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**For issue on or after:  
13 March 2017**

**AS GCE CHEMISTRY B (SALTERS)**

**F332/01** Chemistry of Natural Resources

**ADVANCE NOTICE**

**Duration:** 1 hour 45 minutes



## NOTES FOR GUIDANCE (CANDIDATES)

- 1 This leaflet contains an article which is needed in preparation for a question in the externally assessed examination F332.
- 2 You will need to read the article carefully and also have covered the learning outcomes for Unit F332 (*Chemistry of Natural Resources*). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in Unit F332 to answer these questions. There are 20 marks available on the paper for these questions.
- 3 You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
- 4 For the examination on **9 June 2017** you will be given a fresh copy of this article, together with a Question Paper. You will **not** be able to bring your copy of the article, or other materials, into the examination.
- 5 You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

This document consists of 4 pages. Any blank pages are indicated.

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## Homogeneous catalysts

Article: Adapted from [resources.schoolscience.co.uk/johnsonmatthey](http://resources.schoolscience.co.uk/johnsonmatthey)

### How a homogeneous catalyst works

In homogeneous catalysis the reactants, products and catalyst are all in the same phase. Often the reactants, products and catalyst are all dissolved in the same solvent. Due to environmental considerations this solvent is often water. In these situations the catalyst may be a transition metal ion catalysing a redox reaction.

### Transition metals

The transition metal ion catalyses the original reaction by providing an alternative route between reactants and products that has a lower activation enthalpy. It can do this because transition metals (TM) can form stable compounds in more than one oxidation state and the transition metal ions can therefore readily move between oxidation states. During the catalysed reaction the transition metal ion is oxidised by one reactant to a higher oxidation state. This is then reduced back to the original form by reaction with the other reactant. The reactants are therefore converted to the same products as are formed without the catalyst. The only difference is that the reactants are converted into products more quickly.

reactant 1 + TM ion in low oxidation state  $\rightarrow$  product + TM ion in high oxidation state

reactant 2 + TM ion in high oxidation state  $\rightarrow$  product + TM ion in low oxidation state

### Examples of homogeneous reactions

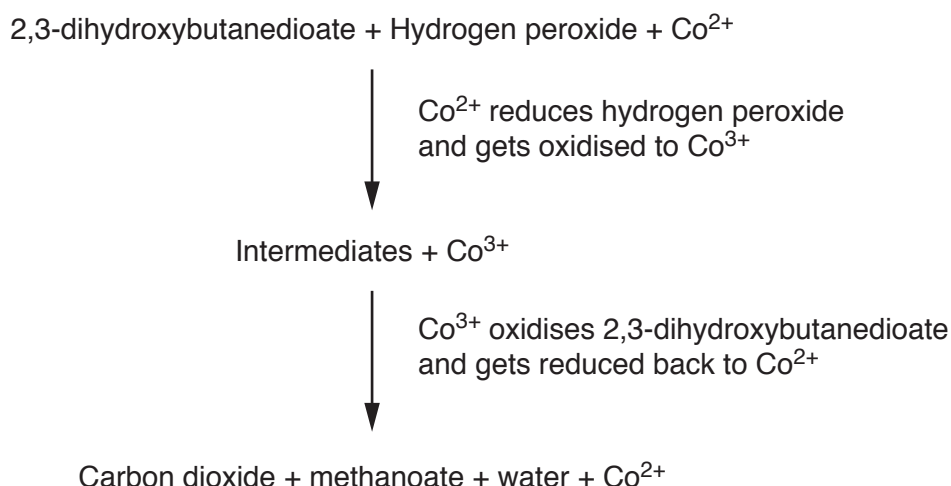
#### The reaction between hydrogen peroxide and 2,3-dihydroxybutanedioate ions

Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , oxidises the 2,3-dihydroxybutanedioate ions,  $\text{C}_4\text{H}_4\text{O}_6^{2-}$ , in potassium sodium 2,3-dihydroxybutanedioate (also known as potassium sodium tartrate or Rochelle salt) to carbon dioxide, methanoate ions,  $\text{HCOO}^-$ , and water.

#### Speeding up the reaction

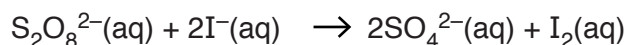
The reaction is slow, even when heated but it can be speeded up using cobalt(II) ions. The catalysed mixture starts off pink due to the presence of cobalt(II) ions. During the reaction the mixture turns green, indicating the presence of cobalt(III) ions. When the reaction is complete the mixture returns to a pink colour.

### Reaction flow chart



### The reaction between peroxodisulfate(VI) ions and iodide ions

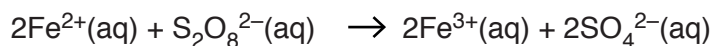
Peroxodisulfate(VI) ions and iodide ions react together in aqueous solution to form sulfate(VI) ions and iodine.



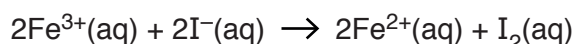
### Transition metal catalysts

This reaction is catalysed by a number of transition metal ions including  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$ .

If a small amount of  $\text{Fe}^{2+}$  ions are added to the reaction mixture, they will reduce the peroxodisulfate(VI) ions to sulfate(VI) ions and will be oxidised to  $\text{Fe}^{3+}$  ions in the process.



The  $\text{Fe}^{3+}$  ions produced will oxidise iodide ions to iodine and will be reduced back to  $\text{Fe}^{2+}$  ions in the process.



The  $\text{Fe}^{2+}$  ions produced can reduce more peroxodisulfate(VI) ions and so the catalysed reaction can continue.

### The CFC story

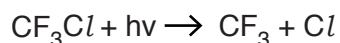
The depletion of the ozone layer has been linked to the release of chlorofluorocarbons (CFCs) into the atmosphere. These molecules were widely used as propellants for aerosols, as refrigerants, as cleaning solvents and as blowing agents for making expanded plastics.

The CFCs are very good for these uses, partly because the molecules are so inert. It is this very inertness, however, that causes the ozone problem. The molecules can persist in the atmosphere for a very long time, up to a hundred years, without being broken down as most molecules are. Eventually they will move to the upper atmosphere. Here they are no longer inert. The high energy ultra violet radiation from the sun breaks them down, releasing highly reactive chlorine atoms.

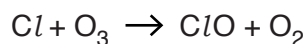
It is these chlorine atoms that catalyse the breakdown of ozone causing the 'hole' in the ozone layer over Antarctica.

### Catalysing ozone removal

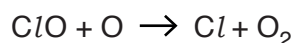
Step 1 In the stratosphere, CFCs are broken down by sunlight releasing very reactive chlorine atoms.



Step 2 The chlorine atoms react with ozone to produce chlorine oxide and dioxygen molecules.



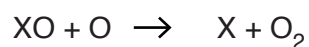
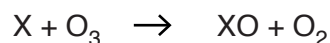
Step 3 The chlorine oxide molecule is also very reactive and can react with oxygen atoms to regenerate the chlorine atom.



Step 4 The chlorine atoms are involved in a catalytic cycle. It is estimated that one chlorine atom can remove about a million ozone molecules.

### Free radicals

Chlorine and bromine atoms are also known as free radicals. Other free radicals in the stratosphere can also remove ozone. If we show a free radical by the general symbol X then the mechanism for the catalytic destruction of ozone is as follows



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