

Climate change and carbon dioxide – Teachers' notes

Background information

See 'The greenhouse effect and global warming.'

How science works

- Use theories, models and ideas to develop and modify scientific explanations
- Use knowledge and understanding to present scientific arguments and scientific ideas
- Analyse and interpret data to provide evidence
- Evaluate methodology, evidence and data and resolve conflicting evidence
- Appreciate the tentative nature of scientific knowledge
- Communicate information and ideas using appropriate terminology.

Answers to questions

1. Fossil fuels contain carbon, which when burnt in sufficient oxygen produces carbon dioxide. Eg:
$$\text{C}_8\text{H}_{18} + 25/2 \text{O}_2 \rightarrow 8 \text{CO}_2 + 9\text{H}_2\text{O}$$
Alternatively, the large hydrocarbons in oil can be represented simply by CH_2 which undergoes complete combustion as:
$$\text{CH}_2 + 3/2 \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}.$$
2. Sources of CO_2 include respiration (animals and plants), decay of dead organisms, volcanic activity, the oceans (as they warm up the CO_2 can come out of solution.) Sinks for CO_2 include photosynthesis, the oceans (which dissolve a large amount), carbonate structures such as shells of molluscs and corals.
3. There are no local emissions to distort the readings.
4. Regular calibration is important to ensure that the readings are as accurate as possible and that there is no 'drift' in the data.
5. Winter will be higher – the rate of photosynthesis will be lower and emissions for heating etc will be higher.
6. 0.038%.
7. The rate at which carbon dioxide concentrations are rising is increasing.
8. The global average temperature has been mainly increasing through the century, with the exception of the 1940s when the temperature decreased.
9. As the century has progressed, the blue line has got thinner. This shows that the level of confidence in the data has increased as the uncertainties have been reduced.
10. No.
11. ^{16}O contains 8 neutrons and ^{18}O contains 10.
12. To ensure that they do not contaminate the ice cores.
13. The pattern is regular with an interval of approximately 100 000 years.

14. Yes.

15. Temperature.

16. No, CO₂ concentrations have never been this high before.

17. As concentrations this high have never been seen before we do not know how the Earth will respond and particularly what will happen to the temperatures. This is effectively a massive chemistry experiment with the Earth's entire atmosphere.

Possible response to summary

Possible causes of climate change over the last half a million years:

- The variation in solar radiation reaching the Earth (Milankovich cycles)
- Rising temperature and carbon dioxide working in feedback with each other.

Possible causes of climate change over the last 150 years:

- Rising temperature and carbon dioxide working in feedback with each other
- Anthropogenic (man-made) carbon dioxide emissions
- Changes in the activity of the Sun – the more sunspots, the more solar energy reaches the Earth.

Parts of the climate and carbon dioxide link which are well understood:

- CO₂ does absorb infrared radiation
- There have been cycles/variations in the temperature of the Earth.
- The temperature of the Antarctic and the concentration of carbon dioxide follow a similar pattern. This is consistent with CO₂ acting as an amplifier of climate change.
- There are natural sources and sinks of carbon dioxide
- Humans are putting carbon dioxide into the atmosphere at a rate never seen before and the concentration is higher than at any time in the last 800 000 years.

Parts of the climate and carbon dioxide link which are not fully understood and where further research is required:

- There is less data for how the temperature of the Earth, apart from Antarctica, has varied in the last 800 000 years.
- It is not known in detail why carbon dioxide concentration and temperature followed a similar pattern in the past.
- It is not certain whether carbon dioxide or temperature began to rise first at the end of the ice ages.
- While it is expected that temperature will rise if carbon dioxide increases, the exact magnitude of the rise is not known.

Further reading

There is a huge amount of information in the media and on the web about climate change and carbon dioxide.

For information in the media, try searching the websites of New Scientist (some of the content is restricted to subscribers) or major newspapers. For example:

<http://environment.newscientist.com/channel/Earth/climate-change/> or try the New Scientist homepage: www.newscientist.com

www.timesonline.co.uk
www.telegraph.co.uk
www.independent.co.uk

For an article about sunspots see <http://news.bbc.co.uk/1/hi/sci/tech/3869753.stm>.

There have been some major studies into the likelihood and implications of climate change. Even the summaries of these are long, but could be understood by most students. Try www.ipcc.ch; this will give access to the assessment reports. The most relevant to this activity is the Working group 1 report: 'The physical science basis'. The Fourth Assessment Report (AR4) was published at the start of 2007.

For a British version, see the Air Quality Expert Group (AQEG) 3rd report available on the Defra website: <http://www.defra.gov.uk/environment/airquality/publications/airqual-climatechange/index.htm>.

For information about the British Antarctic Survey (who participate in drilling and analysing ice cores) see: www.antarctica.ac.uk.

The Royal Society website has a section on climate change controversies which is clear and easy to understand: <http://www.royalsoc.ac.uk/page.asp?id=6229>.

For the most up-to-date data on carbon dioxide concentrations as measured at Mauna Loa see: http://www.esrl.noaa.gov/gmd/ccgg/trends/co2_data_mlo.html.

(All last accessed November 2008.)