GCSE

SCIENCE: Dynamic equilibrium

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Keyword	Definition
Dynamic equilibrium	When the forwards and backwards reactions of a revisable reaction are occurring at the same rate.
Concentration	The amount of a solute dissolved in a certain volume of a solvent. Typical units mol / dm^3 (NB 1 dm^3 = 1 L).
Closed system	When substances cannot enter or leave an observed environment eg a stoppered test tube.
Le Chatelier's Principle	A change of temperature, concentration or pressure to a dynamic equilibrium will result in the point of equilibrium changing to minimise the change.
Dynamic equilibrium vs equilibrium	There are different types of equilibriums. A dynamic equilibrium is specifically an equilibrium in which reactions are constantly taking place but the rates of reactions are identical. You may see both terms being used to mean the same thing during your GCSEs.

Equilibrium

- Take the general reversible reaction $A + B \rightleftharpoons C + D$
- As A and B react their concentrations decrease and so the rate of the forward reaction decreases. At the same time the concentrations of C and D will increase and so the rate of the backwards reaction will increase.
- Eventually the rates of the forward and backward reactions will be the same – equilibrium has been reached.
- At equilibrium both reactions are still happening but there is no change in concentration of reactants or products.
- Equilibrium can only be reached in closed systems. Equilibriums do not usually end with equal concentrations of products.

Reversible reactions & the Haber process

- A reversible reaction is a chemical reaction that can work in both directions. The products of one reaction are the reactants for another.
- The Haber process is a reversible reaction that can reach dynamic equilibrium:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

- Nitrogen is taken from the air and hydrogen is obtained from natural gas.
- The reaction conditions for the Haber process are:
  1. Temperature: 450 ˚C
  2. Pressure: 200 atm (atmospheres)
  3. Iron catalyst present

Position of Equilibrium

- At equilibrium there will typically be either more reactants (A and B - the equilibrium lies to the left) or more products (C and D - the equilibrium lies to the right).
- The exact point of equilibrium depends on the reaction occurring and the following conditions:
  1. Temperature
  2. Pressure (when gases are involved)
  3. Concentrations

HIGHER ONLY - Le Chatelier's principle

- You can predict how the point of equilibrium will change when the conditions are changed. Collectively these rules form what is called Le Chatelier's principle.

Condition	Change	Equilibrium point changes to…
Temperature	increased	endothermic reaction rate increases (heat absorbed from the environment).
	decreased	exothermic reaction rate increases (heat released to the environment).
Pressure of a gas	increased	rate of reaction that produces less moles of gas increases.
	decreased	rate of reaction that produces more moles of gas increases.
Concentration of a substance	increased	rate of reaction that uses up the added substance increases.
	decreased	rate of reaction that forms the removed substance increases.

Worked example

Exothermic →

4 moles of gas $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ 2 moles of gas

← Endothermic

Condition	Change	Equilibrium point changes to…
Temperature	increased	endothermic reaction rate increases – more N_2 and H_2 produced
	decreased	exothermic reaction rate increases – more NH_3 produced
Pressure	increased	rate of reaction that produces less moles of gas increases – more NH_3 produced
	decreased	rate of reaction that produces more moles of gas increases – more N_2 and H_2 produced
Concentration of NH_3	increased	rate of reaction that uses up the added substance increases - more N_2 and H_2 produced
	decreased	rate of reaction that forms the removed substance increases - more NH_3 produced