

Carbon monoxide

Carbon monoxide kills around 50 people in the UK each year, with a further 150 requiring hospital treatment. These are preventable deaths. Educating students about the causes of CO poisoning and how to prevent it may help to reduce the number of incidents. The way the poison works is an interesting piece of blood biochemistry which is easily understood by most students and adds an extra dimension to the activity. There are two available worksheets:

- Carbon monoxide – the silent killer is a comprehension exercise
- Carbon monoxide alert is a research exercise that requires students to make a poster or leaflet to present the information they have found.

Prior knowledge required

None for the poster making.

For the comprehension exercise:

- Balancing equations
- Reversible reactions.

Answers to questions

1. CO is colourless, odourless and tasteless. We cannot sense it without special equipment.
2. $2\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
 $\text{CH}_4 + 1\frac{1}{2}\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}$ or
 $2\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{CO} + 4\text{H}_2\text{O}$
3. The first equation uses two molecules of oxygen for every molecule of methane. The second uses only 1.5 molecules of oxygen for every molecule of methane. When less oxygen is present, carbon monoxide is formed.
4. Answers could include any gas appliances (eg gas cooker, fire, central heating boiler), wood- or paraffin-burning appliances and cigarette smoke. Electric appliances do not produce CO.
5. Carbon monoxide prevents oxygen getting to the cells in your body. This makes you feel tired.
6. \rightleftharpoons means the reaction is reversible.
7. The reaction represented by Equation 4 is not reversible. This means that once carbon monoxide has bonded to your haemoglobin it does not come off easily and so prevents the haemoglobin from carrying oxygen as it should. If there is no CO present, haemoglobin binds oxygen and releases it again easily when it reaches cells that need it.
8. Carbon monoxide changes the haemoglobin and prevents it from giving up any of the oxygen it is carrying to the body cells. In other words, it stops the reaction represented by Equation 3 from being reversible.
9. Unborn babies' haemoglobin binds even more carbon monoxide than the mother's. This means that the baby suffers more at low CO levels than its mother. (It can also alleviate the mother's symptoms as the baby removes CO from her blood.)

Carbon monoxide – the silent killer

Every year in the UK over 50 people are killed and a further 150 hospitalised by a simple gas formed during the burning of fuels containing carbon, eg gas, wood, oil or paraffin. This gas is carbon monoxide.

Formation

When hydrocarbon fuels are burnt in a good supply of air, carbon dioxide and water are formed:

Equation 1 $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ (unbalanced equation)

However, when the air supply is restricted for some reason and there is not enough oxygen for this reaction to take place, carbon monoxide forms instead of carbon dioxide. As the name suggests, carbon monoxide has one oxygen atom for every carbon atom.

Equation 2 $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO} + \text{H}_2\text{O}$ (unbalanced equation)

Carbon monoxide is colourless, odourless and tasteless. It gives no indication of its presence, which makes it very dangerous. It is formed in car engines and can also be produced by faulty gas cookers, water heaters and fires, or when a hydrocarbon-burning appliance is used in a room with inadequate ventilation. It is present in cigarette smoke.

Health effects

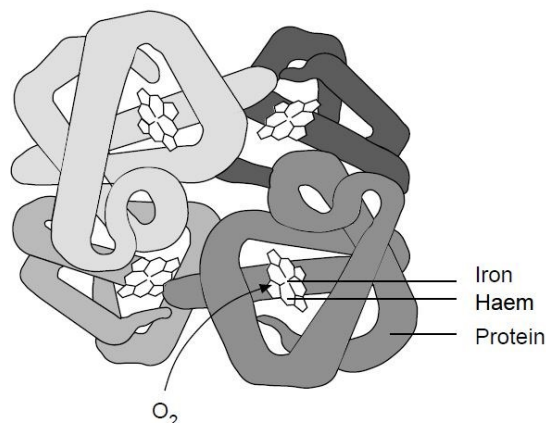
The government's recommended maximum safe CO concentration is 10 ppm (parts per million).

Most people do not experience symptoms below 70 ppm, but above this concentration exposure can cause headaches, fatigue and nausea. The symptoms can be similar to a cold or flu and many people mistake CO poisoning for these illnesses. Levels of 150–200 ppm often result in disorientation or unconsciousness and sometimes even death.

Some people are more sensitive to CO than others and experience symptoms at a lower concentration. People in this sensitive group can include children, the elderly, pregnant women and their unborn babies and people with anaemia.

What makes carbon monoxide toxic?

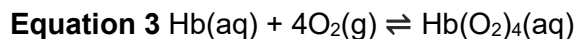
When you breathe, oxygen from the air enters your lungs. It is picked up by your red blood cells and transported to every cell in your body. The main oxygen-carrying substance in red blood cells is the protein haemoglobin. Each haemoglobin molecule contains four iron-containing units called haem groups. Each haem can pick up one molecule of oxygen (O_2) so each haemoglobin molecule can carry up to four oxygen molecules.



When a haemoglobin molecule has picked up its four oxygen molecules it is known as oxyhaemoglobin. Oxyhaemoglobin is a darker red than haemoglobin. (This is why your

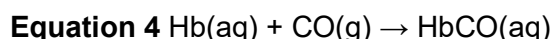
oxygenated blood looks bright red but blood with no oxygen looks bluer.) The oxyhaemoglobin travels round your body and when it reaches cells that do not have much oxygen, it releases its oxygen to them.

This process can be represented by Equation 3. Hb represents haemoglobin; $\text{Hb}(\text{O}_2)_4$ represents oxyhaemoglobin.



The forward reaction takes place in the lungs, the back reaction at cells around the body that are low in oxygen.

Carbon monoxide is toxic because it interferes with this process. It is better at binding to haemoglobin than oxygen is – about 200 times better. This means that, even if there is far more oxygen present than carbon monoxide, the carbon monoxide is more likely to bind to the haemoglobin. This forms a compound called carboxyhaemoglobin:



Since the carbon monoxide sticks so tightly, there are fewer places for oxygen to bind to haemoglobin when carbon monoxide is present. But carbon monoxide does something else as well. It changes the other three oxygen binding sites on the haemoglobin molecule so that they can pick up oxygen but do not release it when they get to the body cells. This means that the haemoglobin stops acting as the body's oxygen delivery system.

The problem is even worse for unborn babies. Their haemoglobin is different from that in older people and is even better at binding to carbon monoxide. This means that unborn babies occasionally die from CO poisoning, even when the dose is not lethal for their mothers.

The cure

To make a person who has been poisoned by CO feel well again, the poisoning process needs to be reversed. The carboxyhaemoglobin eventually breaks down and releases the haemoglobin, which is then able to function once more as the oxygen delivery system in the body. This takes about 320 minutes as long as no further carbon monoxide is breathed in.

If the poisoning is mild, removing the victim to the fresh air is usually enough to help him or her recover. In more severe cases, the person might need hospital treatment. The treatment involves giving the patient oxygen to breathe. This helps break down the bond between the carbon monoxide and the haemoglobin more quickly. Most people make a full recovery.

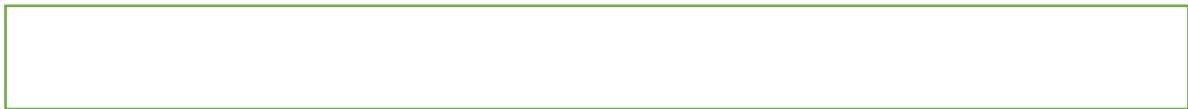
Prevention

There are a number of ways to prevent carbon monoxide poisoning. They include having gas appliances serviced regularly and fitting a carbon monoxide detector. This is not the same as a smoke detector – a CO detector does not detect smoke and a smoke detector does not detect CO.

Questions

1. Why is carbon monoxide so difficult to detect?

2. Copy and balance Equations 1 and 2.



3. How do these equations show that carbon monoxide is formed when not enough oxygen is present?

4. Where in your house might carbon monoxide be formed?

5. Why would breathing carbon monoxide make you feel fatigued (tired)?

6. Look at Equation 3. What does the \rightleftharpoons symbol mean?

7. In Equation 4, the symbol \rightarrow is used instead of \rightleftharpoons to show that a different type of reaction is taking place. Explain the difference between the two types of reaction and why this difference makes carbon monoxide toxic.

8. Carbon monoxide is toxic in a second way. Explain how in your own words.

9. Cigarette smoke is harmful to unborn babies in many ways. Explain why the carbon monoxide in cigarette smoke is worse for the baby than for its mother.

Carbon monoxide alert

Every year in the UK over 50 people are killed and a further 150 hospitalised by a simple gas formed during the burning of fuels containing carbon, eg gas, wood, oil or paraffin. This gas is carbon monoxide.

You are going to do some research to find out about this deadly gas and then present your findings as a warning poster or leaflet.

What you need to find out

- Where and when carbon monoxide is formed
- What effects this poisonous gas can have – what symptoms people should look out for
- Who is most at risk
- How carbon monoxide poisoning can be cured
- How carbon monoxide poisoning can be prevented.

Your leaflet or poster

Your leaflet or poster should be aimed at one of these groups of people:

- Students
- The elderly
- Families with young children.

These websites may be a good place to start your search:

<http://www.hse.gov.uk/gas/domestic/co.htm> – a UK government website

<http://www.carbonmonoxidekills.com>

<http://www.le.ac.uk/ieh/pdf/ExsumA5.pdf> – This website is a report by some scientists at Leicester university. Sections 1, 4 and 6 may be helpful, but this is a long document.

<http://www.howstuffworks.com> – try searching this site for carbon monoxide

All this websites were live in May 2006. You should try to search for some more as well.