Year 12 Chemistry Depth Study

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Abstract

This depth study report explores the role of equilibrium systems and reversible reactions within industrial applications, including the Contact Process and the Solvay Process.

1 Contact Process

The Contact Process is a multi-step industrial process used to produce sulfuric acid.

1. Produce sulfur dioxide from sulfur and excess oxygen
2. Convert sulfur dioxide to sulfur trioxide
3. Produce oleum (fuming sulfuric acid) from sulfur trioxide
4. React oleum with water to produce concentrated sulfuric acid

1.1 Exploring the Contact Process

1.1.1 Producing sulfur dioxide

In order to produce sulfur dioxide, an irreversible exothermic combustion reaction between sulfur and oxygen is used to produce sulfur dioxide.

$$S_{(s)} + O_2(g) \rightarrow SO_2(g) \tag{1}$$

1.1.2 Sulfur dioxide to sulfur trioxide

The conversion of sulfur dioxide to sulfur trioxide is an exothermic reversible reaction.

$$2SO_2(g) + O_2 2SO_3(g) \tag{2}$$

Catalyst A catalyst of **vanadium(V) oxide** is used to reduce the activation energy, hence reducing the energy used for the reaction.

1.1.3 Producing concentrated sulfuric acid

After the production of sulfur trioxide, sulfuric acid is produced. For a more stable reaction, sulfur trioxide is first dissolved in concentrated sulfuric acid, to produce **oleum** (or fuming sulfuric acid). Without this initial step, the reaction would produce sulfuric acid gas.

$$H_2SO_4(l) + SO_3(g) \rightarrow H_2S_2O_7(l) \tag{3}$$

Once oleum is produced, it is safely reacted with water to produce concentrated sulfuric acid.

$$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l) \tag{4}$$

As indicated by the molar ratio in reactions (3) and (4), the production of concentrated sulfuric acid from oleum produces twice as much concentrated sulfuric acid, as was originally used to produce oleum.

1.2 The uses and importance of sulfuric acid

Uses Sulfuric acid is a key primary product used to produce a number of other chemical compounds. In particular, it is a key reactant for the production of phosphate-based fertilisers. For example, calcium phosphates are often used as fertilised and is produced by reacting phosphorite with sulfuric acid.

$$Ca_3(PO_4)_2 + H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2CaSO_4 \tag{5}$$

Phosphate-based fertilisers are critical to the world's food supply, in ensuring that there is enough food production to sustain a growing world population. According to researchers, without phosphate and nitrogen-based fertilisers, humanity would only be able to produce half its current food production. [1] Although sulfur is

[1] Faradji & de Boer, 2016.

2 Bibliography

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