6.4 Stratospheric ozone

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS ozone layer • ultraviolet radiation • CFCs • catalyst • ozone hole • Montreal Protocol

Objective

Build the skills to answer exam questions on **stratospheric ozone** : how the ozone layer protects life, how **ozone-depleting substances** destroy it, and the **Montreal Protocol** .

You must be able to:

- explain how the ozone layer absorbs UV radiation
- explain how CFCs and other ozone-depleting substances destroy ozone
- describe the effects of increased UV on people and ecosystems
- evaluate the Montreal Protocol and its lessons for other problems

1 Key knowledge and worked examples

■ Stratospheric ozone

Ozone (O_3) in the stratosphere absorbs most harmful **ultraviolet** (UV) radiation. UV splits O_2 into oxygen atoms, which join O_2 to make O_3; UV also splits O_3. In a natural balance, ozone is made and broken down at the same rate.

Ozone-depleting substances (ODS): chlorofluorocarbons (**CFCs**) from old fridges, aerosol sprays and foams; halons (fire extinguishers); methyl bromide (pesticide). In the stratosphere, UV breaks them up and releases **chlorine** or **bromine** atoms. One chlorine atom can destroy many thousands of ozone molecules, because it is not used up (it acts as a **catalyst**).

Ozone hole: over Antarctica in spring (September–October). In the very cold winter, polar stratospheric clouds form; on their surfaces chlorine is turned into forms that sunlight in spring quickly breaks into ozone-destroying atoms.

Effects of more UV-B: skin cancer, cataracts (eye damage), weaker immune system; damage to crops and to **phytoplankton**, the base of ocean food chains.

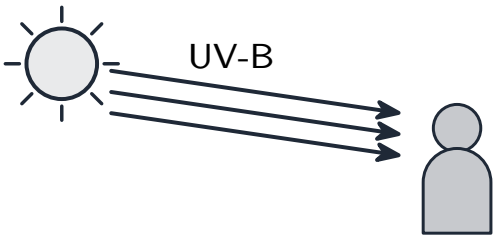
Montreal Protocol (1987): phased out CFCs and most other ODS; signed by every UN member state. Ozone is recovering and should return to 1980 levels over Antarctica around 2066. Some replacements (HFCs) are strong greenhouse gases, so the

Kigali Amendment (2016) phases them down too.

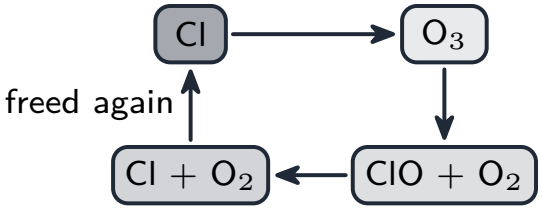
Answer shapes: link each step: CFC → UV releases chlorine → chlorine breaks ozone → more UV reaches the surface → named harm.

2 Practice

2.1 State **two** effects on human health of more UV-B radiation reaching the ground. [2]



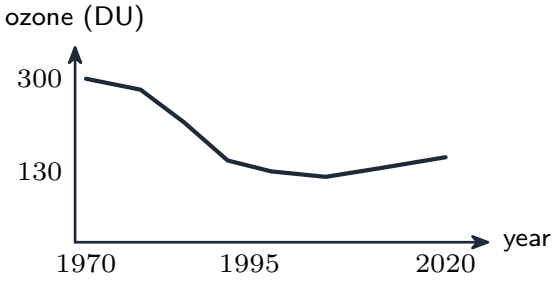
2.2 Explain how CFCs destroy ozone in the stratosphere. [3]



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3 Exam-style questions

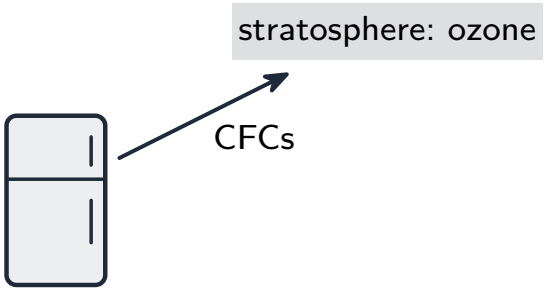
3.1 The graph shows the mean October ozone over Antarctica (approximate values).



(a) Describe the trend shown. [2]

(b) Explain why the ozone hole forms over Antarctica in spring. [2]

3.2 The Montreal Protocol is often called the most successful environmental agreement.

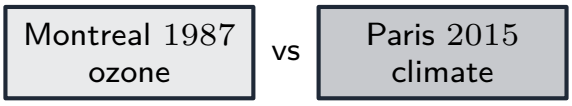


(a) Outline **two** reasons why the Montreal Protocol worked. [2]

(b) Explain why the ozone layer will take many decades to recover. [3]

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3.3 Some people say climate change should be solved like ozone depletion.



Discuss whether the success of the Montreal Protocol can be repeated for climate change. [5]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

any two: skin cancer; cataracts / eye damage; sunburn; weaker immune system

2.2

CFCs rise slowly into the stratosphere, where UV breaks them up and releases chlorine atoms; a chlorine atom reacts with ozone, forming oxygen; the chlorine is freed again, so one atom can destroy thousands of ozone molecules (catalyst)

3.1

(a) ozone fell sharply from about 300 DU in 1970 to about 130 DU in the 1990s; since about 2000 it has stopped falling and is rising slowly

(b) the very cold winter forms polar stratospheric clouds, where chlorine is changed into active forms; when sunlight returns in spring, it releases chlorine atoms that destroy ozone quickly

3.2

(a) any two: replacement chemicals were available at low cost; only a few firms made CFCs; clear scientific evidence and visible ozone hole; a fund helped poorer countries switch; trade limits with non-members

(b) CFCs stay in the atmosphere for decades to a century; CFCs are still released from old fridges, foams and landfills; some illegal production continues, and chlorine keeps destroying ozone as a catalyst until it is removed

3.3

award up to [5]: similarities: a global problem needing every country; strong science; help for poorer countries can work; differences: ODS came from a few products with cheap substitutes, but CO_2 comes from almost all energy use, transport, farming and industry; cutting CO_2 costs more and affects whole economies and jobs; Montreal had binding phase-out dates and trade limits; Paris targets are voluntary; conclusion: lessons on funding and review apply, but climate is much harder, with justification

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