rightleftharpoons 2NO_2$ $K_c = 4.64 \times 10^{-3}$] * inverse of one another

M $2NO_2 \rightleftharpoons N_2O_4$ $K_c = 216$

E 0.0107 0.0246

Suppose the volume decreases by 1/2

I 0.0214 0.0492 $Q_c = \frac{0.0492}{0.0214^2}$ ↳ = 107 $Q_c < K_c$ shift R

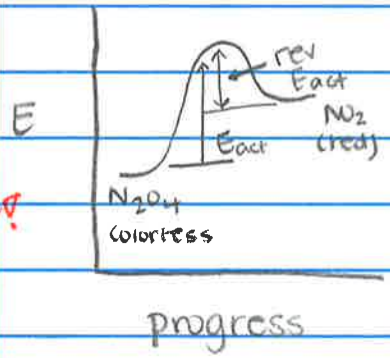
C −2x +x

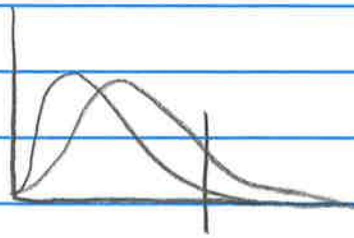
E

February 12th

Lechatlier #3: K_c can only be changed by changing the temperature!
↓↓↓↓↓

↑T always favors the uphill direction (endothermic)





Increased temp {$[NO_2]$ ↑, $[N_2O_4]$ ↓}

K_c ↑ ← $K_c = \frac{[NO_2]^2}{[N_2O_4]}$ ↑

b/c endothermic rxn

	Kinetics	equilibrium
	k_{fwd} k_{rev}	K_c, K_p
Incr temp	↑ k_{fwd} & k_{rev}	endo K_c↑ K_p↑ exo K_c↓ K_p↓