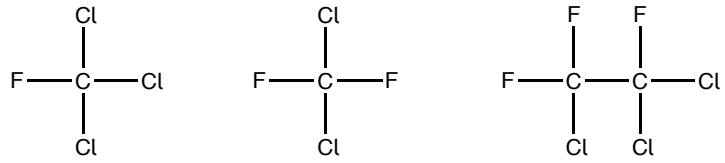
CFCs & OZONE

What are CFCs?

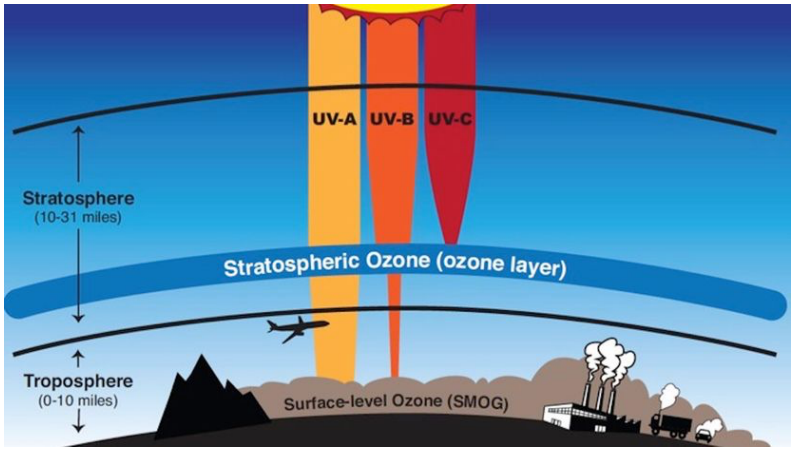
- CFCs are chlorofluorocarbons.
- CFCs were used as
  - coolant in refrigerators
  - propellant in aerosols
  - degreaser for circuit boards

e.g.



What is ozone?

- Ozone is a form of oxygen, O_3
- There is a "layer" of ozone in the stratosphere (a region where there is a higher concentration of ozone)
- The ozone layer absorbs harmful UV radiation. This radiation can damage DNA and cause, for example, skin cancer.



What CFCs do to the ozone layer

- CFCs escape and rise into the stratosphere.
- CFCs break down in the stratosphere to form Cl● free radicals by the breaking of a C–Cl bond. The energy comes from UV light. For example

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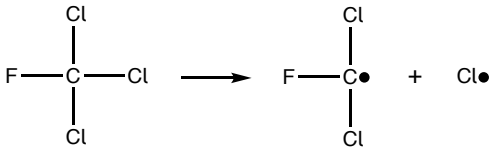

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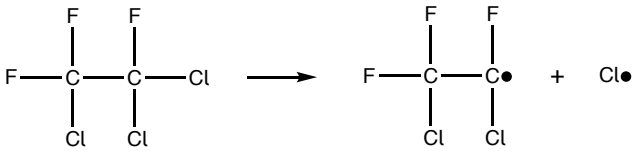


- These Cl● free radicals catalyse the destruction of ozone in a free radical chain reaction.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$$

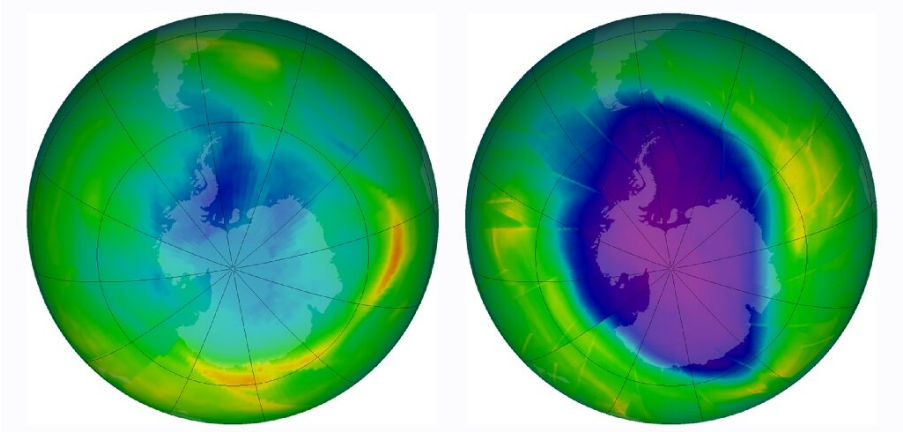
$$\text{Overall } 2O_3 \rightarrow 3O_2$$

- One Cl● free radical can catalyse the destruction of a huge number of ozone molecules.

Ozone depletion

- The concentration of ozone in the ozone layer fell significantly as CFCs went into large scale use.
- The fall in concentration was particularly significant over the Earth's poles. These areas are often referred to as "holes" in the ozone layer.
- Chemists suspected that the large-scale use of CFCs would lead to depletion of the ozone layer. In 1974, Molina and Rowland published research to show how CFCs would damage the ozone layer.
- In the early 1980s, evidence started to appear to show that the ozone layer was being depleted, in particular near the Earth's poles. Since then, skin cancer has become a much greater problem, especially in countries nearer the poles such as Australia.
- In 1995 Molina and Rowland won the Nobel Prize for Chemistry for their work on ozone and CFCs.

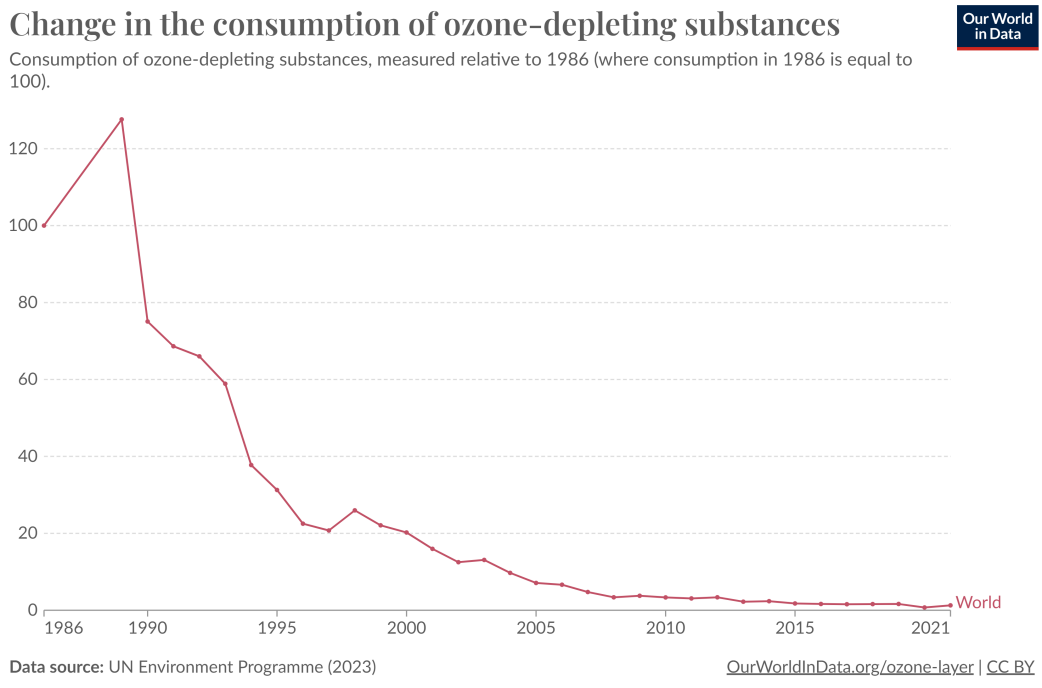
Antarctica ozone "hole"



1979 2009

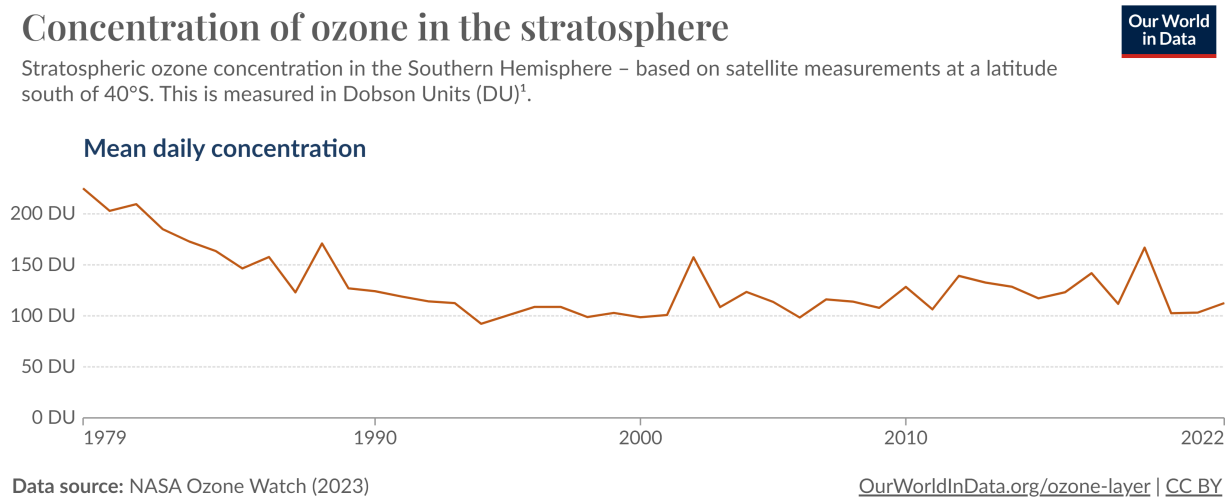
Montreal Protocol

- In 1987, several countries (including the UK) signed the Montreal Protocol to ban the use of CFCs.
- More countries have since banned their use and so the use of CFCs has fallen dramatically.
- The banning of the use of CFCs is one of the most effective environmental actions ever.



The ozone layer since the banning of CFCs

- The concentration of ozone in the atmosphere has stopped falling in recent years. The
- There are still some CFCs in use, for example in old refrigerators. While the CFCs are properly removed and disposed of from many old refrigerators, this is not always the case and so some are still being emitted into the atmosphere.
- It is predicted that the ozone concentration will start to rise again over time, but we have stopped its depletion.



Alternatives to CFCs

- CFCs have been replaced by chemicals that do not contain chlorine, e.g.
  - 1,1,1,2-tetrafluoroethane as the coolants in refrigerators, CF_3CH_2F
  - butane as the propellant in aerosols, $CH_3CH_2CH_2CH_3$
- They cannot break down to produced chlorine free radicals as they do not contain any chlorine atoms.
- It should noted that all the CFC replacements are greenhouse gases (as are CFCs) and so they are not without some problems still.

TASK – CFCs & OZONE

1 **a** Write an equation to show the formation of ozone destroying free radicals from CFC-12, CF_2Cl_2

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b Write a pair of equations to show how free radicals from part **a** destroy ozone molecules.

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2 **a** Write an equation to show the formation of ozone destroying free radicals from CFC-114, CF_2ClCF_2Cl

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b Write a pair of equations to show how free radicals from part **a** destroy ozone molecules.

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c Explain why one free radical from part **a** can destroy very many ozone molecules.

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3 R-134a (CF_3CH_2F) is commonly used as a refrigerant in place of CFCs. Explain why this compound cannot destroy ozone.

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