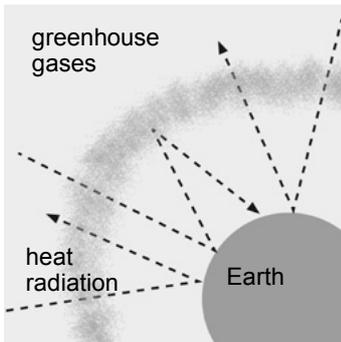


## Worksheet 3 (answer sheet): Greenhouse effect in a drinking cup – A model for illustrating climate change

### Sheet 1: The atmosphere is important

#### Task 1

Carefully read the text and then answer the question.



The atmosphere surrounds the Earth like a protective layer. It contains nitrogen, oxygen, some noble gases and only a small amount of carbon dioxide. The atmosphere extends over 600 km into space. The atmosphere protects us from the sun's dangerous ultraviolet radiation. People need this radiation in small amounts to make e.g. vitamin D. In greater amounts, ultraviolet radiation can cause cancer in humans.

The atmosphere has yet another important function: it ensures that it stays warm on Earth. Without an atmosphere, it would be so cold that life on Earth as we know it would not be possible.

The infra-red, visible and ultraviolet radiation from the sun passes through the Earth's atmosphere without much radiation being absorbed. After the radiation from the sun has passed through the atmosphere, the Earth's surface is heated. The warm ground in turn emits radiated heat, but of a different wavelength. This heat radiation is partially reflected by the greenhouse gases in the atmosphere onto the Earth's surface again. This natural effect causes the Earth to have an average temperature of 15 °C. Without this effect we would have a mean temperature of -18 °C on Earth. This effect is also called the “**natural greenhouse effect**” and it is caused mainly by water vapor, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), laughing gas (nitrous oxide, N<sub>2</sub>O) and ozone (O<sub>3</sub>) gases.

Describe why the Earth has an average temperature of +15 °C and not of -18 °C.

The reason for this is the atmosphere, which allows the infra-red, visible and ultraviolet radiation from the sun to pass through unchanged. This radiation heats the ground, which in turn emits thermal radiation. The greenhouse gases in the atmosphere partially reflect this radiated heat, which results in additional warming of the Earth.

#### Task 2

Create a new group with two other pupils or students. Each member of the new group must have read a different text. All members of this group report on their texts.

#### Task 3

Then solve the tasks on Sheet 4 together with the other members of the group.

## Sheet 2: What is a greenhouse?

### Task 1

Carefully read the text and answer the question.

Many people talk about the “greenhouse effect” on Earth. But what does the Earth have to do with a greenhouse? To answer this, one must know how a greenhouse works.



Plants that need a lot of heat can grow in a greenhouse. In the autumn and in the winter the temperature is often so cold that the plants would die outside the greenhouse. For the most part, a greenhouse is made of glass or transparent plastic. There is often no heating inside the greenhouse, as it would cost too much money to heat the greenhouse over several months. Using a trick, the greenhouse effect, you need only the sun and a house made of glass. The heat radiation from the sun passes through the glass without being absorbed.

In the greenhouse, the heat radiation from the sun warms up the floor and the objects inside. These warm objects now also emit radiation. However, this heat radiation has a different wavelength and can only partially get through the glass to the outside. The other part is reflected back into the greenhouse. Therefore, it is warmer inside the greenhouse than outside and so the plants can even grow in winter.

Describe why it is warmer inside a greenhouse than outside the greenhouse.

The heat radiation from the sun penetrates the glass walls of the greenhouse almost without any absorption. The radiation then heats the floor and the objects inside. These objects in turn emit their own radiation, which is reflected by the walls of the greenhouse due to the different wavelength.

That is why it is warmer inside the greenhouse than outside.

### Task 2

Create a new group with two other students. Each member of the new group must have read a different text. All members of this group report on their texts.

### Task 3

Then solve the tasks on Sheet 4 together with the other members of the group.

## Sheet 3: Who causes the greenhouse effect?

### Task 1

Carefully read the text and answer the question.



During the combustion of fossil fuels (such as coal, oil, gasoline, and natural gas) we produce about 18.3 billion tons of carbon dioxide per year. The burning of tropical forests results in an additional 8.8 billion tons of carbon dioxide per year. From 1800 until today the concentration of carbon dioxide has increased by approximately 30%.

Other gases produced by humans also cause the greenhouse effect:

- Carbon dioxide (CO<sub>2</sub>): contributes about 50% towards the greenhouse effect
- Chlorofluorocarbons (CFCs): 20%
- Methane (CH<sub>4</sub>): 15%
- Ozone (O<sub>3</sub>): approximately 10%

If more of these greenhouse gases are produced in the future, the greenhouse effect will get stronger. Because this effect is caused by human beings themselves, we call this effect “anthropogenic global warming”. Most scientists assume that this is the cause of global warming. They anticipate that the average temperature on Earth will increase by 1.5 °C to 4.5 °C over the next 50 years.

Explain why the greenhouse effect has increased during the past 200 years.

The greenhouse effect depends on the concentration of greenhouse gases in the atmosphere.

The higher the concentration of these gases, the stronger the greenhouse effect. In the past 200 years, man has increased this concentration by, for example, burning fossil fuels and burning down the rainforests.

### Task 2

Create a new group with two other students. Each member of the new group must have read a different text. All members of this group report on their texts.

### Task 3

Then solve the tasks on Sheet 4 together with the other members of the group.

## Sheet 4: Common tasks

### Task 1

What does global warming have to do with a greenhouse? Describe the similarities.

Global warming and heating a greenhouse have similar causes.

The sun emits radiation that permeates the atmosphere/greenhouse walls without being absorbed. This radiation heats up the objects inside. These objects then emit their own infra-red radiation of a different wavelength. This thermal radiation is reflected (due to its different wavelength) by the atmosphere/greenhouse walls back onto the objects. Thus, the objects are heated again.



What's going on at the South Pole?

### Task 2

Describe the differences between the “natural greenhouse effect” and the “anthropogenic global warming”.

The “natural greenhouse effect” comes from the fact that greenhouse gases in the atmosphere reflect the heat radiation emitted from the Earth’s surface back onto the Earth. This results in further heating of the Earth’s surface. The “anthropogenic global warming” is the greenhouse effect caused by human beings. It arises from the fact that human beings increase the concentration of greenhouse gases in the atmosphere by the burning fossil fuels. The higher concentration of greenhouse gases leads to an increased warming of the Earth's surface.