**The Earth’s Atmosphere Mastery Booklet**

The atmosphere is a layer of gas surrounding the Earth. This unit will look at its history, its current composition and how human activity is affecting it.

**The Early Atmosphere**

Scientists believe the Earth was formed around 4.6 billion years ago from giant rocks colliding. These collisions generated a huge amount of heat and for its first billion years the Earth will have been very hot.

The Earth will have had thousands of volcanoes which would release mostly carbon dioxide, water vapour and nitrogen, creating the Earth’s first atmosphere. This atmosphere would be similar to that of Mars and Venus today.

1. How do scientists believe the Earth formed?
2. Use page 194 to give the formulae of the gases in the Earth’s early atmosphere
3. Why was the early Earth significantly hotter than the Earth today?

**“Scientists Believe”**

Because the Earth was formed so long ago, it is difficult for scientists to know exactly what it was like then. This is why we often use the phrase “scientists believe”; scientists have theories based on evidence, but at this point in time they cannot be sure. Hopefully in the future we will be able to collect better evidence.

1. Use page 194 to give two examples of evidence that scientists use when thinking about the early atmosphere
2. Where did the gases forming the early atmosphere come from?
3. Why could the early atmosphere not support life?

**The Oceans**

Over time, the Earth cooled. This enabled the water vapour in the atmosphere to condense and form oceans.

1. To what temperature would the Earth need to have cooled to for the water vapour to condense?
2. Use page 194 to give two possible sources for the water that formed our oceans

**Life**

About 3.4 billion years ago, life began to appear. Scientists have many different theories as to how this occurred. Algae is a simple organism that appeared around 2.7 billion years ago. Algae could take carbon dioxide and water from the atmosphere and convert them to glucose and oxygen. This process is known as photosynthesis.

This increased the amount of oxygen in the atmosphere, and allowed other and more complex forms of life to develop as they could now respire.

Photosynthesis: carbon dioxide + water 🡪 glucose + oxygen
Respiration: glucose + oxygen 🡪 carbon dioxide + water

1. How did algae affect the amount of carbon dioxide in the atmosphere?
2. How did algae affect the amount of oxygen in the atmosphere?
3. Why do scientists have many different theories about how life first developed?
4. Why did algae need to develop before other life forms?

**Changing Carbon Dioxide Levels**

Plants began to take carbon dioxide out of the atmosphere. Animals, through respiration, put it back into the atmosphere. However, there were processes that removed carbon dioxide “permanently.” Scientists often refer to this process as “locking up” carbon.

* Algae and plants used carbon dioxide to make glucose which helped them grow. When animals ate these plants some of the carbon became part of their bones. When these animals died, eventually their skeletons came to form:
	1. Rocks like calcium carbonate, locking up the carbon in rock.
	2. Underground deposits of fossil fuels, locking the carbon up underground
* After the oceans formed, carbon dioxide from the atmosphere dissolved in them. It reacted with metal oxides in the water and formed insoluble carbonate compounds that eventually became rock, again “locking up” the carbon.
1. Why do scientists refer to animals using carbon to make their bones as “locking up” the carbon?
2. Much of the carbon dioxide from the Earth’s early atmosphere is now locked up in calcium carbonate rock. Give two ways in which this occurred.
3. What effects did the formation of the oceans have on the gases in the atmosphere? Explain your answer fully and in detail.

**Nitrogen**

Once oxygen had formed, it also caused other gases in the atmosphere to change. Volcanoes released a small amount of ammonia (NH3), which could react with oxygen to form nitrogen gas (N2) and water as another product. Nitrogen gas is highly unreactive so its levels gradually built up over time.

1. Use the information above to write a symbol equation for the reaction between ammonia and oxygen
2. Use the formulae above to write a symbol equation for the reaction in question 16
3. State the effects of increasing amounts of oxygen in the atmosphere on the amount of:
	1. Ammonia
	2. Carbon dioxide
	3. Nitrogen

**The atmosphere today**

The atmosphere today contains approximately:

* 80% nitrogen
* 20% oxygen

As well as very small amounts of other gases like carbon dioxide, water vapour and noble gases.

1. Describe the change in the amount of oxygen in the atmosphere over time
2. Explain why it has changed
3. Explain why scientists cannot be sure of how the amount of oxygen has changed over time
4. Making reference to its structure and bonding, explain why oxygen has a low melting and boiling point.
5. The formula for glucose is C6H12O6. Write a symbol equation for photosynthesis
6. Use your symbol equation to explain how the amounts of different gases in the atmosphere have changed over time
7. Why did the early atmosphere contain so little nitrogen, but our current atmosphere is 80% nitrogen?

**Greenhouse gases**

The atmosphere acts a layer of insulation keeping the planet warm. This is because some of the gases in the atmosphere are “greenhouse” gases. This occurs as follows:

* Electromagnetic radiation from the Sun radiates to the Earth
* About 30% is reflected back to space by the atmosphere
* The remaining radiation warms the Earth
* Some of the radiation is “short wave” radiation like UV which passes through the atmosphere
* The Earth radiates this energy back to space, but as “long wave” infrared radiation
* This infrared radiation is absorbed by greenhouse gases
* This increases the temperature of the atmosphere and the Earth as the radiation does not go back to space
1. Draw a sketch diagram in your exercise book showing these processes. Label it fully. You can use figure 1 on page 198 as a guide.

By adding more greenhouse gases to the atmosphere, more radiation is absorbed and the overall temperature increases. Carbon dioxide, methane and water vapour are greenhouse gases.

Humans are adding greenhouse gases to the atmosphere in a number of ways:

* Burning fossil fuels releases carbon dioxide
* Deforestation results in fewer trees to take in carbon dioxide through photosynthesis
* Rice fields release methane
* Grazing cattle release methane
1. Name three greenhouse gases and give their formulae (use the textbook if you need to)
2. How does the radiation arriving at the Earth’s surface from the Sun differ from the radiation leaving it?
3. How could burning fossil fuels increase the temperature of the Earth?
4. The combustion of methane releases carbon dioxide into the atmosphere. How would this affect the amount of greenhouse gas in the atmosphere?
5. How would eating less rice affect the amount of methane in the atmosphere?

**The Evidence**

Almost all scientists believe that the Earth’s temperature is increasing because we are adding greenhouse gases to the atmosphere. They use **peer-reviewed** evidence which is published in scientific journals. This is evidence that has been thoroughly checked by other scientists.

Scientists use ice core and other evidence to look at how the amount of CO2 has changed over time and also how the temperature has changed over time. Because the amount of CO2 has increased, and because the temperature has increased, most scientists believe they are related.

Some scientists believe that they are not related and that the Earth’s temperature has always been changing and has nothing to do with human activity.

Because the atmosphere is enormous and complex, it is very difficult for scientists to make predictions based on their findings. This makes their theories harder to prove.

1. What is peer reviewed evidence?
2. Why is peer reviewed evidence important?
3. Why do some scientists not believe that burning fossil fuels will contribute to global warming?
4. Why is it difficult for scientists to prove their theories about greenhouse gases?
5. Give three ways in which carbon dioxide has been “locked up” historically
6. Since the industrial revolution, how has carbon dioxide been released from where it has been locked up?

**Global Climate Change**

Scientists believe that an increase in the Earth’s **overall average temperature** will lead to global climate change. This could lead to:

* Rising sea levels due to melting ice caps. Low-lying land and islands could be flooded.
* Severe weather events like storms
* Changes in the temperature and amount of rain, as well as when in the year it occurs. Most crops that we use for food require very specific rain conditions
* Changes to where wildlife can live, putting ecosystems under stress

You must learn these four reasons off by heart.

It is important to note that the data must be taken as a whole. If it is cold in August in London, that is not proof that climate change does not exist. We must look at the whole planet over a long time to establish what is occurring.

1. How could climate change result in their being less food available for humans?
2. How could climate change cause humans to have to leave their homes in large numbers?
3. Why are sea levels rising?
4. How could this affect polar bear populations?
5. A student took data for the temperature in December over five years. She noticed that the temperature was decreasing over time. Explain why she would be incorrect to claim that “global warming is a myth”

**Carbon footprints**

The carbon footprint of a product is the total amount of carbon dioxide and greenhouse gases released by that product through its full **life cycle**. The life cycle includes the greenhouse gases released in manufacture and disposal. The carbon footprint of a product can be reduced by:

* Using renewable sources of energy e.g. solar and wind
* Using products less frequently (e.g. walking instead of driving)
* Building more efficient products that waste less energy e.g. more efficient engines or home insulation
* Carbon capture and storage methods to remove carbon dioxide from the atmosphere
* Taxing emissions and allowing companies to not pay them if they plant trees instead
* Using biofuels which are “carbon neutral”

Reducing carbon emissions globally requires international cooperation. However, not all countries agree that climate change is occurring. For others, taking some of the measures above would reduce their economic productivity.

1. When does the life cycle of a car start?
2. When buying a car, what things should be considered in terms of its carbon footprint?
3. A country whose citizens have limited access to electricity is unlikely to agree to international measures to reduce carbon emissions. Why?
4. Use page 200 to explain the process of carbon capture and storage and explain why it could be important
5. In terms of climate change, why is it better to take public transport to school than to get a lift?
6. Why is it important for homes to be properly insulated?

**Atmospheric Pollutants**

Until now we have looked at how human activity influences the amount of greenhouse gas in the atmosphere. Human activity also causes other changes to the atmosphere which have nothing to do with global warming and climate change.

Burning fuels results in the pollutants below being released:

|  |  |  |
| --- | --- | --- |
| Pollutant | Origin | Effect |
| Carbon monoxide | Incomplete combustion of fuels | Colourless and odourless but toxic gas |
| Particulates (soot and unburned hydrocarbons) | Incomplete combustion of fuels especially in diesel engines | Global dimming and respiratory problems and potential to cause cancer |
| Sulphur dioxide | Sulphur impurities in the fuel reacting with oxygen | Acid rain and respiratory problems |
| Oxides of nitrogen | Nitrogen from the air being heated near an engine and reacting with oxygen | Acid rain and respiratory problems |

1. The government collects data on the amount of particulates in different places. Explain why this is important.
2. Most houses have carbon monoxide detectors. Explain why this is important.
3. State the difference between complete and incomplete combustion.
4. A new engine is invented which allows much more oxygen to react with the fuel than before. Explain why this is important.
5. Ethane is combusted to produce carbon monoxide and water. Write a balanced symbol equation for this reaction at room temperature.
6. A factory does not allow gases to escape before passing them through a base. Explain why this is important.
7. The factory uses calcium carbonate powder for this. Explain why this is better than big lumps.
8. Natural gas contains fewer impurities than other fossil fuels. Explain why this is important.
9. People living in large cities can be more prone to certain health problems. Explain why.

**Summary task**

Below are a number of key words and phrases from this unit connected by lines. Above each line write a sentence containing the words from each end of the line. Three have been done for you.

Rainfall

Crop production

Global warming

The **atmosphere** today contains only very small amounts of **carbon dioxide**, but human activity is increasing this amount.

Carbon footprint

When **oxides of nitrogen** are released into the atmosphere they can cause **acid rain**

**Methane** is a greenhouse gas. It can contribute to global warming and climate change which leads to **severe weather events**

Respiration

Acid rain

Oxides of nitrogen

Severe weather events

Photosynthesis

Methane

Carbon dioxide

**The Atmosphere**

Sulphur impurities

Greenhouse gas

Climate change

Oxygen

Early atmosphere

Algae