LeChatelier and "K" calculations

1. $SO_2\,(g) + NO_2\,(g) \rightleftarrows SO_3\,(g) + NO\,(g)$

	SO_2	NO_2	SO_3	NO
E	4.0 M	0.50 M	3.0 M	2.0 M

$K = \frac{(3)(2)}{(4)(\frac{1}{2})}$

1.5 mol of the $NO_2(g)$ is added to the 1.00 L equilibrium vessel.
What is the new equilibrium concentration of all species?
Graph both equilibrium concentrations on the same graph.

	SO_2	NO_2	SO_3	NO
E_1	4.0 M	0.50 M	3.0 M	2.0 M
R	$-x$	$+1.5M - x$	$+x$	$+x$
E_2	$4.0-x$	$2.0-x$	$3.0+x$	$2.0+x$

$$K_{eq} = \frac{[SO_3][NO]}{[SO_2][NO_2]} = \frac{(3.0+x)(2.0+x)}{(4.0-x)(2.0-x)} = 3.0$$

set limits $0 < x < 2$

$$3 = \frac{6 + 5x + x^2}{8 - 6x + x^2}$$

$$24 - 18x + 3x^2 = 6 + 5x + x^2$$

$$2x^2 - 23x + 18 = 0$$

$x = 0.84$ ~~$x = 10$ (ish)~~

$[SO_2] = 4.0 - 0.84 = 3.2$

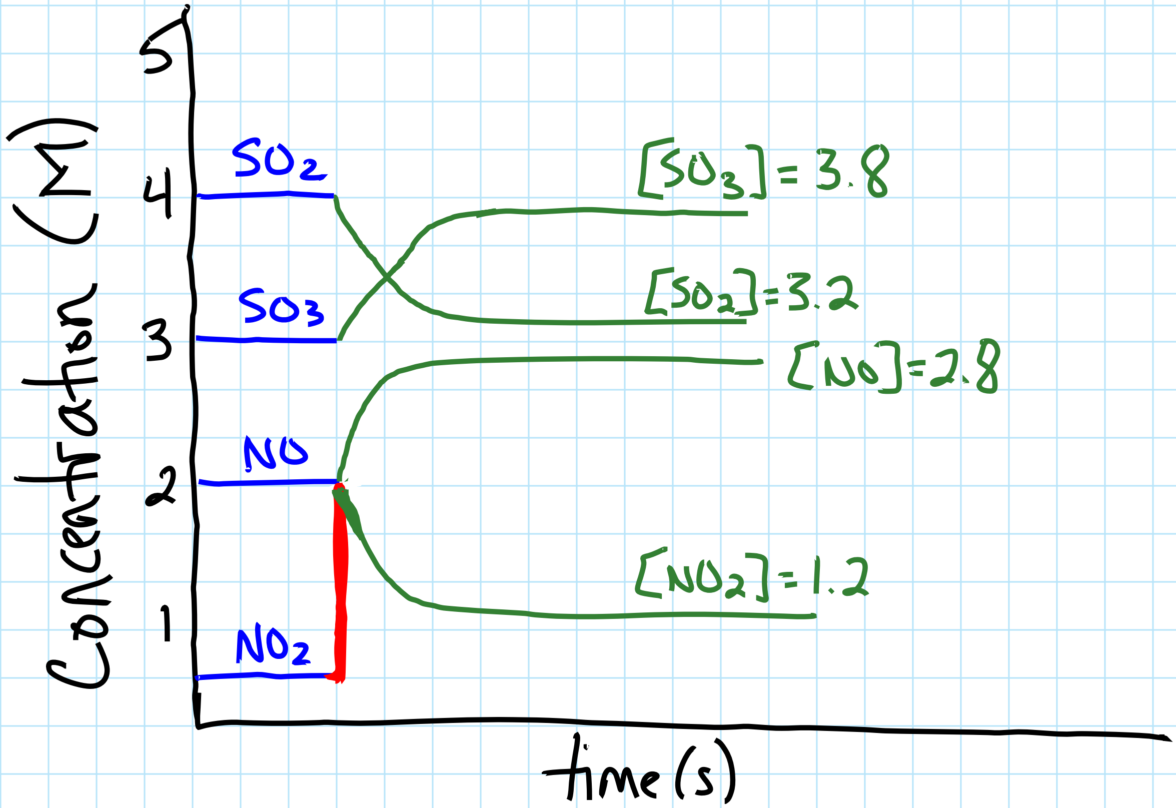
$[NO_2] = 2.0 - 0.84 = 1.2$

$[SO_3] = 3.0 + 0.84 = 3.8$

$[NO] = 2.0 + 0.84 = 2.8$

check

$K = \frac{(3.8)(2.8)}{(3.2)(1.2)} = 2.8$


Concentration (M)
5
4
3
2
1
SO_2
SO_3
NO
NO_2
$[SO_3] = 3.8$
$[SO_2] = 3.2$
$[NO] = 2.8$
$[NO_2] = 1.2$
time (s)

2.	SO_2 (g)	+	NO_2 (g)	⇄	SO_3 (g)	+	NO (g)
E_1	4.0 M		0.50 M		3.0 M		2.0 M
	↓		+ x ↓ →		↑		↑
R	−1.0M		−1.0M		+1.0M		+1.0M
E_2	3.0		0.50 + x − 1.0 = x − 0.50		4.0 M		3.0

What was the stress imposed on this equilibrium system?
(Give a numerical answer, as well as a solution statement).

Same K as #1

$$3.0 = \frac{(4.0)(3.0)}{(3.0)(x-0.5)}$$

$$3 = \frac{4}{x-0.5}$$

$$3x - 1.5 = 4$$

$$3x = 5.5$$

$$x = 1.8\cancel{3}$$ 2SF

limit
$x > 0.5$

The stress applied was the addition of 1.8 M NO_2

3. Given:
a) $K = 1.5 \times 10^{12}$
b) $K = 0.15$
c) $K = 4.3 \times 10^{-15}$

Which one has a large ratio of products to reactants? WHY?

4. $H_2(g) + S(s) \rightleftarrows H_2S(g) + kJ$

Given: $\frac{0.200\text{mol}}{2.00\text{ L}}$ = .100M (WATCH!) X $\frac{0.200\text{ mol}}{2.00\text{ L}}$ = .100M

Qn # 1: explain why it doesn't matter that I didn't take into account that sulphur is octatomic when I balanced my equation.

$8H_2(g) + S_8(s) \rightleftarrows 8H_2S(g) + kJ$

$$K = \frac{[H_2S]^8}{[H_2]^8} \quad \text{OR} \quad K = \frac{[H_2S]}{[H_2]}$$

Qn#2: Is the given data at equilibrium?
(If K at this temperature is given as 14.3).
If not, what must happen for this system to be at equilibrium?

In your answer, we must start using the following notation:

K_{eq} > / < / = K_{trial}

alphabetical order

$$K_{TRIAL} = \frac{.100}{.100} = 1$$

$K_{eq} > K_T$
14.3 1

Since $K_{eq} > K_{TRIAL}$ the system must proceed to the RIGHT to reach equilibrium and then $\frac{[H_2S]\uparrow}{[H_2]\downarrow}$ →

If $K_{eq} < K_T$ would shift left to achieve EQUIL. ←

If $K_{eq} = K_T$ it is AT EQUIL!

$$14.3 = \frac{(.100 + x)}{(.100 - x)}$$

$$x = 0.087$$

At equilibrium $[H_2S] = .187$

$[H_2] = .013$

Check $K = \frac{.187}{.013} = 14.4$ ✓

5. A (g) ⇄ 2B (g) + C (g

	A (g)	2B (g)	C (g
I	$\frac{1.00 \text{ mol}}{4.00 \text{ L}}$ = .250 M (TRICKY!)	-----	-----
R	−.05 (← mole RATIO)	+.10	+.05
E	.20	0.10 M	0.05 M

$K = 2.5 \times 10^{-3}$

Calculate $[A]_e$ — DONE!

$$K = \frac{(.10)^2(.05)}{(.20)} = .0025 \quad \text{YAY!}$$

b. A (g) ⇄ 2B (g) + C (g

	A (g)	2B (g)	C (g
E_1	.20 M	0.10 M	0.05 M
	+ 0.10 M		
R	−x	+2x	+x
E_2	.30 − x	.10 + 2x	.05 + x

Calculate the new $[A]_e$ $[B]_e$ $[C]_e$ at the same temperature, under the stress that was imposed as shown in E_1.

$$K = \frac{[B]^2[C]}{[A]} = \frac{(.10+2x)^2(.05+x)}{(.30-x)} = 2.5 \times 10^{-3}$$

Set limits: $0 < x < 0.30$

$x = .0068$

Trial and error, or guess and check is a suitable solving method

[A] = .29 [B] = .11 [C] = .06
2 decimal places!

6a. H_2 (g) + CO_2 (g) ⇄ H_2O (g) + CO (g)

	H_2 (g)	CO_2 (g)	H_2O (g)	CO (g)
I (INITIAL)	0.500 M	0.500 M	0	0
R	$-x$	$-x$	$+x$	$+x$
E	$.5-x$	$.5-x$	x	x

Calculate all four [ ]$_e$ if K = 2.00.

$$K = \frac{[H_2O][CO]}{[H_2][CO_2]}$$

$$\sqrt{2.00} = \sqrt{\frac{x^2}{(.5-x)^2}}$$

Set limits $0 < x < 0.5$

→ $x = 0.293$ M

$[H_2O] = [CO] = .293$ M

$[H_2] = [CO_2] = .207$ M

6b. Given new E_2 concentrations, calculate K and describe what stresses could have caused this shift, resulting in these new concentrations:

E_1	.207	.207	.293	.293
E_2	0.105 M	0.105 M	0.145 M	0.145 M

check K@E_2: $\frac{(.145)^2}{(.105)^2} = 1.91$

ORIGINAL $K_{eq} = 2.00$

Assume no change in K

If Temp had changed, Products + Reactants can't both decrease ∴ this is ⇧ VOLUME = ⇩ pressure

NO SHIFT! Moles equal on both sides!

6c. Given new E_2 concentrations, calculate K and describe what stresses could have caused this shift, resulting in these new concentrations:

E_3	0.240 M	0.240 M	0.133 M	0.133 M

$K = \frac{(.133)^2}{(.240)^2} = .307$

MUST be a Temp change

K↓ but don't know if reaction is endo/exo

So NOT sure if Temp ↑ or ↓

6d. Given new E_2 concentrations, calculate K and describe why we could not explain a stress that would cause the concentrations to change to these numbers (i.e. why these "equilibrium" values would be impossible):

	H_2 (g)	+	CO_2 (g)	⇄	H_2O (g)	+	CO (g)
E_2	0.117 M		0.117 M		0.133 M		0.133 M

$$K = \frac{(.133)^2}{(.117)^2} = 1.29$$

BUT all products ↓ AND all reactants ↓

How can that be?

error in data

SHIFT is not explainable

6e.

	H_2 (g)	+	CO_2 (g)	⇄	H_2O (g)	+	CO (g)
E_1	0.117 M		0.117 M		0.133 M		0.133 M
R	+.033M		+.033		−.033		−.033
E_2	0.150 M		.150		.100+x		.100

Fresh start

START HERE!

+x

Calculate how much H_2O (g) was added to the E_1 vessel if K at **this** temperature is equal to 1.29.

$$K = \frac{(.133)^2}{(.117)^2}$$

$$1.29 = \frac{(.100+x)(.100)}{(.150)^2}$$

LIMITS $x > 0$

$x = .190M$ of $H_2O(g)$ was added to the reaction vessel

6f. On a separate piece of paper (fill the page) graph the equilibrium values, stresses, shifts and new equilibrium values for questions ~~6b and 6c~~. 6e!

Graph Qn 6f Of question 6d and 6e