

**Teacher’s Guide**

 **What’s the Deal with Climate Change?**

***October 2021***

**Table of Contents**

[Anticipation Guide](#_Anticipation_Guide) 2

Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 3

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#_Graphic_Organizer)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#_Answers_to_Reading)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 8](#_Additional_Resources)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

[Chemistry Concepts, Standards, and Teaching Strategies 9](#_Chemistry_Concepts,_Standards,)

# Anticipation Guide

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Climate change leads to loss of sea ice, more intense heat waves and droughts, and rising sea levels.
 |
|  |  | 1. The scientific community recognized that large-scale burning of fossil fuels affects climate about 10 years ago.
 |
|  |  | 1. The 10 warmest years on record occurred in the past 16 years.
 |
|  |  | 1. The most abundant gas in the atmosphere is oxygen (O2).
 |
|  |  | 1. Carbon dioxide (CO2) traps infrared radiation.
 |
|  |  | 1. Methane and halogen-containing gases used as refrigerants are less potent greenhouse gases than CO2.
 |
|  |  | 1. Clouds increase warming of Earth’s surface.
 |
|  |  | 1. Warming permafrost areas increases methane emissions which increases global warming.
 |
|  |  | 1. Plants capture carbon before it reaches the atmosphere.
 |
|  |  | 1. Sustainable energy technologies such as wind and solar power can help reduce global warming.
 |

# Student ReadingComprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: Use the article to answer the questions below.

1. Why was the Intergovernmental Panel on Climate Change developed?
2. What is the primary driver of climate change?
3. List three global problems cause by climate change.
4. Define radiative efficiency.
5. Explain the difference between positive feedback and negative feedback in terms of climate change.
6. Define global warming potential.
7. How much did the average level of CO2 in the atmosphere change from 2020 to April of 2021?
8. Give the proportion of the 20 year global warming potential of N2O as compared to CO2.
9. Which greenhouse gas makes up a small percentage of warming gases but has the greatest global warming potential compared to CO2?
10. How does CO2 impact climate if it is such a small percentage of the atmosphere?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Explain how the increased warming of permafrost is an example of positive feedback in the climate system.
2. In the mid-1900’s the level of CO2 in the atmosphere rose to 300ppm. Explain what the measure 300 ppm means.
3. Research one promising technology for removing CO2 from the atmosphere. Write a paragraph explaining the way the method would remove CO2 and draft a proposal for how this technology might function in your community.
4. The article mentions that to keep global warming below 2ºC we will need to utilize conventional abatement technologies, emitting technologies, and carbon removal technologies. Research and describe two abatement technologies that prevent CO2 from entering the atmosphere.

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe what we know about climate change, how we know it is happening, and what can be done to slow the change.

|  |  |  |
| --- | --- | --- |
| **Questions** | **Evidence** | **Reasoning linking claim to evidence** |
| **How do we know climate change is happening?** |  |  |
| **Why is CO2 a particular problem?** |  |  |
| **What are some problems caused by climate change?** |  |  |
| **What can we do to prevent temperatures from rising further?** |  |  |

**Summary:** On the back of this sheet, write a short email to a friend describing three things you can do to help prevent further global warming.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Why was the Intergovernmental Panel on Climate Change developed?**

*The Intergovernmental Panel on Climate Change was established to assess the science around climate change.*

1. **What is the primary driver of climate change?**

*The rising levels of carbon dioxide released by burning fossil fuels is one of the primary drivers of climate change.*

1. **List three global problems cause by climate change.**

*Three problems caused by climate change are loss of sea ice, more intense heat waves and droughts, and rising sea levels.*

1. **What is radiative efficiency?**

*Radiative efficiency is a measure of how readily matter absorbs energy in the infrared.*

1. **Explain the difference between positive feedback and negative feedback in terms of climate change.**

*Positive feedback reinforces warming while negative feedback reduces warming.*

1. **Define global warming potential.**

*Global warming potential is a measure of how much energy a greenhouse gas would add to the atmospheric warming in a given time compared to CO2.*

1. **How much did the average level of CO2 in the atmosphere change from 2020 to April of 2021?**

*The average level of CO2 increased 3.5 ppm from 2020 to April of 2021.*

1. **Give the proportion of the 20 year global warming potential of N2O as compared to CO2.**

*The 20 year GWP for N2O is 289 times greater than that of CO2.*

1. **Which greenhouse gas makes up a small percentage of warming gases but has the greatest global warming potential compared to CO2?**

*Sulfur Hexafluoride has the greatest global warming potential.*

1. **How does CO2 impact climate if it is such a small percentage of the atmosphere?**

*CO2 is a greenhouse gas that absorbs thermal infrared radiation and raises atmospheric temperatures.*

**Questions for Further Learning**

1. **Explain how the increased warming of permafrost is an example of positive feedback in the climate system.**

*The increased warming of permafrost is an example of positive feedback because as the permafrost melts, methane, a greenhouse gas, is released into the atmosphere where it contributes to climate warming.*

1. **In the mid-1900’s the level of CO2 in the atmosphere rose to 300ppm. Explain what the measure 300 ppm means.**

*300 ppm means that for every one million molecules of dry air, there were on average 300 CO2 molecules.*

1. **Research one promising technology for removing CO2 from the atmosphere. Write a paragraph explaining the way the method would remove CO2 and draft a proposal for how this technology might function in your community.**

*Student responses will vary.*

1. **The article mentions that to keep global warming below 2ºC we will need to utilize conventional abatement technologies, emitting technologies, and carbon removal technologies. Research and describe two abatement technologies that prevent CO2 from entering the atmosphere.**

*Student responses will vary.*

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# Additional Resources

**Labs and demos**

[“Greenhouse Gas Lab”](https://serc.carleton.edu/eslabs/weather/2d.html): In this lab activity students will test the greenhouse potential of water vapor and carbon dioxide.

**Simulations**

[“The Greenhouse Effect”](https://phet.colorado.edu/sims/cheerpj/greenhouse/latest/greenhouse.html?simulation=greenhouse): This PhET simulation allows students to investigate the interaction of photons with atmospheric gases, which can assist them in explaining why greenhouse gases affect temperature.

**Lessons and lesson plans**

[“Climate Change and the Keeling Curve”](https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/lesson-plans/keeling-curve-lesson-plan.html): This ACS lesson plan includes inquiry-based activities designed to help students identify how scientists developed an understanding of global warming by using evidence collected over decades.

[“Visualizing and Understanding the Science of Climate Change”](https://explainingclimatechange.com/index.html): This site provides eight interactive lessons to help students understand climate change, climate feedback loops, and the impact of climate change, and how to respond to climate change. The lessons include vocabulary and simulations and are written so students can work through them on their own or as a class.

**Projects and extension activities**

[“Solving the Carbon Dioxide Problem”](https://scied.ucar.edu/activity/solving-carbon-dioxide-problem): In this activity students are asked to review data in order to construct a plan to reduce and remove carbon dioxide from the atmosphere.

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Chemical change
* Physical properties
* Renewable energy
* Observations
* Gases

**Correlations to Next Generation Science Standards**

This article can be used to achieve the following performance expectations of NGSS:

|  |
| --- |
| **HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. **HS-ESS2-2.** Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.**HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. |

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* ESS2.A: Earth Materials and Systems
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Cause and effect
* Energy and matter
* Stability and change
* Systems and system models

**Science and Engineering Practices:**

* Developing and using models
* Analyzing and interpreting data

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students what they know about climate change, and what can be done to fight it. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about greenhouse gases, climate change, and how to combat climate change.
* After students have read and discussed the article, consider showing the ACS Reactions Video “How Chemistry Makes Carbon Dioxide Removal Possible” (7:39) at <https://youtu.be/wu3hoo3p4Kk>. After the video, challenge the students to think of other methods to remove carbon dioxide from the atmosphere.