Consider the reaction below:

$$2H_2S(g) + 3O_2(g) \leftrightarrow 2H_2O(l) + 2SO_2(g) \quad + \text{heat}$$

5 moles 2 moles

The heat of the reaction is ΔH = -1036 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 H_2O 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 H_2S and O_2 being formed to use up that heat + counteract stress

Right iii) the volume of the container is decreased (so P ↑) Since # gas particles affect pressure, system shifts R to form less gas particles (b/c less particles means less collisions w/ container so P will ↓)

Left — iv) the amount of H_2S is decreased System needs to make up for the loss in H_2S, so shift to left will form more H_2S to counteract the stress

Practice

For the following reaction:

5 moles 6 moles

$$5\ CO(g) + I_2O_5(s) \leftrightarrow I_2(g) + 5\ CO_2(g) \quad \Delta H = -1175\ kJ$$

+ heat (exothermic)

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

	Change	Direction of Shift (→; ←; or no change)	Effect on Quantity	Effect (increase, decrease, no change)
A	decrease in volume ↑ P	← left	Kc products/reactants	decrease
B	raise temperature	← left	amount of CO(g)	increase
C	Addition of $I_2O_5(s)$	no shift	amount of CO(g)	no change
D	addition of $CO_2(g)$	left ←	amount of I_2O_5 (s)	amount increases but position doesn't change *
E	Removal of I_2 (g)	right →	amount of CO_2 (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?

$Ni(s) + 4\ CO(g) \leftrightarrow Ni(CO)_4(g)$ + heat $\Delta H = -161$ kJ (exo)

	Change	Direction of Shift (→; ←; or no change)	Effect on Quantity	Effect (increase, decrease, no change)
A	Add Ni (s)	no change	$Ni(CO)_4$ (g)	no change
B	Raise temperature	← left	Kc prod/react	decrease
C	Add CO (g)	→ right	Amount of Ni (s)	amount decreases but no effect on equilibrium
D	Remove Ni(CO)4 (g)	→ right	CO (g)	decreases
e	Decrease in volume ↑ P	→ right	$Ni(CO)_4$ (g)	increases
F	Lower temperature	→ right	CO (g)	decrease
g	Remove CO (g)	← left	Kc prod/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:

$9KJ + 2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$
3 mol   2 mol

disturbance	Effect on $[SO_2]$	Effect on $[O_2]$	Effect on $[SO_3]$	Direction of shift
Decrease $[SO_2]$	increases	increases	decreases	Left
Increase $[O_2]$	decrease	decrease	Increases	Right
Increase $[SO_3]$	increases	increases	decreases	Left
Increase pressure	decrease	decrease	increase	Right
Decrease temp	increase	increase	decrease	Left

2 mol   1 mol

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + 100KJ$

disturbance	effect on $[N_2]$	effect on $[H_2]$	effect on $[NH_3]$	Direction of shift
Increase $[N_2]$	decrease	decrease	increase	Right
Decrease $[H_2]$	increase	increase	decrease	Left
Increase $[NH_3]$	increase	increase	decrease	Left
Increase pressure	decrease	decrease	increase	Right
Decrease temp	decrease	decrease	increase	Right

More Kinetics Practice

$Rate = k[A]^a[B]^b$ for reaction $A + B \rightarrow$ products

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

$2\ NO_2\ (g) + F_2\ (g) \rightarrow 2\ NO_2F\ (g)$

	$[NO_2]$ (mol/L)	$[F_2]$ (mol/L)	initial rate (mol/L • s)
experiment 1	0.30	0.30	7.22×10^{-5}
experiment 2	0.60	0.30	14.4×10^{-5}
experiment 3	0.30	0.60	7.22 x 10-5

Solve for the orders with respect to NO_2, F_2, the overall order, K (with units), and ~~the~~ give the rate law.

For NO
use expts 2 + 1

$$\frac{\text{rate of 2}}{\text{rate of 1}} = \frac{k[F_2]^b[0.60]^a}{k[F_2]^b[0.30]^a} = \frac{14.4\times10^{-5}}{7.22\times10^{-5}}$$

$$2^a = 2$$
$$a = 1 \quad \therefore \text{order of } NO_2 = 1$$

For F_2
use expts 3 + 1

$$\frac{\text{rate of 3}}{\text{rate of 1}} = \frac{k[NO_2]^a[0.60]^b}{k[NO_2]^a[0.30]^b} = \frac{7.22\times10^{-5}}{7.22\times10^{-5}}$$

$$2^b = 1$$
$$b = 0 \quad \therefore \text{order of } F_2 = 0$$

(it can happen)

Overall order = 1 + 0 = 1

rate law: $rate = k[NO_2]^1[F_2]^0$

or $\boxed{rate = k[NO_2]}$

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

expt 1: $rate = k[NO_2]$

$$7.22\times10^{-5}\ mol/(L\cdot s) = k\ [0.30\ mol/L]$$

$$\frac{7.22\times10^{-5}\ \cancel{mol/L}\cdot s)}{0.30\ \cancel{mol/L}} = k$$

$$\boxed{2.4\times10^{-4}\ s^{-1} = k}$$