FHSST Authors

The Free High School Science Texts: Textbooks for High School Students Studying the Sciences Chemistry Grades 10 - 12

Version 0
November 9, 2008

STOP!!!!

Did you notice the **FREEDOMS** we've granted you?

Our copyright license is **different!** It grants freedoms rather than just imposing restrictions like all those other textbooks you probably own or use.

- We know people copy textbooks illegally but we would LOVE it if you copied our's - go ahead copy to your hearts content, **legally!**
- Publishers' revenue is generated by controlling the market, we don't want any money, go ahead, distribute our books far and wide - we DARE you!
- Ever wanted to change your textbook? Of course you have! Go ahead, change ours, make your own version, get your friends together, rip it apart and put it back together the way you like it. That's what we really want!
- Copy, modify, adapt, enhance, share, critique, adore, and contextualise. Do it all, do it with your colleagues, your friends, or alone but get involved! Together we can overcome the challenges our complex and diverse country presents.
- So what is the catch? The only thing you can't do is take this book, make a few changes and then tell others that they can't do the same with your changes. It's share and share-alike and we know you'll agree that is only fair.
- These books were written by volunteers who want to help support education, who want the facts to be freely available for teachers to copy, adapt and re-use. Thousands of hours went into making them and they are a gift to everyone in the education community.

FHSST Core Team

Mark Horner ; Samuel Halliday ; Sarah Blyth ; Rory Adams ; Spencer Wheaton

FHSST Editors

Jaynie Padayachee ; Joanne Boulle ; Diana Mulcahy ; Annette Nell ; René Toerien ; Donovan Whitfield

FHSST Contributors

Rory Adams ; Prashant Arora ; Richard Baxter ; Dr. Sarah Blyth ; Sebastian Bodenstein ; Graeme Broster ; Richard Case ; Brett Cocks ; Tim Crombie ; Dr. Anne Dabrowski ; Laura Daniels ; Sean Dobbs ; Fernando Durrell ; Dr. Dan Dwyer ; Frans van Eeden ; Giovanni Franzoni ; Ingrid von Glehn ; Tamara von Glehn ; Lindsay Glesener ; Dr. Vanessa Godfrey ; Dr. Johan Gonzalez ; Hemant Gopal ; Umeshree Govender ; Heather Gray ; Lynn Greeff ; Dr. Tom Gutierrez ; Brooke Haag ; Kate Hadley ; Dr. Sam Halliday ; Asheena Hanuman ; Neil Hart ; Nicholas Hatcher ; Dr. Mark Horner ; Robert Hovden ; Mfandaidza Hove ; Jennifer Hsieh ; Clare Johnson ; Luke Jordan ; Tana Joseph ; Dr. Jennifer Klay ; Lara Kruger ; Sihle Kubheka ; Andrew Kubik ; Dr. Marco van Leeuwen ; Dr. Anton Machacek ; Dr. Komal Maheshwari ; Kosma von Maltitz ; Nicole Masureik ; John Mathew ; JoEllen McBride ; Nikolai Meures ; Riana Meyer ; Jenny Miller ; Abdul Mirza ; Asogan Moodaly ; Jothi Moodley ; Nolene Naidu ; Tyrone Negus ; Thomas O'Donnell ; Dr. Markus Oldenburg ; Dr. Jaynie Padayachee ; Nicolette Pekeur ; Sirika Pillay ; Jacques Plaut ; Andrea Prinsloo ; Joseph Raimondo ; Sanya Rajani ; Prof. Sergey Rakityansky ; Alastair Ramlakan ; Razvan Remsing ; Max Richter ; Sean Riddle ; Evan Robinson ; Dr. Andrew Rose ; Bianca Ruddy ; Katie Russell ; Duncan Scott ; Helen Seals ; Ian Sherratt ; Roger Sieloff ; Bradley Smith ; Greg Solomon ; Mike Stringer ; Shen Tian ; Robert Torregrosa ; Jimmy Tseng ; Helen Waugh ; Dr. Dawn Webber ; Michelle Wen ; Dr. Alexander Wetzler ; Dr. Spencer Wheaton ; Vivian White ; Dr. Gerald Wigger ; Harry Wiggins ; Wendy Williams ; Julie Wilson ; Andrew Wood ; Emma Wormauld ; Sahal Yacoob ; Jean Youssef

Contributors and editors have made a sincere effort to produce an accurate and useful resource. Should you have suggestions, find mistakes or be prepared to donate material for inclusion, please don't hesitate to contact us. We intend to work with all who are willing to help make this a continuously evolving resource!

www.fhsst.org

Contents

Chapter 22

The Atmosphere - Grade 11

Our earth is truly an amazing planet! Not only is it exactly the right distance from the sun to have temperatures that will support life, but it is also one of the only planets to have liquid water on its surface. In addition, our earth has an atmosphere that has just the right composition to allow life to exist. The **atmosphere** is the layer of gases that surrounds the earth. We may not always be aware of them, but without these gases, life on earth would definitely not be possible. The atmosphere provides the gases that animals and plants need for respiration (breathing) and photosynthesis (the production of food), it helps to keep temperatures on earth constant and also protects us from the sun's harmful radiation.

In this chapter, we are going to take a closer look at the chemistry of the earth's atmosphere and at some of the human activities that threaten the delicate balance that exists in this part of our planet.

22.1 The composition of the atmosphere

Earth's atmosphere is a mixture of gases. Two important gases are nitrogen and oxygen, which make up about 78.1% and 20.9% of the atmosphere respectively. A third gas, Argon, contributes about 0.9%, and a number of other gases such as carbon dioxide, methane, water vapour, helium and ozone make up the remaining 0.1%. In an earlier chapter, we discussed the importance of nitrogen as a component of proteins, the building blocks of life. Similarly, oxygen is essential for life because it is the gas we need for respiration. We will discuss the importance of some of the other gases later in this chapter.

Interesting Fact

The earth's early atmosphere was very different from what it is today. When the earth formed around 4.5 billion years ago, there was probably no atmosphere. Some scientists believe that the earliest atmosphere contained gases such as water vapour, carbon dioxide, nitrogen and sulfur which were released from inside the planet as a result of volcanic activity. Many scientists also believe that the first stage in the evolution of life, around 4 billion years ago, needed an oxygen-free environment. At a later stage, these primitive forms of plant life began to release small amounts of oxygen into the atmosphere as a product of photosynthesis. During photosynthesis, plants use carbon dioxide, water and sunlight to produce simple sugars. Oxygen is also released in the process.

$$6CO_2 + 6H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$$

This build-up of oxygen in the atmosphere eventually led to the formation of the ozone layer, which helped to filter the sun's harmful UV radiation so that plants were able to flourish in different environments. As plants became more widespread and photosythesis increased, so did the production of oxygen. The increase in the amount of oxygen in the atmosphere would have allowed more forms of life to exist.

If you have ever had to climb to a very high altitude (altitude means the 'height' in the atmosphere), you will have noticed that it becomes very difficult to breathe, and many climbers suffer from 'altitude sickness' before they reach their destination. This is because the density of gases becomes less as you move higher in the atmosphere. It is **gravity** that holds the atmosphere close to the earth. As you move higher, this force weakens slightly and so the gas particles become more spread out. In effect, when you are at a high altitude, the gases in the atmosphere haven't changed, but there are fewer oxygen molecules in the same amount of air that you are able to breathe.

Definition: Earth's atmosphere
The Earth's atmosphere is a layer of gases that surround the planet, and which are held there by the Earth's gravity. The atmosphere contains roughly 78.1% nitrogen, 20.9% oxygen, 0.9% argon, 0.038% carbon dioxide, trace amounts of other gases, and a variable amount of water vapour. This mixture of gases is commonly known as air. The atmosphere protects life on Earth by absorbing ultraviolet solar radiation and reducing temperature extremes between day and night.

22.2 The structure of the atmosphere

The earth's atmosphere is divided into different layers, each with its own particular characteristics (figure 22.1).

22.2.1 The troposphere

The **troposphere** is the lowest level in the atmosphere, and it is the part in which we live. The troposphere varies in thickness, and extends from the ground to a height of about 7km at the poles and about 18km at the equator. An important characteristic of the troposphere is that its temperature *decreases* with an increase in altitude. In other words, as you climb higher, it will get colder. You will have noticed this if you have climbed a mountain, or if you have moved from a city at a high altitude to one which is lower; the average temperature is often lower where the altitude is higher. This is because the troposphere is heated from the 'bottom up'. In other words, places that are closer to the Earth's surface will be warmer than those at higher altitudes. The heating of the atmosphere will be discussed in more detail later in this chapter.

The word troposphere comes from the Greek *tropos*, meaning *turning* or *mixing*. The troposphere is the most turbulent part of the atmosphere and is the part where our **weather** takes place. Weather is the state of the air at a particular place and time e.g. if it is warm or cold, wet or dry, and how cloudy or windy it is. Generally, jet aircraft fly just above the troposphere to avoid all this turbulence.

22.2.2 The stratosphere

Above the troposphere is another layer called the **stratosphere**, where most long distance aircraft fly. The stratosphere extends from altitudes of 10 to 50km. If you have ever been in an aeroplane and have looked out the window once you are well into the flight, you will have noticed

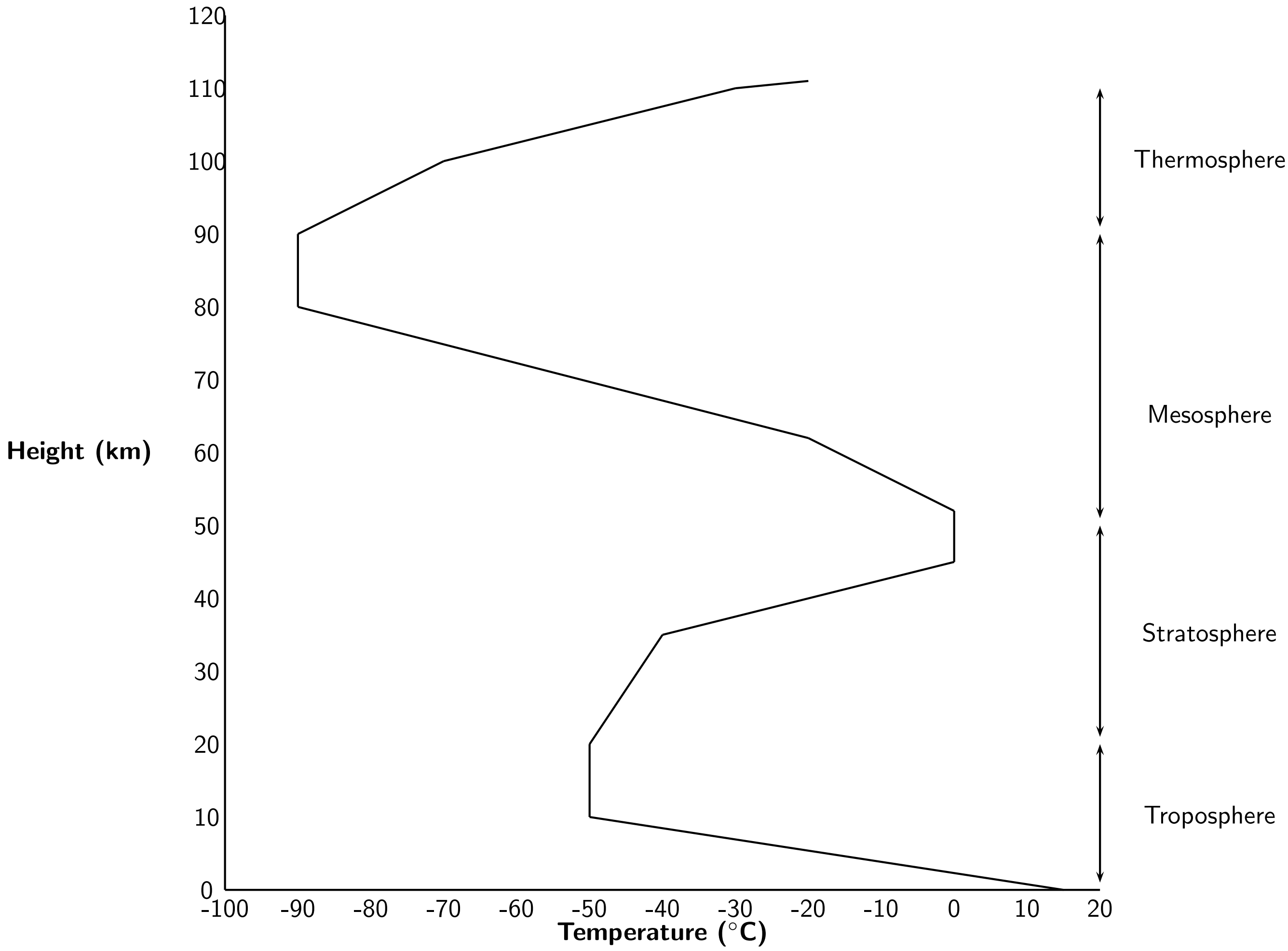


Figure 22.1: A generalised diagram showing the structure of the atmosphere to a height of 110 km

that you are actually flying above the level of the clouds. As we have already mentioned, clouds and weather occur in the troposphere, whereas the stratosphere has very stable atmospheric conditions and very little turbulence. It is easy to understand why aircraft choose to fly here!

The stratosphere is different from the troposphere because its temperature *increases* as altitude increases. This is because the stratosphere absorbs solar radiation directly, meaning that the upper layers closer to the sun will be warmer. The upper layers of the stratosphere are also warmer because of the presence of the **ozone layer**. Ozone (O_3) is formed when solar radiation splits an oxygen molecule (O_2) into two atoms of oxygen. Each individual atom is then able to combine with an oxygen molecule to form ozone. The two reactions are shown below:

$$O_2 \rightarrow O + O$$

$$O + O_2 \rightarrow O_3$$

The change from one type of molecule to another produces energy, and this contributes to higher temperatures in the upper part of the stratosphere. An important function of the ozone layer is to absorb UV radiation and reduce the amount of harmful radiation that reaches the Earth's surface.

Extension: CFCs and the ozone layer

You may have heard people talking about 'the hole in the ozone layer'. What do they mean by this and do we need to be worried about it?

Most of the earth's ozone is found in the stratosphere and this limits the amount of UV radiation that reaches the earth. However, human activities have once again disrupted the chemistry of the atmosphere. Chlorofluorocarbons (CFC's) are compounds found in aerosol cans, fridges and airconditioners. In aerosol cans, it is the CFC's that cause the substance to be sprayed outwards. The bad side of CFC's is that, when they are released into the atmosphere, they break down ozone molecules so that the ozone is no longer able to protect us as much from UV rays. The 'ozone hole' is actually a thinning of the ozone layer approximately above Antarctica. Let's take a closer look at the chemical reactions that are involved in breaking down ozone:

1. When CFC's react with UV radiation, a carbon-chlorine bond in the chlorofluorocarbon breaks and a new compound is formed, with a chlorine atom.

$$CFCl_3 + UV \rightarrow CFCl_2 + Cl$$

2. The single chlorine atom reacts with ozone to form a molecule of chlorine monoxide and oxygen gas. In the process, ozone is destroyed.

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

3. The chlorine monoxide then reacts with a free oxygen atom (UV radiation breaks O_2 down into single oxygen atoms) to form oxygen gas and a single chlorine atom.

$$ClO + O \rightarrow Cl + O_2$$

4. The chlorine atom is then free to attack more ozone molecules, and the process continues. A single CFC molecule can destroy 100 000 ozone molecules.

One possible consequence of ozone depletion is an increase in the incidence of skin cancer because there is more UV radiation reaching earth's surface. CFC replacements are now being used to reduce emissions, and scientists are trying to find ways to restore ozone levels in the atmosphere.

22.2.3 The mesosphere

The mesosphere is located about 50-80/85km above Earth's surface. Within this layer, temperature decreases with increasing altitude. Temperatures in the upper mesosphere can fall as low as -100°C in some areas. Millions of meteors burn up daily in the mesosphere because of collisions with the gas particles that are present in this layer. This leads to a high concentration of iron and other metal atoms.

22.2.4 The thermosphere

The thermosphere exists at altitudes above 80 km. In this part of the atmosphere, ultraviolet (UV) and shorter X-Ray radiation from the sun cause neutral gas atoms to be *ionised*. At these radiation frequencies, photons from the solar radiation are able to dislodge electrons from neutral atoms and molecules during a collision. A *plasma* is formed, which consists of negative free electrons and positive ions. This part of the atmosphere is called the **ionosphere**. At the same time that ionisation takes place however, an opposing process called recombination also begins. Some of the free electrons are drawn to the positive ions, and combine again with them if they are in close enough contact. Since the gas density increases at lower altitudes, the recombination process occurs more often here because the gas molecules and ions are closer together. The ionisation process produces energy which means that the upper parts of the thermosphere, which are dominated by ionisation, have a higher temperature than the lower layers where recombination takes place. Overall, temperature in the thermosphere increases with an increase in altitude.

Extension: The ionosphere and radio waves

The ionosphere is of practical importance because it allows **radio waves** to be transmitted. A radio wave is a type of electromagnetic radiation that humans use to transmit information without wires. When using high-frequency bands, the ionosphere is used to reflect the transmitted radio beam. When a radio wave reaches the ionosphere, the electric field in the wave forces the electrons in the ionosphere into oscillation at the same frequency as the radio wave. Some of the radio wave energy is given up to this mechanical oscillation. The oscillating electron will then either recombine with a positive ion, or will re-radiate the original wave energy back downward again. The beam returns to the Earth's surface, and may then be reflected back into the ionosphere for a second bounce.

The ionosphere is also home to the **auroras**. Auroras are caused by the collision of charged particles (e.g. electrons) with atoms in the earth's upper atmosphere. Charged particles are energised and so, when they collide with atoms, the atoms also become energised. Shortly afterwards, the atoms emit the energy they have gained, as light. Often these emissions are from oxygen atoms, resulting in a greenish glow (wavelength 557.7 nm) and, at lower energy levels or higher altitudes, a dark red glow (wavelength 630 nm). Many other colours can also be observed. For example, emissions from atomic nitrogen are blue, and emissions from molecular nitrogen are purple. Auroras emit visible light (as described above), and also infra-red, ultraviolet and x-rays, which can be observed from space.

Exercise: The composition of the atmosphere

1. Complete the following summary table by providing the missing information for each layer in the atmosphere.

Atmospheric layer	Height (km)	Gas composition	General characteristics
Troposphere	0-18		Turbulent; part of atmosphere where weather occurs
			Ozone reduces harmful radiation reaching Earth
Mesosphere			High concentration of metal atoms
	more than 80 km		

2. Use your knowledge of the atmosphere to explain the following statements:

(a) Athletes who live in coastal areas need to acclimatise if they are competing at high altitudes.
(b) Higher incidences of skin cancer have been recorded in areas where the ozone layer in the atmosphere is thin.
(c) During a flight, turbulence generally decreases above a certain altitude.

22.3 Greenhouse gases and global warming

22.3.1 The heating of the atmosphere

As we mentioned earlier, the distance of the earth from the sun is not the only reason that temperatures on earth are within a range that is suitable to support life. The composition of the atmosphere is also critically important.

The earth receives electromagnetic energy from the sun in the *visible spectrum*. There are also small amounts of infrared and ultraviolet radiation in this incoming solar energy. Most of the radiation is *shortwave* radiation, and it passes easily through the atmosphere towards the earth's surface, with some being reflected before reaching the surface. At the surface, some of the energy is absorbed, and this heats up the earth's surface. But the situation is a little more complex than this.

A large amount of the sun's energy is re-radiated from the surface back into the atmosphere as **infrared** radiation, which is invisible. As this radiation passes through the atmosphere, some of it is absorbed by **greenhouse gases** such as carbon dioxide, water vapour and methane. These gases are very important because they re-emit the energy back towards the surface. By doing this, they help to warm the lower layers of the atmosphere even further. It is this 're-emission' of heat by greenhouse gases, combined with surface heating and other processes (e.g. conduction and advection) that maintain temperatures at exactly the right level to support life. Without the presence of greenhouse gases, most of the sun's energy would be lost and the Earth would be a lot colder than it is! A simplified diagram of the heating of the atmosphere is shown in figure 22.2.

22.3.2 The greenhouse gases and global warming

Many of the greenhouse gases occur naturally in small quantities in the atmosphere. However, human activities have greatly increased their concentration, and this has led to a lot of concern about the impact that this could have in *increasing* global temperatures. This phenomenon is known as **global warming**. Because the natural concentrations of these gases are low, even a small increase in their concentration as a result of human emissions, could have a big effect on temperature. But before we go on, let's look at where some of these human gas emissions come from.

- **Carbon dioxide** (CO_2)

  Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g. the manufacture of cement). Carbon dioxide can also be *removed* from the atmosphere when it is absorbed by plants during photosynthesis.

- **Methane** (CH_4)

  Methane is emitted when coal, natural gas and oil are produced and transported. Methane emissions can also come from livestock and other agricultural practices and from the decay of organic waste.

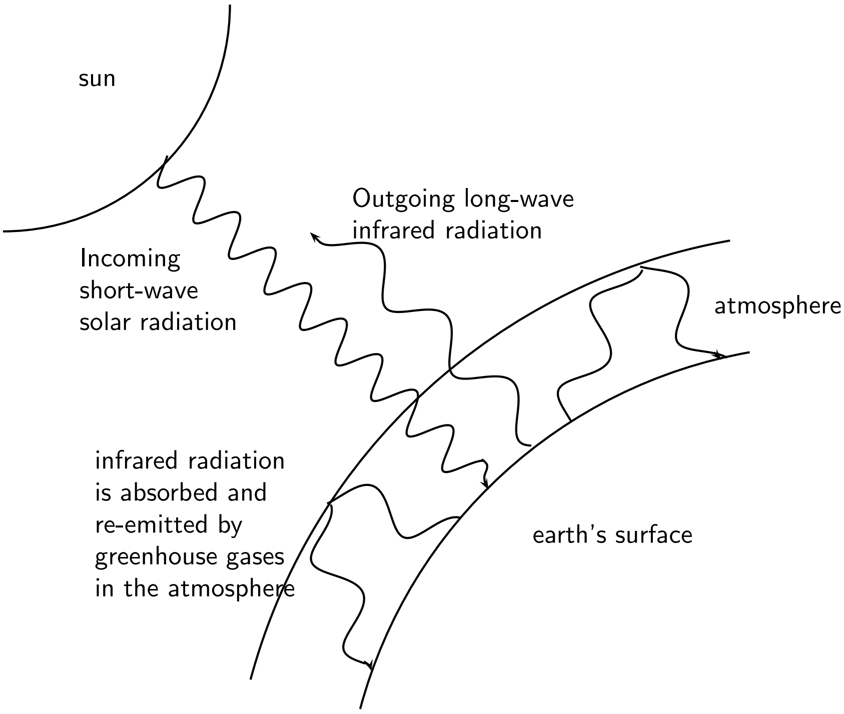


Figure 22.2: The heating of the Earth's atmosphere

- **Nitrous oxide** (N_2O)

  Nitrous oxide is emitted by agriculture and industry, and when fossil fuels and solid waste are burned.

- **Fluorinated gases** (e.g. hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride)

  These gases are all *synthetic*, in other words they are man-made. They are emitted from a variety of industrial processes. Fluorinated gases are sometimes used in the place of other ozone-depleting substances (e.g. CFC's). These are very powerful greenhouse gases, and are sometimes referred to as High Global Warming Potential gases ('High GWP gases').

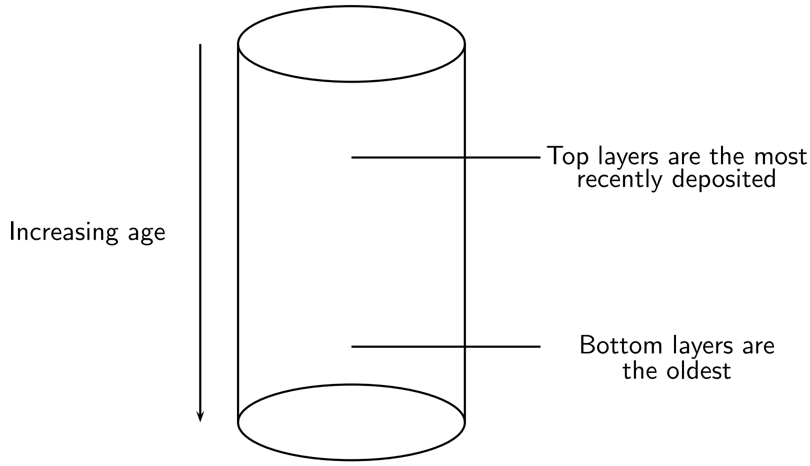
Overpopulation is a major problem in reducing greenhouse gas emissions, and in slowing down global warming. As populations grow, their demands on resources (e.g. energy) increase, and so does their production of greenhouse gases.

Extension: Ice core drilling - Taking a look at earth's past climate

Global warming is a very controversial issue. While many people are convinced that the increase in average global temperatures is directly related to the increase in atmospheric concentrations of carbon dioxide, others argue that the climatic changes we are seeing are part of a natural pattern. One way in which scientists are able to understand what is happening at present, is to understand the earth's *past* atmosphere, and the factors that affected its temperature.

So how, you may be asking, do we know what the earth's *past* climate was like? One method that is used is **ice core drilling**. Antarctica is the coldest continent on earth, and because of this there is very little melting that takes place. Over thousands of years, ice has accumulated in layers and has become more and more compacted as new ice is added. This is partly why Antarctica is also on average one of the *highest* continents! On average, the ice sheet that covers Antarctica is 2500 m thick, and at its deepest location, is 4700 m thick.

As the snow is deposited on top of the ice sheet each year, it traps different chemicals and impurities which are dissolved in the ice. The ice and impurities hold information about the Earth's environment and climate at the time that the ice was deposited. Drilling an ice core from the surface down, is like taking a journey back in time. The deeper into the ice you venture, the older the layer of ice. By analysing the gases and oxygen isotopes that are present (along with many other techniques) in the ice at various points in the earth's history, scientists can start to piece together a picture of what the earth's climate must have been like.



One of the most well known ice cores was the one drilled at a Russian station called **Vostok** in central Antarctica. So far, data has been gathered for dates as far back as 160 000 years!

Activity :: Case Study : Looking at past climatic trends

Make sure that you have read the 'Information box' on ice core drilling before you try this activity.

The values in the table below were extrapolated from data obtained by scientists studying the Vostok ice core. 'Local temperature change' means by how much the temperature at that time was different from what it is today. For example, if the local temperature change 160 000 years ago was -9°C, this means that atmospheric temperatures at that time were 9°C *lower* than what they are today. 'ppm' means 'parts per million' and is a unit of measurement for gas concentrations.

Years before present (x 1000)	Local temperature change (°C)	Carbon dioxide (ppm)
160	-9	190
150	-10	205
140	-10	240
130	-3	280
120	+1	278
110	-4	240
100	-8	225
90	-5	230
80	-6	220
70	-8	250
60	-9	190
50	-7	220
40	-8	180
30	-7	225
20	-9	200
10	-2	260
0 (1850)	-0.5	280
Present		371

Questions

1. On the same set of axes, draw graphs to show how temperature and carbon dioxide concentrations have changed over the last 160 000 years. Hint: 'Years before present' will go on the x-axis, and should be given *negative* values.
2. Compare the graphs that you have drawn. What do you notice?
3. Is there a relationship between temperature and the atmospheric concentration of carbon dioxide?
4. Do these graphs *prove* that temperature changes are determined by the concentration of gases such as carbon dioxide in the atmosphere? Explain your answer.
5. What other factors might you need to consider when analysing climatic trends?

22.3.3 The consequences of global warming

Activity :: Group Discussion : The impacts of global warming
In groups of 3-4, read the following extracts and then answer the questions that follow.

By 2050 Warming to Doom Million Species, Study Says

By 2050, rising temperatures exacerbated by human-induced belches of carbon dioxide and other greenhouse gases could send more than a million of Earth's land-dwelling plants and animals down the road to extinction, according to a recent study. "Climate change now represents at least as great a threat to the number of species surviving on Earth as habitat-destruction and modification," said Chris Thomas, a conservation biologist at the University of Leeds in the United Kingdom.

The researchers worked independently in six biodiversity-rich regions around the world, from Australia to South Africa, plugging field data on species distribution and regional climate into computer models that simulated the ways species' ranges are expected to move in response to temperature and climate changes. According to the researchers' collective results, the predicted range of climate change by 2050 will place 15 to 35 percent of the 1 103 species studied at risk of extinction.

National Geographic News, 12 July 2004

Global Warming May Dry Up Africa's Rivers, Study Suggests

Many climate scientists already predict that less rain will fall annually in parts of Africa within 50 years due to global warming. Now new research suggests that even a small decrease in rainfall on the continent could cause a drastic reduction in river water, the lifeblood for rural populations in Africa.

A decrease in water availability could occur across about 25 percent of the continent, according to the new study. Hardest hit would be areas in northwestern and southern Africa, with some of the most serious effects striking large areas of Botswana and South Africa.

To predict future rainfall, the scientists compared 21 of what they consider to be the best climate change models developed by research teams around the world. On average, the models forecast a 10 to 20% drop in rainfall in northwestern and southern Africa by 2070. With a 20% decrease, Cape Town would be left with just 42% of its river water, and "Botswana would completely dry up," de Wit said. In parts of northern Africa, river water levels would drop below 50%.

Less river water would have serious implications not just for people but for the many animal species whose habitats rely on regular water supplies.

National Geographic News, 3 March 2006

Discussion questions

1. What is meant by 'biodiversity'?
2. Explain why global warming is likely to cause a *loss of biodiversity*.
3. Why do you think a loss of biodiversity is of such concern to conservationists?
4. Suggest some plant or animal species in South Africa that you think might be particularly vulnerable to extinction if temperatures were to rise significantly. Explain why you chose these species.
5. In what way do people, animals and plants rely on river water?
6. What effect do you think a 50% drop in river water level in some parts of Africa would have on the people living in these countries?
7. Discuss some of the other likely impacts of global warming that we can expect (e.g. sea level rise, melting of polar ice caps, changes in ocean currents).

22.3.4 Taking action to combat global warming

Global warming is a major concern at present. A number of organisations, panels and research bodies have been working to gather accurate and relevant information so that a true picture of our current situation can be painted. One important orgaisation that you may have heard of is the **Intergovernmental Panel on Climate Change** (IPCC). The IPCC was established in 1988 by two United Nations organizations, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), to evaluate the risk of climate change brought on by humans. You may also have heard of the **Kyoto Protocol**, which will be discussed a little later.

Activity :: Group Discussion : World carbon dioxide emissions

The data in the table below shows carbon dioxide emissions from the consumption of fossil fuels (in million metric tons of carbon dioxide).

Region or Country	1980	1985	1990	1995	2000	2004
United States	4754	4585	5013	5292	5815	5912
Brazil	186	187	222	288	345	336
France	487	394	368	372	399	405
UK	608	588	598	555	551	579
Saudi Arabia	175	179	207	233	288	365
Botswana	1.26	1.45	2.68	3.44	4.16	3.83
South Africa	234	298	295	344	378	429
India	299	439	588	867	1000	1112
World Total	18333	19412	21426	22033	23851	27043

Questions

1. Using a coloured pen, highlight those countries that are 'developed' and those that are 'developing'.
2. Explain why CO_2 emissions are so much higher in developed countries than in developing countries.
3. How does South Africa compare to the other developing countries, and also to the developed countries?

Carbon dioxide emissions are a major problem worldwide. The **Kyoto Protocol** was signed in Kyoto, Japan in December 1997. Its main objective was to reduce global greenhouse gas emissions by encouraging countries to become signatories to the guidelines that had been laid out in the protocol. These guidelines set targets for the world's major producers to reduce their emissions within a certain time. However, some of the worst contributors to greenhouse gas emissions (e.g. USA) were not prepared to sign the protocol, partly because of the potential effect this would have on the country's economy, which relies on industry and other 'high emission' activities.

Panel discussion

Form groups with 5 people in each. Each person in the group must adopt one of the following roles during the discussion:

- the owner of a large industry
- an environmental scientist
- an economist
- a politician
- a chairperson for the discussion

In your group, you are going to discuss some of the economic and environmental implications for a country that decides to sign the Kyoto Protocol. Each person will have the opportunity to express the view of the character they have adopted. You may ask questions of the other people, or challenge their ideas, provided that you ask permission from the chairperson first.

22.4 Summary

- The **atmosphere** is the layer of gases that surrounds Earth. These gases are important in sustaining life, regulating temperature and protecting Earth from harmful radiation.
- The gases that make up the atmosphere are nitrogen, oxygen, carbon dioxide and others e.g. water vapour, methane.
- There are four layer in the atmosphere, each with their own characteristics.

- The **troposphere** is the lowest layer and here, temperature decreases with an increase in altitude. The troposphere is where weather occurs.

- The next layer is the **stratosphere** where temperature increases with an increase in altitude because of the presence of ozone in this layer, and the direct heating from the sun.

- The depletion of the ozone layer is largely because of CFC's, which break down ozone through a series of chemical reactions.

- The **mesosphere** is characterised by very cold temperatures and meteor collisions. The mesosphere contains high concentrations of metal atoms.

- In the **thermosphere**, neutral atoms are ionised by UV and X-ray radiation from the sun. Temperature increases with an increase in altitude because of the energy that is released during this ionisation process, which occurs mostly in the upper thermosphere.

- The thermosphere is also known as the **ionosphere**, and is the part of the atmosphere where radio waves can be transmitted.

- The **auroras** are bright coloured skies that occur when charged particles collide with atoms in the upper atmosphere. Depending on the type of atom, energy is released as light at different wavelengths.

- The Earth is heated by radiation from the sun. Incoming radiation has a short wavelength and some is absorbed directly by the Earth's surface. However, a large amount of energy is re-radiated as longwave infrared radiation.

- **Greenhouse gases** such as carbon dioxide, water vapour and methane absorb infrared radiation and re-emit it back towards the Earth's surface. In this way, the bottom layers of the atmsophere are kept much warmer than they would be if all the infrared radiation was lost.

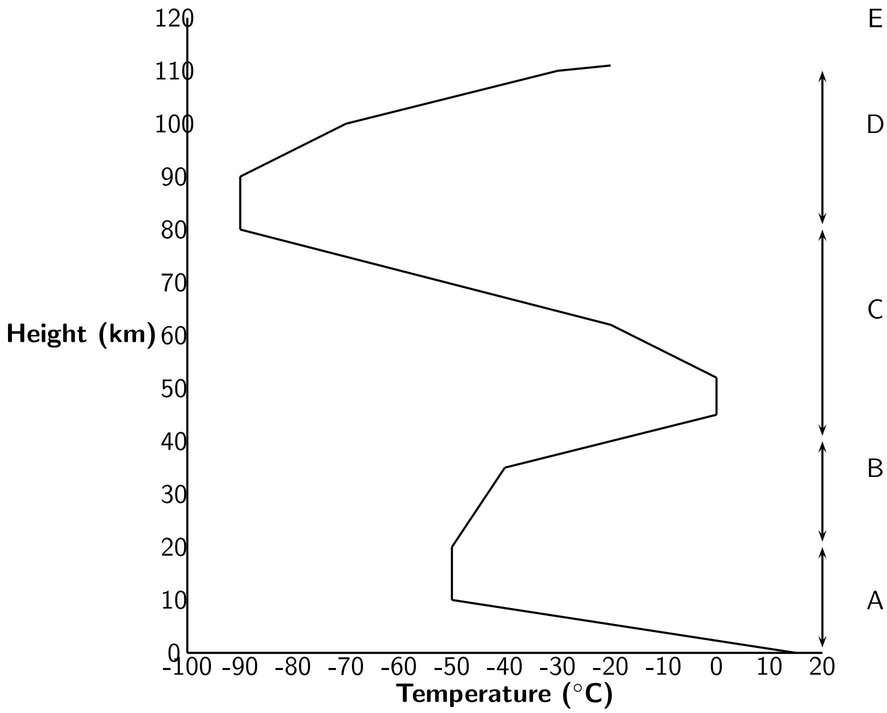
- Human activities such as the burning of fossil fuels, increase the concentration of greenhouse gases in the atmosphere and may contribute towards **global warming**.

- Some of the impacts of global warming include changing climate patterns, rising sea levels and a loss of biodiversity, to name a few. Interventions are needed to reduce this phenomenon.

?

Exercise: Summary Exercise

1. The atmosphere is a relatively thin layer of gases which support life and provide protection to living organisms. The force of gravity holds the atmosphere against the earth. The diagram below shows the temperatures associated with the various layers that make up the atmosphere and the altitude (height) from the earth's surface.



(a) Write down the names of the layers A, B and D of the atmosphere.

(b) In which one of the layers of the atmosphere is ozone found?

(c) Give an explanation for the decrease in temperature as altitude increases in layer A.

(d) In layer B, there is a steady increase in temperature as the altitude increases. Write down an explanation for this trend.

2. **Planet Earth in Danger**

It is now accepted that greenhouse gases are to blame for planet earth getting warmer. The increase in the number of sudden floods in Asia and droughts in Africa; the rising sea level and increasing average temperatures are global concerns. Without natural greenhouse gases,like carbon dioxide and water vapour,life on earth is not possible. However, the increase in levels of carbon dioxide in the atmosphere since the Industrial Revolution is of great concern. Greater disasters are to come, which will create millions of climate refugees. It is our duty to take action for the sake of future generations who will pay dearly for the wait-and-see attitude of the current generation. Urgent action to reduce waste is needed. Global warming is a global challenge and calls for a global response now, not later.
(Adapted from a speech by the French President, Jacques Chirac)

(a) How do greenhouse gases, such as carbon dioxide, heat up the earth's surface?

(b) Draw a Lewis structure for the carbon dioxide molecule

(c) The chemical bonds within the carbon dioxide molecule are polar. Support this statement by performing a calculation using the table of electronegativities.

(d) Classify the carbon dioxide molecule as polar or non-polar. Give a reason for your answer.

(e) Suggest ONE way in which YOU can help to reduce the emissions of greenhouse gases.

3. Plants need carbon dioxide (CO_2) to manufacture food. However, the engines of motor vehicles cause too much carbon dioxide to be released into the atmosphere.

(a) State the possible consequence of having too much carbon dioxide in the atmosphere.

(b) Explain **two** possible effects on humans if the amount of carbon dioxide in the atmosphere becomes too low.

(DoE Exemplar Paper Grade 11, 2007)

you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections A and A above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

1. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
2. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
3. State on the Title page the name of the publisher of the Modified Version, as the publisher.
4. Preserve all the copyright notices of the Document.
5. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
6. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
7. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
8. Include an unaltered copy of this License.
9. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

10. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

11. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

12. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

13. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.

14. Do not re-title any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.

15. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties–for example, statements of peer review or that the text has been approved by an organisation as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section A above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section A is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section A. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section A) to Preserve its Title (section A) will typically require changing the actual title.

TERMINATION

You may not copy, modify, sub-license, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sub-license or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

> Copyright © YEAR YOUR NAME. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License".

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the "with...Texts." line with this:

with the Invariant Sections being LIST THEIR TITLES, with the Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.