CAIE Chemistry IGCSE

6.3 Reversible reactions and equilibrium

Flashcards

What is a reversible reaction?

What is a reversible reaction?

A reaction in which the products can react to reform the original reactants.

Denoted by the symbol: $\rightleftharpoons$

How can the direction of a reversible reaction be altered?

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Changing the reaction conditions.

E.g. Temperature, pressure, concentration.

The dehydration of copper (II) sulfate is a reversible reaction. Describe how the conditions can be altered to change the reaction direction.

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Anhydrous copper (II) sulfate + water ⇌ hydrated copper (II) sulfate

The white solid will turn blue in the presence of water.

- Add water to cause the forward reaction to occur.
- Heat the hydrated copper (II) sulfate to evaporate the water so that the backwards reaction occurs.

The dehydration of cobalt (II) chloride is a reversible reaction. Describe how the conditions can be altered to change the reaction direction.

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Anhydrous cobalt(II) chloride + water ⇌ hydrated cobalt(II) chloride

The blue solid will turn pink in the presence of water.

- Add water to cause the forward reaction to occur.
- Heat the hydrated cobalt(II) chloride to evaporate the water so that the backwards reaction occurs.

What is meant by the term dynamic equilibrium?

(extended only)

What is meant by the term dynamic equilibrium? (extended only)

Dynamic equilibrium is when the rate of the forward reaction equals the rate of the backwards reaction. This means the concentration of reactants and products remain the same even though reactions are constantly occurring, in a closed system.

What is a closed system?
(extended only)

What is a closed system? (extended only)

A system where nothing is added or removed. All reactants and products remain in the reaction vessel.

Why is equilibrium only reached if the reaction takes place in a closed system? (extended only)

Why is equilibrium only reached if the reaction takes place in a closed system? (extended only)

The closed system prevents any reactants and products escaping so that they are able to react continuously.

Explain the effect of changing the temperature of a reversible reaction if the forward reaction is endothermic (extended only)

Explain the effect of increasing the temperature of a reversible reaction if the forward reaction is endothermic (extended only)

The forward reaction is endothermic so increasing the temperature favours the forward reaction. The position of equilibrium will shift towards the right and the yield of the products will increase.

Explain the effect of changing the pressure on the position of equilibrium (extended only)

Explain the effect of increasing the pressure on the position of equilibrium (extended only)

An increase in pressure will favour the reaction that produces the least number of molecules.

The equilibrium position will shift towards the side that produces the fewest gaseous molecules.

Explain the effect of changes in concentration on the position of equilibrium (extended only)

Explain the effect of changes in concentration on the position of equilibrium (extended only)

Change in concentration	Effect on position of equilibrium (P.O.E)
Conc. of reactant increases	P.O.E shifts to the right
Conc. of reactant decreases	P.O.E shifts to the left
Conc. of product increases	P.O.E shifts to the left
Conc. of product decreases	P.O.E shifts to the right

Describe the effect of a catalyst on the position of equilibrium (extended only)

Describe the effect of a catalyst on the position of equilibrium (extended only)

A catalyst will have no effect on the position of equilibrium.

A catalyst speeds up the forward and reverse reactions equally so equilibrium is reached more quickly

Give the symbol equation for the Haber process

(extended only)

Give the symbol equation for the Haber process (extended only)

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

Suggest the sources for the reactants in the Haber process

(extended only)

Suggest the sources for the reactants in the Haber process (extended only)

The reactants: nitrogen and hydrogen
Nitrogen: Extracted from the air through fractional distillation
Hydrogen: Methane reacted with steam, hydrogen is one of the products

Give the typical conditions for the Haber process

(extended only)

Give the typical conditions for the Haber process (extended only)

Temperature: 450°C

Pressure: 200,000 kPa or 200 atm

An iron catalyst is used

Give the symbol equation for the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

Give the symbol equation for the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Give the sources of sulfur dioxide and oxygen in the Contact process (extended only)

Give the sources of sulfur dioxide and oxygen in the Contact process (extended only)

Sulfur dioxide: The first stage of the Contact process produces sulfur dioxide by burning sulfur in air (sulfur + oxygen). Sulfur dioxide can also be obtained from roasting sulfide ores.

Oxygen: Extracted from the air around us

Give the typical conditions for the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

Give the typical conditions for the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

Temperature: 450°C

Pressure: 200 kPa or 2 atm

A vanadium (V) oxide catalyst is used

The equation for the Haber process is

$$N_2 + 3H_2 \rightleftharpoons 2NH_3.$$

The forward reaction is exothermic.

Explain the effect of decreasing the temperature on the yield of ammonia

(extended only)

The equation for the Haber process is $N_2 + 3H_2 \rightleftharpoons 2NH_3$ .The forward reaction is exothermic. Explain the effect of decreasing the temperature on the yield of ammonia (extended only)

Decreasing the temperature shifts the position of equilibrium in the exothermic (forward) direction so increasing the yield of ammonia

Why is a compromise temperature of 450°C used in the Haber process and the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

Why is a compromise temperature of 450°C used in the Haber process and the conversion of sulfur dioxide to sulfur trioxide in the Contact process (extended only)

Low temperatures would favour the forward (exothermic) reaction for both these processes, but low temp. means a slow rate of reaction, so a compromise temp is used

The equation for the Haber process is N_2 (g) + $3H_2$ (g) $\rightleftharpoons$ $2NH_3$ (g).
Explain the effect of increasing the pressure on the yield of ammonia
(extended only)

The equation for the Haber process is

$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$.

Explain the effect of increasing the pressure on the yield of ammonia (extended only)

Increasing the pressure will shift equilibrium to the right as there are fewer molecules of gas. The yield of ammonia will increase.

Why is a catalyst used in the Haber process

(extended only)

Why is a catalyst used in the Haber process (extended only)

An iron catalyst speeds up the rate of the forward and reverse reaction equally so that equilibrium is reached faster.

Catalyst has no effect on the position of equilibrium.

Rate of reaction is faster = a lower temperature can be used whilst still keeping the production of ammonia high

What safety and economic concerns are there for the conditions in the Haber process?

(extended only)

What safety and economic concerns are there for the conditions in the Haber process?

(extended only)

High pressure means high cost due to high energy costs and more expensive equipment.

Increasing the pressure too much in a closed system can also be highly dangerous as there is a risk of explosion.

Recycling unreacted hydrogen and nitrogen back into the process reduces the cost of producing more reactants.

The reversible reaction in the Contact process is

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.

The forward reaction is exothermic.

Explain the effect of increasing the temperature on the yield of sulfur trioxide

(extended only)

The reversible reaction in the Contact process is $2SO_2 + O_2 \rightleftharpoons 2SO_3$ .The forward reaction is exothermic.

Explain the effect of increasing the temperature on the yield of sulfur trioxide (extended only)

Increasing the temperature shifts the position of equilibrium in the endothermic (reverse) direction so decreasing the yield of sulfur trioxide

The reversible reaction in the Contact process is

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.

Explain the effect of increasing the pressure on the yield of sulfur trioxide.

(extended only)

The reversible reaction in the Contact process is $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.
Explain the effect of increasing the pressure on the yield of sulfur trioxide (extended only)

Increasing the pressure will shift equilibrium to the right as there are fewer molecules of gas. The yield of sulfur trioxide will increase.

What safety and economic concerns are there for the conditions in the Contact process?

(extended only)

What safety and economic concerns are there for the conditions in the Haber process?

(extended only)

Even though a higher pressure would result in more product, sulfur trioxide is an acidic gas so the risk of explosion is too high.

Higher pressures also mean higher cost of equipment.

If there are equal gaseous molecules of the reactant and product in a reversible reaction, what effect will changing the pressure have on the equilibrium position?

(extended only)

If there are equal gaseous molecules of the reactant and product in a reversible reaction, what effect will changing the pressure have on the equilibrium position? (extended only)

No effect