

C6: The Rate and Extent

of chemical change

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Le Chatelier's Principle

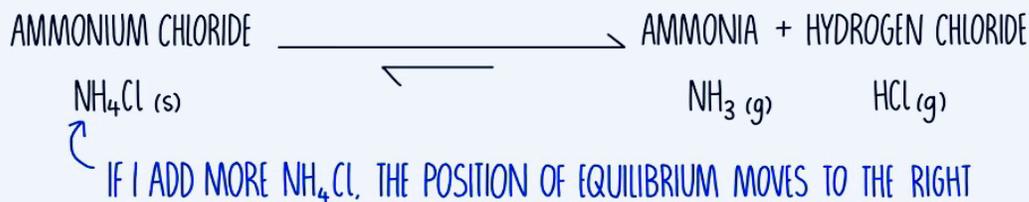
- The relative amounts of all the reactants and products at equilibrium depend on the conditions of the reaction.
- This balance is framed in an important concept known as **Le Chatelier's Principle**, named after Henri Le Chatelier who was a French military engineer in the 19th century

“This principle states that when a change is made to the conditions of a system at equilibrium, the system automatically moves to oppose the change”

- The principle is used to predict changes to the position of equilibrium when there are changes in **temperature**, **pressure** or **concentration**.
- To **increase** the percentage yield, the position of the equilibrium needs to move towards the **right side**, which is the **product** side, and therefore make a **higher concentration of product** at the point of dynamic equilibrium.
- If the equilibrium moves to the left, the reactant side, then the concentration of reactant will be higher at the equilibrium point and the percentage yield will be lower, as there is less product.
- If a chemical reaction is being carried out then the point is to **make product** and not be left with unreacted reactant, so the principle is key to keeping the costs of chemical products low and is often discussed as '**chemical economics**'
- There are changes in some factors to predict changes to the position of equilibrium that are
 1. Concentration
 2. Pressure
 3. Temperature
 4. Catalyst

1. Concentration

- If the concentration of a reactant is increased, the position of equilibrium shifts to the right to favour the formation of products.



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For Example:

- a sealed container filled with ammonium chloride which is decomposing into ammonia and hydrogen chloride.
- The reaction has reached **dynamic equilibrium** but then I add **more ammonium chloride**. The position of equilibrium will then move to the **right**, to **make more products** and balance things out.
- The same is true for the other way round - if I added more product to the container the position of equilibrium would shift to the left to favour the formation of reactants.

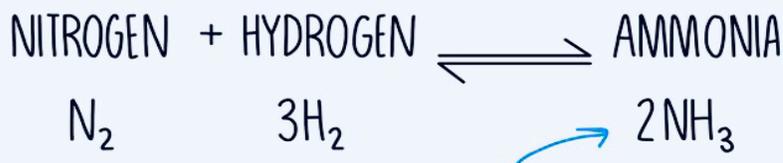
2. Pressure

- If the pressure is increased, the position of equilibrium shifts to the side with the **fewest moles of gas**.

“An increase in Pressure favours the side with fewest Gas molecules”

For example:

- The equation below represents the Haber Process which is an industrial process used to make ammonia for use in fertilisers.
- From the balanced symbol equation we can see that there are a total of **four moles** of gas on the **left** hand side of the equation and only **two** on the **right**. If we **increase the pressure**, the position of equilibrium will shift to the **right hand side** (towards ammonia) as this is the side with the **fewest moles of gas**.
- Alternatively, if we decrease the pressure, the position of equilibrium would shift to the left hand side where there are more moles.



IF PRESSURE IS INCREASED, THE POSITION OF EQUILIBRIUM SHIFTS TO THE RIGHT

THERE ARE 4 GAS MOLECULES ON THE LEFT BUT ONLY 2 ON THE RIGHT

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3. Temperature

- If we increase the temperature of a reaction at equilibrium, the position of equilibrium will shift in the **endothermic direction** to lower the temperature.

“An increase in Temperature favour the Endothermic Reaction”

For example.

- Hydrogen can be manufactured by reacting carbon with steam, as shown in the equation below. The **forward** reaction is **endothermic** and the reverse reaction is **exothermic**.
- This means that if we **increase the temperature**, the position of equilibrium will shift in the **endothermic forward direction** (towards the products).
- Alternatively, if we decrease the temperature, the position of equilibrium will shift in the exothermic reverse direction (towards the reactants).



IF TEMPERATURE IS INCREASED, THE POSITION OF EQUILIBRIUM WILL SHIFT TO THE RIGHT (IN ENDOTHERMIC DIRECTION)

4. Catalyst

- A catalyst does **NOT** change the position of equilibrium. This is because it **speeds up the forward and reverse reactions by the same amount**.