

Lesson Plan: Atomic Number, Mass Number, Isotopes and Isotopic Ratios, and Isotopic Compositions as Climate Proxies

As a **high school** or **undergraduate** teacher of **Chemistry** or **Earth Sciences**, you can use this set of computer-based tools to help you in teaching **atomic number, mass number, isotopes and isotopic ratios**, the use of **isotopic ratios to calculate temperature**, and the use of **isotopic composition to recreate past temperatures and climate**.

This lesson plan allows students to understand isotopes, isotopic ratios, the relationship between isotopic compositions and temperature, and how isotopic compositions are used to recreate past temperature and climate.

Thus, the use of this toolkit allows you to integrate the teaching of a climate science topic with a core topic in Chemistry or Earth Sciences.

Use this lesson plan to help your students find answers to:

- *What is an isotope?*
- *What is the relationship between isotopic compositions and temperature?*
- *How can you use oxygen isotope data in an ice core to determine temperature?*
- *How can you use isotopic compositions to reconstruct past climate?*

About the Lesson Plan

Grade Level

High School, Undergraduate

Discipline	Chemistry, Earth Sciences
Topic(s) in Discipline	Atomic Number, Mass Number, Isotopes and Isotopic Ratios, How isotopic ratios are used to calculate temperature, How isotopic composition is used to recreate past temperatures and climate
Climate Topic	Climate and the Cryosphere, Climate Variability Record
Location	Global
Access	Online, Offline
Language(s)	English (Simulation tool available in multiple languages)
Approximate Time Required	130-150 min

1 Contents

- 1. Micro-lecture (video) (~10 min)**

A micro-lecture that introduces the concepts of atomic number, mass number, and isotopes.

<https://www.khanacademy.org/science/chemistry/atomic-structure-and-properties/introduction-to-the-atom/v/atomic-number-mass-number-and-isotopes>
- 2. Reading (20-30 min)**

A reading about isotopic ratios, the relationship between isotopic compositions and temperature, and how isotopic compositions are used to recreate past temperature and climate.

<https://www.seas.harvard.edu/climate/eli/research/equable/isotope.html>

3. Classroom/Laboratory Activity (~90 min)

A classroom/laboratory activity to recreate the climate of the last 500,000 years approximately using oxygen and hydrogen isotopic compositions of ice cores from Antarctica.

University of Washington Program on Climate Change: Laboratory Activity, From Isotopes to Temperature (Spruce Schoenemann, UW Earth and Space Sciences)

<https://pcc.uw.edu/education/curriculum/climate-teaching-modules/uwhs-atms-211-from-isotopes-to-temperature-influences-of-orbital-forcing-on-ice-core-records/>

4. Suggested questions/assignments for learning evaluation

- *What is an isotope?*
- *What is the relationship between isotopic compositions and temperature?*
- *How can you use oxygen isotope data in an ice core to determine temperature?*
- *How can you use isotopic compositions to reconstruct past climate?*

2 Step-by-step User Guide



Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Introduce the topic through a micro-lecture (video)

- Discuss the components of an atom.
- Play the micro-lecture (video), "[Atomic number, mass number, and isotopes](#)", to introduce the concepts of atomic number, mass number, and isotopes. The video will help students understand the definitions of the terms through examples of hydrogen, carbon, and uranium isotopes.

The video, "Atomic number, mass number, and isotopes" from Khan Academy is available at <https://www.khanacademy.org/science/chemistry/atomic-structure-and-properties/introduction-to-the-atom/v/atomic-number-mass-number-and-isotopes>.

Note: For a more detailed exploration of isotopes, atomic mass, and methods to calculate the average atomic mass, you may use the PhET simulation tool and associated activity listed in the Additional Resources section of this lesson plan. This activity will enable your students to calculate the average atomic mass of sample mixtures of isotopes by using various methods.

2. Discuss using an online reading

Next, read and discuss “[Isotope Analysis](#)” from Harvard University to introduce the occurrence and distribution of oxygen isotopes. Further, the reading will help your students understand isotopic ratios, the relationship between isotopic compositions and temperature, and how scientists can use isotopic compositions to recreate past temperature and climate.

The reading, “Isotope Analysis” from Harvard University is available at <https://www.seas.harvard.edu/climate/eli/research/equable/isotope.html>

3. Conduct a classroom/laboratory activity

Now, explore the relationship between isotopic compositions and climate through a hands-on classroom/laboratory activity, “From Isotopes to Temperature”, created by Spruce Schoenemann, UW Earth and Space Sciences:

In this activity, your students will analyze isotopic compositions of ice core data from Antarctica to infer past temperatures and climate. Students will plot graphs in MS Excel to perform data analysis and interpretation.

- Download the documents for the From Isotopes to Temperature Lab from <https://pcc.uw.edu/education/classroom-resources/climate-teaching-modules/uwhs-atms-211-from-isotopes-to-temperature-influences-of-orbital-forcing-on-ice-core-records/>.
- Read the content in the PowerPoint Presentation (background information).
- Download the files and conduct the activity described in Lab 1 of the module.

4. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- *What is an isotope?*

- *What is the relationship between isotopic compositions and temperature?*
- *How can you use oxygen isotope data in an ice core to determine temperature?*
- *How can you use isotopic compositions to reconstruct past climate?*

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define isotopes and list examples of isotopes
- describe how isotopic ratios can be used to infer temperature
- explain how past temperatures and climate can be determined by analyzing ice-core isotope data
- understand natural variability of Earth's climate and climate change due to anthropogenic causes

4 Additional Resources



If you or your students would like to explore the topic further, these additional resources will be useful.

1. Simulation and associated classroom activity

Interactive simulation, "Isotopes and Atomic Mass" from PhET Simulations

<https://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass>

AND

An associated classroom activity, “Isotopes and Atomic Mass – Guided Inquiry Activity”, developed by Timothy Herzog:

<https://phet.colorado.edu/en/contributions/view/3964?>

2. Reading

Scientific American: How are past temperatures determined from an ice core?

<https://www.scientificamerican.com/article/how-are-past-temperatures/>

3. Classroom/Laboratory Activity

Columbia University: The Climate System course (taught by Peter Schlosser, Stephanie Pfirman, Mingfang Ting, Jason Smerdon)

Laboratory Activity, Vostok Ice Core:

<http://eesc.columbia.edu/courses/eesc/climate/labs/vostok/>

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and ownership details for each tool by following the individual links provided.

We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. Micro-lecture, “Atomic number, mass number, and isotopes”

Khan Academy: Introduction to the Atom, “Atomic number, mass number, and isotopes”

<https://www.khanacademy.org/science/chemistry/atomic-structure-and-properties/introduction-to-the-atom/v/atomic-number-mass-number-and-isotopes>

2. Reading, “Isotope Analysis”

Harvard University

<https://www.seas.harvard.edu/climate/eli/research/equable/isotope.html>

3. Classroom/Laboratory Activity, “From Isotopes to Temperature”

University of Washington Program on Climate Change (Spruce Schoenemann, UW Earth and Space Sciences)

<https://pcc.uw.edu/education/curriculum/climate-teaching-modules/uwhs-atms-211-from-isotopes-to-temperature-influences-of-orbital-forcing-on-ice-core-records/>;

4. Additional Resources

PhET Simulations, <https://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass>

Timothy Herzog, using “Isotopes and Atomic Mass” Simulation from PhET, <https://phet.colorado.edu/en/contributions/view/3964?>

Scientific American, <https://www.scientificamerican.com/article/how-are-past-temperatures/>

Columbia University, taught by Peter Schlosser, Stephanie Pfirman, Mingfang Ting, Jason Smerdon, <http://eesc.columbia.edu/courses/ees/climate/labs/vostok/>