Mario Molina puts the atmosphere and ozone on the political agenda

(Version 1)

A. Understanding ozone

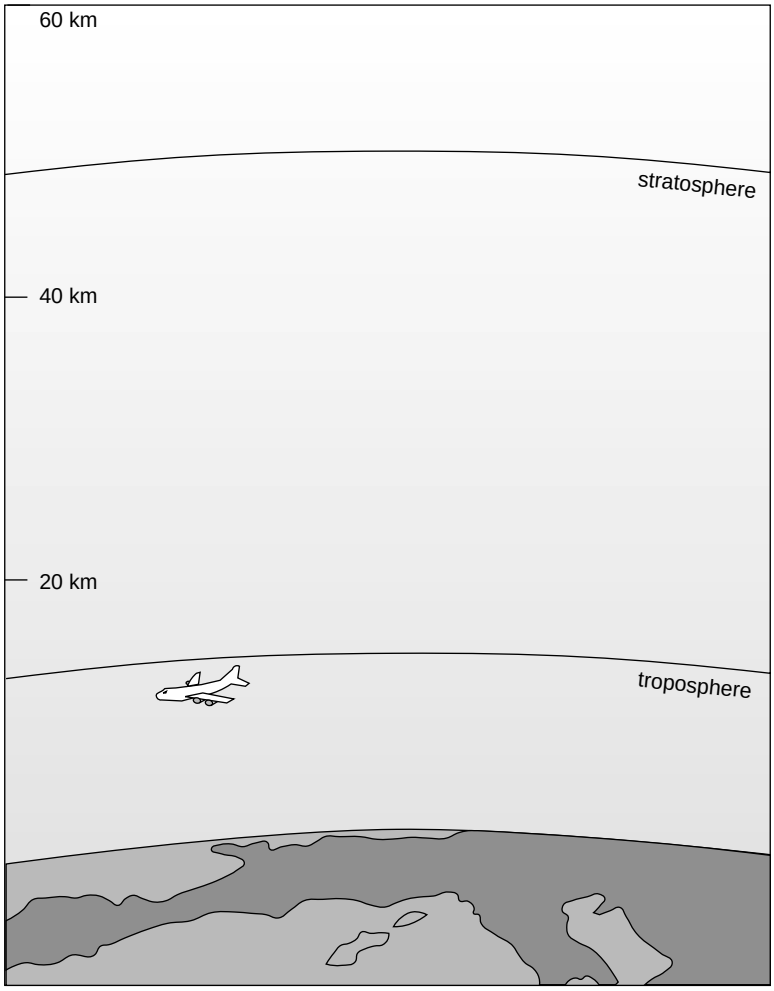


Diagram of our atmosphere
(Reproduced with permission from The Ozone Layer, UNEP/GEMS Environment Library No. 2, 1987, UNEP, Nairobi, Kenya.)

The chemical formula for ozone is O_3. The molecule contains three oxygen atoms. Ozone is quite harmful and is described by the following hazard symbols.

Ozone forms at ground level when pollutants such as nitrogen oxides and unburnt hydrocarbons react in sunlight.

Ozone in the stratosphere absorbs and protects the earth from harmful UV radiation, and is known as the ozone layer. Exposure to too much UV radiation leads to skin cancer and damages plants.

Question 1 How much do you know about sunbathing? Complete the table by ticking the correct box.

	True	**False**
A sun tan is healthy		
A tan will protect you from the sun		
You can get burnt on a cloudy day		
You can get burnt if you are in water		
With sunscreen to protect me, I can sunbathe for much longer.		

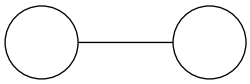
Sunburn facts

Ozone forms naturally in the upper atmosphere. Oxygen from lower levels rises into the stratosphere where it absorbs the sun's energy in the shorter wavelengths of ultraviolet radiation. This separates the two atoms in the molecules. These free atoms then combine with other oxygen molecules to form ozone.

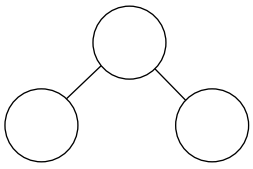
$$O_2 \xrightarrow{\text{short wavelength UV}} 2O$$

$$O_2 + O \longrightarrow O_3$$

$$O_3 \xrightarrow{\text{long wavelength UV}} O_2 + O$$



Oxygen



Ozone

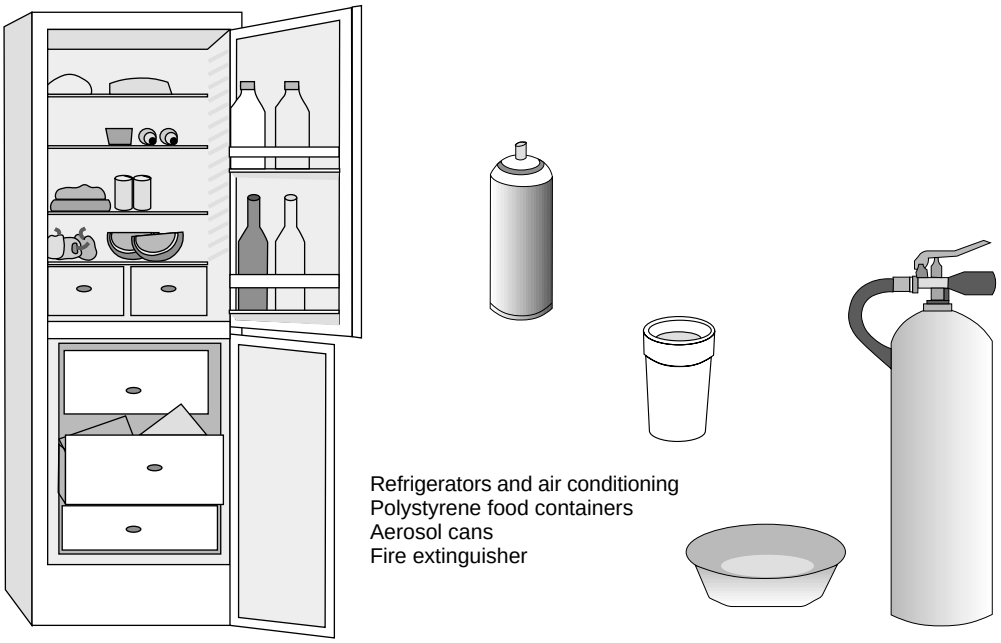
Oxygen and ozone molecules

The amount of ozone does not build-up endlessly since the energy from longer wavelengths of ultraviolet radiation breaks down the ozone molecules to produce oxygen. This process is greatly assisted by the presence in the high atmosphere of substances, such as oxides of nitrogen, which act as catalysts.

There is a very fine balance between the constant ozone production and destruction. Almost all the ultraviolet light from the sun which reaches the atmosphere is absorbed by the ozone layer. If this balance is upset, and too much ozone is destroyed, then UV light would damage plant and marine life and crop production, as well as causing skin cancer and cataracts in humans.

B. The CFC-ozone story

CFCs



The booming CFC industry of the early 1970s

$CFCl_3$ is a CFC used in air conditioners and refrigerators.

Question 1 Name the elements in a CFC molecule.

The molecules are very stable.

What type of bonding do they have?

The problem

After carrying out some calculations in 1973, Mario Molina, a research scientist, believed that CFCs could destroy the ozone layer in the stratosphere, and the Earth would no longer be protected from the harmful UV radiation.

The CFC-ozone story

The CFC-ozone story can be told by using a timeline. Your teacher will either supply you with a ready made timeline or give you a worksheet, so that you can make your own.

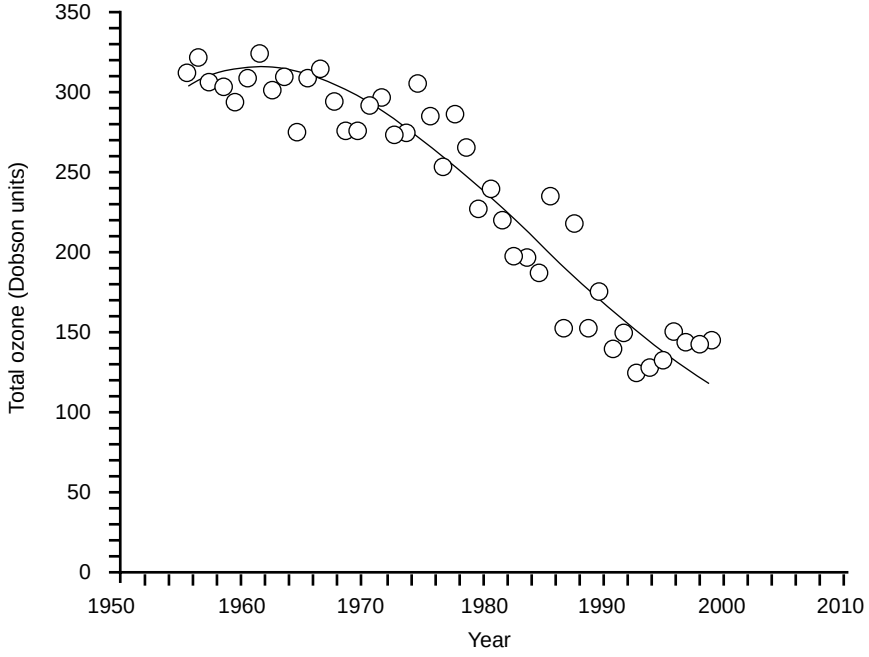
Timeline questions

1. Imagine that it is 1975, and you are working for a company such as Du Pont, that produces CFCs. What is your reaction when the State of Oregon bans the use of CFCs in aerosols?
2. Why do you think Du Pont announced that it would stop CFC production in 1988?
3. Do you agree with Du Pont's 1988 decision?

It is important to realise that the story is not yet over. Every day scientists record the ozone level in the atmosphere, alternative chemicals to CFCs are being researched, and it will be a long time before the hole in the ozone layer is gone.

Looking at the evidence

When Rowland and Molina first told the world their CFC-ozone theory in 1974, it was all based on theory, with no experimental evidence. Laboratory experiments later confirmed and modified the model. The amount of ozone in the stratosphere has been closely monitored at the Halley (since 1956), Rothera (since 1997) and Vernadsky / Faraday (since 1957) stations in Antarctica.

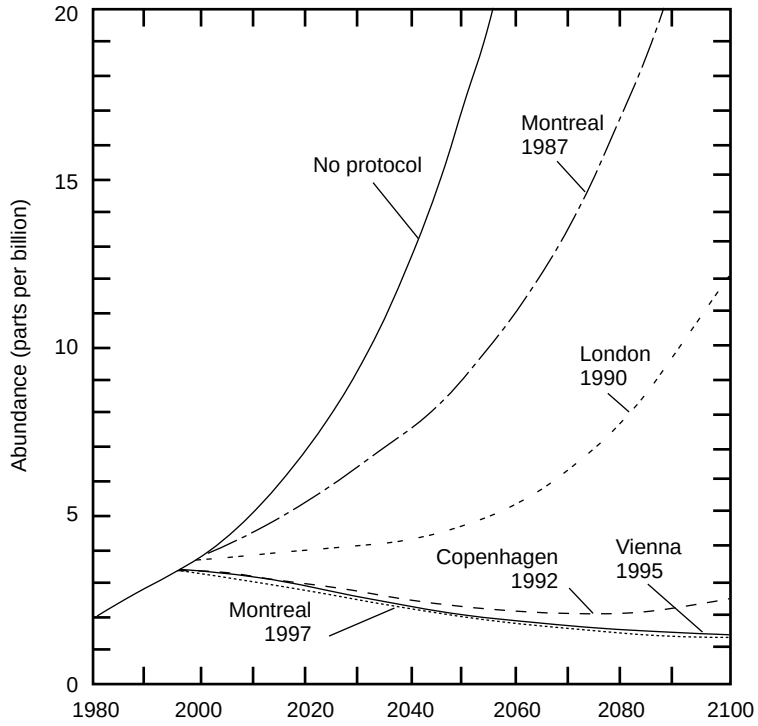


The mean October ozone levels recorded at the Halley station
(Reproduced with kind permission of J Shanklin, British Antarctic Survey (BAS).)

Evidence Questions

1. In which year did the ozone levels start to decrease?

2. From the data, do you think the ozone hole is still getting bigger?



Measured (1960-90) and projected (from 1990 onwards) concentrations of the chlorine in the atmosphere, under the terms of the original Montreal Protocol and later amendments
(Source: Action on Ozone 2000, UNEP, Nairobi, Kenya.)

On 14th September 1987, representatives from 43 different countries met together in Montreal to discuss the ozone problem. At the end of the meeting they agreed to freeze the production and consumption of CFCs at 1986 levels. By 1999, the levels of CFCs would be reduced by 50%.

3. Study the figure above showing the concentration of chlorine in the atmosphere and use the data presented here to either support or reject your answer to question 2.

4. In your own words explain why the Montreal Protocol and the later Amendments were a major breakthrough for the protection of the environment.

At the Antarctic Stations, constant monitoring of ozone levels has revealed that ozone levels naturally fluctuate throughout the year.

Either visit the British Antarctic Survey (BAS) website **http://www.antarctica.ac.uk/met/jds/ozone** (accessed September 2005), look up the ozone data or look at the data your teacher has given you. Then answer the following questions:

5. In which month of the year are the ozone levels highest?

6. In which month of the year are the ozone levels lowest?

7. How much do the ozone levels fluctuate on a daily basis?

8. Compare the present ozone level with the levels recorded before 1977.

9. In which month of the year is the temperature in the stratosphere highest?

10. In which month of the year is the temperature in the stratosphere lowest?

11. Can you find a relationship between ozone levels and temperature in the stratosphere?

12. Suggest a reason why ozone levels fluctuate.

Optional – you will need access to the Internet to work through this section

The Meteorological Office makes regular measurements of ozone at two sites in the United Kingdom. They use TOMS to provide accurate, detailed information. Visit their website at **http://www.metoffice.gov.uk/research/stratosphere/ozone/index.html** (accessed September 2005) (there is a direct link from the BAS site) to find out:

13. Where are the Metereological Office stations?

14. What long-term trends are seen at each station?

15. What does TOMS stand for?

16. Find a satellite picture showing the ozone hole.

17. Find the ozone level over the UK today.

To answer questions 16&17, you may need to surf other websites. A good place to start is at the Centre for Atmospheric Science, Cambridge University, with the 'The Ozone Hole Tour'. **http://www.atm.ch.cam.ac.uk/tour/index.html** (accessed September 2005)

The story continues…

CFCs and Ozone still makes the papers…even with all the data from scientific research, it is still a controversial subject. In developing countries economic reasons have meant that these chemicals are still being used, and even in the developed world there is still controversy. Read the following newspaper extract.

Greens see red / Overseas news
World summary

Sydney: The environmental group Greenpeace has asked a court to order the Olympics Co-ordinating Authority to stop styling the 2000 Olympics as the Green Games because it says that an ozone-depleting chemical will be used in the cooling system at one of the venues

30 March 1999, 'The Times', p.15

18. Do you support the views of Greenpeace? Visit the Greenpeace website at **http://www.greenpeace.org** (accessed September 2005) to find out more.

19. Research and find out about methods of cooling *ie* refrigerants and air conditioning systems that do not use CFCs.

20. Write a word-processed letter to the London 2012 Olympic Games Committee, either supporting Greenpeace or supporting the Olympics Co-ordinating Authority, on the subject of 'Green Games'. You should include scientific / technological evidence to back up your opinion.