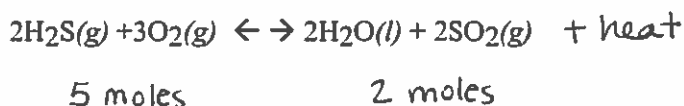


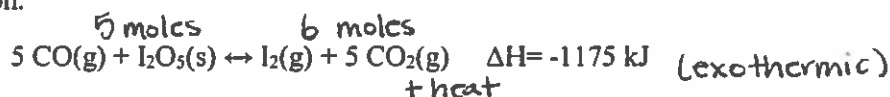
Consider the reaction below:



The heat of the reaction is  $\Delta H = -1036 \text{ kJ}$ . Given the reaction is at equilibrium, predict the direction the reaction will shift when the following stresses are applied:

- No shift    i) the amount of  $\text{H}_2\text{O}$  is increased    Liquids do not affect equilibrium position
- Left        ii) the temperature of the reaction is increased    Excess heat in the system leads to more  $\text{H}_2\text{S}$  and  $\text{O}_2$  being formed to use up that heat + counteract stress
- Right      iii) the volume of the container is decreased    Since # gas particles affect pressure, (so  $P \uparrow$ ) system shifts R to form less gas particles (b/c less particles)
- Left — iv) the amount of  $\text{H}_2\text{S}$  is decreased    means less collisions w/ container so  $P$  will  $\downarrow$  System needs to make up for the loss in  $\text{H}_2\text{S}$ , so shift to left will form more  $\text{H}_2\text{S}$  to counteract the stress

Practice For the following reaction:

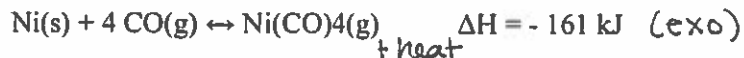


Predict the equilibrium shift and the effect on the indicated quantity for each change listed.

	Change	Direction of Shift ( $\rightarrow$ ; $\leftarrow$ ; or no change)	Effect on Quantity	Effect (increase, decrease, no change)
A	decrease in volume $\uparrow P$	$\leftarrow$ left	$K_c$ $\frac{\text{products}}{\text{reactants}}$	decrease
B	raise temperature	$\leftarrow$ left	amount of $\text{CO}(\text{g})$	increase
C	Addition of $\text{I}_2\text{O}_5(\text{s})$	no shift	amount of $\text{CO}(\text{g})$	no change
D	addition of $\text{CO}_2(\text{g})$	left $\leftarrow$	amount of $\text{I}_2\text{O}_5(\text{s})$	amount increases* but position doesn't change
E	Removal of $\text{I}_2(\text{g})$	right $\rightarrow$	amount of $\text{CO}_2(\text{g})$	increase

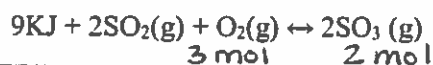
Solids have a constant concentration but the amount (mass) will increase. Volume increases with it so its conc still remains constant, + position is the same (since that depends on concentration)

In which direction will the equilibrium shift in response to each change, and what will be the effect on the indicated quantity?

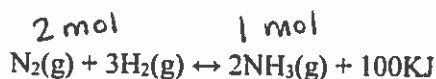


	Change	Direction of Shift (→; ←; or no change)	Effect on Quantity	Effect (increase, decrease, no change)
A	Add Ni (s)	no change	Ni(CO) <sub>4</sub> (g)	no change
B	Raise temperature	← left	K <sub>c</sub> $\frac{\text{prod}}{\text{react}}$	decrease
C	Add CO (g)	→ right	Amount of Ni (s)	amount decreases but no effect on equilibrium
D	Remove Ni(CO) <sub>4</sub> (g)	→ right	CO (g)	decreases
e	Decrease in volume ↑ P	→ right	Ni(CO) <sub>4</sub> (g)	increases
F	Lower temperature	→ right	CO (g)	decrease
g	Remove CO (g)	← left	K <sub>c</sub> $\frac{\text{prod}}{\text{react}}$	decrease

Use arrows (up/down) to indicate the effect of each of these disturbances (stresses) on the concentration of the reactants and products in this equilibrium:



disturbance	Effect on [SO <sub>2</sub> ]	Effect on [O <sub>2</sub> ]	Effect on [SO <sub>3</sub> ]	Direction of shift
Decrease [SO <sub>2</sub> ]	increases	increases	decreases	Left
Increase [O <sub>2</sub> ]	decrease	decrease	increases	Right
Increase [SO <sub>3</sub> ]	increases	increases	decreases	Left
Increase pressure	decrease	decrease	increase	Right
Decrease temp	increase	increase	decrease	Left



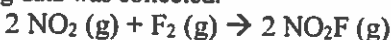
disturbance	effect on [N <sub>2</sub> ]	effect on [H <sub>2</sub> ]	effect on [NH <sub>3</sub> ]	Direction of shift
Increase [N <sub>2</sub> ]	decrease	decrease	increase	Right
Decrease [H <sub>2</sub> ]	increase	increase	decrease	Left
Increase [NH <sub>3</sub> ]	increase	increase	decrease	Left
Increase pressure	decrease	decrease	increase	Right
Decrease temp	decrease	decrease	increase	Right

### More Kinetics Practice

$$\text{Rate} = k[A]^a[B]^b \quad \text{for reaction}$$

$$A + B \rightarrow \text{products}$$

1. For the reaction below the following data was collected.



	[NO <sub>2</sub> ] (mol/L)	[F <sub>2</sub> ] (mol/L)	initial rate (mol/L · s)
experiment 1	0.30	0.30	7.22 × 10 <sup>-5</sup>
experiment 2	0.60	0.30	14.4 × 10 <sup>-5</sup>
experiment 3	0.30	0.60	7.22 × 10 <sup>-5</sup>

Solve for the orders with respect to NO<sub>2</sub>, F<sub>2</sub>, the overall order, K (with units), and give the rate law.

For NO<sub>2</sub>  
use expts 2 + 1

$$\frac{\text{rate of 2}}{\text{rate of 1}} = \frac{k[\text{F}_2]^b [0.60]^a}{k[\text{F}_2]^b [0.30]^a} = \frac{14.4 \times 10^{-5}}{7.22 \times 10^{-5}}$$

$$2^a = 2$$

$$a = 1 \quad \therefore \text{order of NO}_2 = 1$$

For F<sub>2</sub>  
use expts 3 + 1

$$\frac{\text{rate of 3}}{\text{rate of 1}} = \frac{k[\text{NO}_2]^a [0.60]^b}{k[\text{NO}_2]^a [0.30]^b} = \frac{7.22 \times 10^{-5}}{7.22 \times 10^{-5}}$$

$$2^b = 1$$

$$b = 0 \quad \therefore \text{order of F}_2 = 0$$

(it can happen)

$$\text{Overall order} = 1 + 0 = 1$$

rate law:  $\text{rate} = k[\text{NO}_2]^1[\text{F}_2]^0$

or  $\boxed{\text{rate} = k[\text{NO}_2]}$

To find k select any experiment and substitute the data w/ units

expt 1:  $\text{rate} = k[\text{NO}_2]$

$$7.22 \times 10^{-5} \text{ mol/L} \cdot \text{s} = k [0.30 \text{ mol/L}]$$

$$\frac{7.22 \times 10^{-5} \text{ mol/L} \cdot \text{s}}{0.30 \text{ mol/L}} = k$$

$$\boxed{2.4 \times 10^{-4} \text{ s}^{-1} = k}$$