

Name: _____

Date: _____

Class: _____

IB ESS

6.2 Stratospheric Ozone

Significant ideas:

Stratospheric ozone is a key component of the atmospheric system because it protects living systems from the negative effects of ultraviolet radiation from the Sun.

Human activities have disturbed the dynamic equilibrium of stratospheric ozone formation.

Pollution management strategies are being employed to conserve stratospheric ozone.



Ultraviolet Radiation and Ozone

1. List the potential harmful effects of ultraviolet radiation on living tissue.

Damages human tissue increasing the incidence of cataracts, mutation during cell division, skin cancer and suppression of immune system.
Damage to photosynthetic organisms, especially phytoplankton

2. Explain how increased levels of UV radiation can influence biological productivity.

UV radiation destroys chlorophyll which reduces the rate of photosynthesis, phytoplankton which live in the upper layer of water are most affected. As phytoplankton are consumed by zooplankton their numbers are depleted - overall reduction in productivity.

3. With reference to the three types of UV radiation, outline how the frequency of the radiation affects its potential to cause harm to living tissues.

UVa - low energy, long wavelength, least harmful

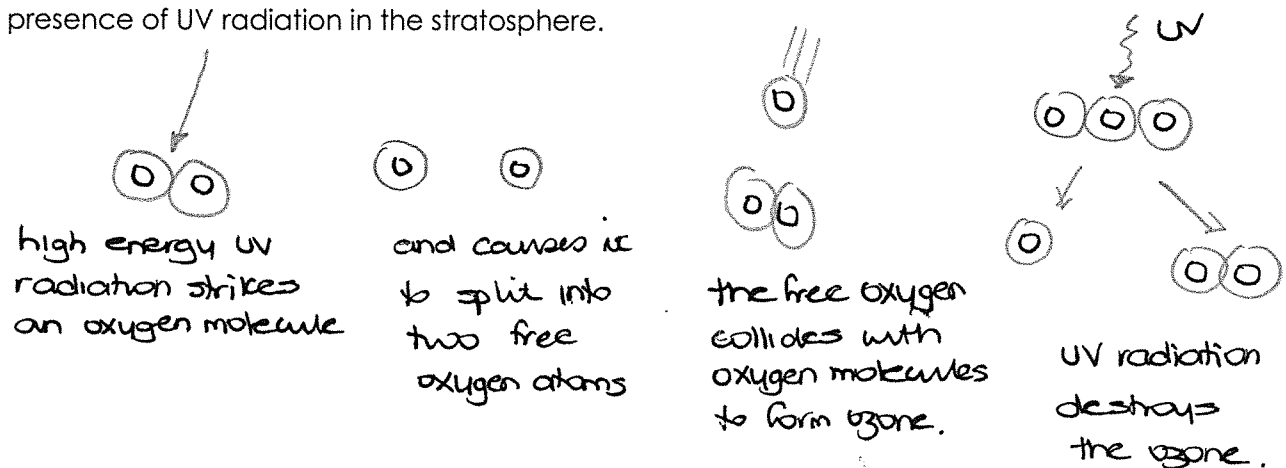
UV b

UV c - highest energy, shortest wavelength most harmful

4. State why the stratospheric ozone is said to exist in a "dynamic equilibrium".

Ozone formation and breakdown is a natural process. Ozone is constantly produced by sunlight and destroyed by NO_x in stratosphere

5. Draw a diagram to summarise the natural formation and destruction of ozone in the presence of UV radiation in the stratosphere.



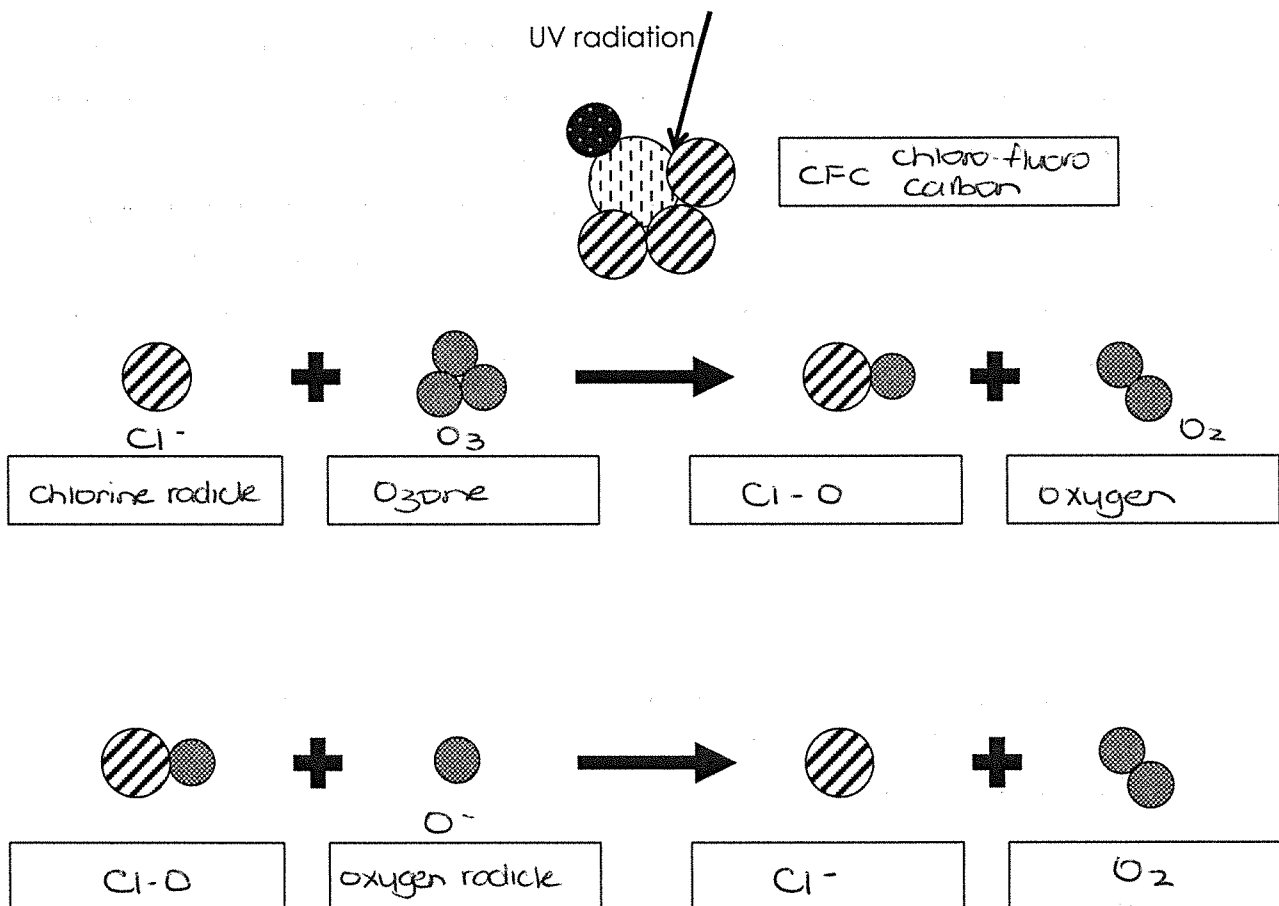
Ozone-Depleting Substances

1. Chloroflourocarbons (CFCs) can deplete ozone levels. List the uses of CFCs:

Manufacture of aerosol sprays, foams, packing materials, refrigerants, pesticides, flame retardants

2. The diagram below represents the depletion of ozone as a consequence of CFC emission. Label each molecule below. Use the following words:

Chlorine radical, ClO, CFC, Oxygen molecule, Ozone molecule, Oxygen radical



Note: You don't need to know words like "radical", and you don't need to memorise any equations. The diagram above is to help with your understanding, but you aren't expected to learn it by heart.

3. From the diagram above, you should understand the following points:

- Chlorofluorocarbons release Chlorine atoms when exposed to UV radiation in the atmosphere.
- The chlorine atom reacts with ozone and breaks it down to molecular oxygen (and produces ClO).
- ClO can then be split up to regenerate a chlorine atom. This can continue to deplete levels of stratospheric ozone.

4. State the effect of CFC release on the amount of UV radiation reaching living things:

More UV reaches Earth and affects tissues and productivity

5. Explain the formation of the "hole in the ozone layer".

The amount of ozone in the stratosphere above Antarctica decreases significantly during spring (September and October) and increased again in November. Apart from this annual cycle during the last 30 years, the minimum thickness of the ozone layer has reduced drastically and recovery has been taken longer hence the use of the term 'hole' Ozone depletion is the result of air pollution by chemicals that are mostly human-made.

6. Complete the table to list ozone depleting substances and their uses/sources.

ODS	Use or Source
CFCs chlorofluoro-carbons	propellants in spray cans, plastic foam expanders
HCFCs hydrochlorofluoro carbons	An alternative to CFCs (Less harmful, but still harmful)
Halons	Fire Extinguishers
Methyl Bromide	Pesticide
NO _x	Bacterial breakdown of nitrites and nitrates in soil (intensive farming) high-flying supersonic aircraft



Pollution Management Strategies for ODSs

1. Using the pollution management strategy model (the table below), summarize methods to reduce ozone depleting substances.

Strategy for reducing pollution	
Altering human activity	Replace gas-blown plastics Replace CFCs with carbon dioxide, propane or air as a propellant Replace aerosols with pump action sprays Replace methyl bromide pesticides
Regulating and reducing pollutants at the source	Recover and recycle CFCs from refrigerators and AC units Legislate to have fridges returned to the manufacturer and coolants removed and stored Capture CFCs from scrap car air conditioner units
Clean up and restoration	Add ozone to or remove chlorine from stratosphere - not practical



3. Evaluate the role of national and international organisations in reducing the emissions of ozone-depleting substances.

Hint: UNEP and the Montreal Protocol should be included in your answers.

UNEP has played a key role in providing information and creating and evaluating international agreements for the protection of stratospheric ozone. In 1987 UNEP brought together 24 countries to sign the initial Montreal Protocol on substances that deplete the ozone layer. Now 197 countries have signed the protocol. Production of ODSs fell from 1.8 million tonnes in 1987 to 45 000 tonnes in 2010. UNEP hopes to end the production of HCFCs by 2040. This has been a successful programme.

The Montreal Protocol is the most successful and significant agreement relating to an environmental issue, with many governments signing up and implementing the changes. The success has led to a reduced phasing-out schedule.

The Protocol raised public awareness of the use of CFCs and provided an incentive for countries to find an alternative. Technology has been transferred to LEDCs to allow them to replace ODSs, but some substances used are still ozone depleting like HCFCs. Some HCFCs have been replaced by hydrofluorocarbons (HFCs) but these are powerful GHGs.

There are some issues that are hard to overcome

- It is harder for LEDCs to implement changes
- The second-hand appliance market means that old fridges are still in circulation.
- It is a protocol that depends on national governments being willing to comply
- The long life of the chemicals in the atmosphere means that the damage will continue for some time - until 2100

Overall a successful agreement. Some countries, for example Australia, have a swift response to phasing out the use of ODSs. However Australia accounts for less than 1% of these global emissions. To assist this process Australia participates in the Multilateral Fund for the Implementation of the Montreal Protocol which helps LEDCs implement the protocol thereby increasing its effectiveness.

