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Le Châtelier's Principle: <https://youtu.be/BPDKi92NCUs>

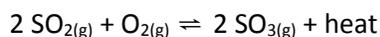
<http://screencast.com/t/9S4FF4rT>

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When a stress is applied to a system at equilibrium, the system will readjust by shifting the equilibrium to relieve the effect of the stress. An applied stress can be in the form of:

- A change in concentration of one or more of the materials in the reaction.
- A change in temperature.
- A change in pressure or volume of a gaseous system. (This is equivalent to a change in concentration of materials).
- Addition of a catalyst.
- Addition of an inert gas.

Sample Problem: Explain the affect of the following stresses to the equilibrium:



- Increase in the concentration of sulfur dioxide:** The equilibrium shifts right to use up the extra SO_2 , producing more sulfur trioxide and using up some oxygen.
- Decreasing the partial pressure of sulfur trioxide:** This is equivalent to decreasing the concentration of sulfur trioxide. The equilibrium will shift right to make more sulfur trioxide and decreasing the amounts of sulfur dioxide and oxygen.
- Decreasing the temperature of the system:** The system will shift right to produce more heat compensating for the loss of heat. This will increase the concentration of sulfur trioxide and decrease the concentrations of sulfur dioxide and oxygen. Also the K_{eq} will increase.
- Increasing the volume of the container:** This results in more space between the molecules and the stress is reduced by producing more gas molecules. The system will shift left as there are more total gas molecules on that side (3 vs. 2).
- Adding helium at constant volume:** Since the volume of the container remains constant, the concentration of the gases also remains constant. Therefore no stress has been applied and the equilibrium is unaffected.
- Adding helium at constant pressure:** In order for pressure to remain constant, the volume of the container must increase. The equilibrium will shift left to produce more gas molecules.
- Adding a catalyst:** A catalyst works by increasing the rate of the forward and reverse reactions by the same amount. Therefore the equilibrium is unaffected and there is no shift.

Exercise: Complete the following questions on a separate piece of paper.

- For the system: $\text{heat} + 2 \text{H}_2\text{O}_{(g)} \rightleftharpoons 2 \text{H}_2_{(g)} + \text{O}_{2(g)}$ indicate in which direction the equilibrium shifts when the following stresses are applied to the system. Justify your answer for each.
 - The [hydrogen] is increased.
 - The partial pressure of water is increased.
 - The [oxygen] of decreased.
 - The temperature is increased.
 - The volume of the container is decreased.
 - A catalyst is added.
 - Helium is added at constant volume.
 - Argon gas is added at constant pressure.

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2. Consider the equilibrium $\text{H}_2\text{O}_{(l)} + \text{heat} \rightleftharpoons \text{H}_2\text{O}_{(g)}$. Discuss the effect of:
 - a) Increased pressure
 - b) Decreased pressure
 - c) Increased vapour pressure
 - d) Decreased vapour pressure
 - e) Increased temperature
 - f) Decreased temperature

3. Iodine crystals are in equilibrium with iodine vapour.
 - a) Write the equation for the equilibrium system.
 - b) What is the effect of reducing temperature?
 - c) What is the effect of reducing the pressure?

4. Ice is in equilibrium with water.
 - a) Write the equation for the equilibrium system.
 - b) What happens to the volume of water when it freezes?
 - c) Which is easier to compress liquid or solid water?
 - d) What is the effect of reducing temperature?
 - e) What is the effect of increasing the pressure?

5. For the system in which ammonia and oxygen are in equilibrium with nitrogen monoxide and water (all species are in the gas phase) complete the following. The forward reaction is exothermic.
 - a) Write the equation for the equilibrium system.
 - b) How could you increase the concentration of the products by varying the pressure and temperature?

6. Bromine vapor reacts with chlorine gas to produce bromine mono-chloride gas. What effect would pressure have on this equilibrium?

7. List and explain 3 ways that the equilibrium $2 \text{NO}_{2(g)} + \text{heat} \rightleftharpoons 2 \text{NO}_{(g)} + \text{O}_{2(g)}$ could be forced to shift to the right.

8. Carbon solid reacts with oxygen gas to form carbon monoxide gas. $2 \text{C}_{(s)} + \text{O}_{2(g)} \rightleftharpoons 2 \text{CO}_{(g)}$. Explain the effect of the following stresses to the equilibrium.
 - a) Addition of carbon monoxide at constant volume and temperature
 - b) Addition of oxygen at constant volume and temperature
 - c) Addition of solid carbon
 - d) Decreasing the volume of the container
 - e) Adding helium keeping volume constant