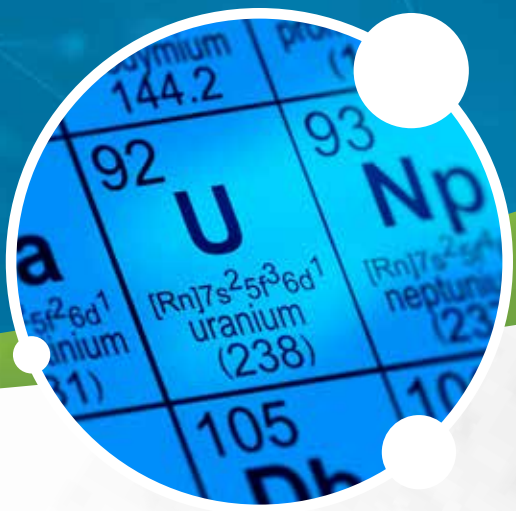
lesson plan

Understanding Isotopes

What are isotopes?



overview

LESSON CONTEXT

In order to have an understanding of radioisotopes such as those involved in nuclear fission, it is important to first have an understanding of isotopes.

LEARNING GOALS

- Understand the atomic structure of isotopes.
- Calculate weighted atomic masses and relative abundance of isotopes.
- Formulate conceptual definitions of atomic number, atomic mass, mass number and isotope.

LEARNING ACTIVITIES

In this lesson, students will construct an explanatory model of isotopes using coins. Based on their understanding of weighted average atomic mass, students will make predictions as to the types of representative isotopes (old and new nickels) present in an unidentified sample of nickels.

BIG IDEAS

Isotopes are different types of atoms of the same element, each having a different mass number. Isotopes of an element have nuclei with the same number of protons (the same atomic number), but different numbers of neutrons.

time
65-75
MINUTES

subjects
SCIENCE
CHEMISTRY

skills
COLLABORATION
COMMUNICATION

assessment & evaluation

PRIOR KNOWLEDGE AND SKILLS

- Familiarity with the periodic table
- Basic understanding of the concepts of atomic number and atomic mass
- Familiarity with the atom and its basic structure
- Ability to calculate averages and solve equations with a single variable
- Experience working in cooperative small groups

SUCCESS CRITERIA

- Students participate meaningfully in hands-on investigation
- Students demonstrate understanding of atomic number, atomic mass, mass number and isotope during class discussions

ASSESSMENT STRATEGIES

- Review of **Introduction to Isotopes BLM**
- Review of **Understanding Isotopes Investigation BLM**
- Review of **Understanding Isotopes Application Questions BLM**

resources & materials required

- DOC PDF **BLM – Introduction to Isotopes** – one per student
- DOC PDF **BLM – Understanding Isotopes Investigation** – one per student
- DOC PDF **BLM – Understanding Isotopes Application Questions** – one per student
- PDF **BLM – Introduction to Isotopes Answer Page** – for teacher use
- PDF **BLM – Understanding Isotopes Application Questions Answer Page** – for teacher use
- PDF Curriculum alignment
- Electronic (digital) balance with accuracy to 0.01 g – 0.1 g per group
- Empty 35 mm film canister (or similarly-sized container) – one per group
- Periodic table – one per student
- Canadian nickels made in 2006 or earlier (old) – seven per group
- Canadian nickels made in 2007 or after (new) – seven per group
- Canadian nickels (mix of old and new) – 10 per group
- Masking tape
- Permanent marker

preparation

- Students should be divided into small groups prior to the lesson.
- Before the lesson, prepare the canisters in the following manner:
  - » Write a code letter on the top of each film canister/container using permanent marker. Be sure to keep a record of the code letters on a sheet of paper.
  - » Weigh each empty canister with its top. Print the mass (to two digits after the decimal place) on a label (or masking tape) placed on the side of the canister.
  - » Place 10 nickels in each canister. Each canister should contain a random combination of old and new nickels. Record the number of old and new nickels next to the appropriate code letters on the sheet of paper.
  - » Seal the container. If you seal the canisters with instant glue or epoxy, then the canisters can be reused from year to year.

minds-on

20 MINUTES

- Provide students with the **Introduction to Isotopes BLM** and a periodic table. Have the students write down what they believe the terms atomic number, atomic mass, mass number and isotope mean (Question 1). Do not review the answers at this point – later in the lesson, students will be asked to reflect upon and revise, if needed, these definitions.
- Explain to students that most elements have various isotopes (versions) that vary only in the number of neutrons in the nucleus. The result is that some isotopes are heavier or lighter than others. For instance, there are two principal stable isotopes of chlorine: chlorine-35 and chlorine-37. Have the students identify the number of protons and neutrons in for each isotope of chlorine in Question 2 on the BLM (chlorine-35 has 17 protons and 18 neutrons, while chlorine-37 has 17 protons and 20 neutrons).

DID YOU KNOW?

The way that the Royal Canadian Mint makes its nickels has changed over the years. Our familiar five-cent coin contained 99.9% nickel until 1982, when its composition was modified. From 1982 until as late as 2006, nickels were made of 75% copper, and 25% nickel. In 2000, they changed again, to nickel-plated steel. Because of this change in composition, there are slight differences in the masses of nickels over the years. For more information about the history of coin production and their compositions and weights, visit the Royal Canadian Mint website.
(Retrieved August 2019)

- Next, have the students look at the periodic table and see if they can find any atomic masses that are whole numbers, then answer Question 3 on the BLM. Have the students share their answers. The students may not be correct at this point and should be encouraged to revisit and revise their answer at the end of the lesson.
- Explain that the atomic masses that are listed on the periodic table are weighted averages based on the relative quantities of the various isotopes that have been discovered so far in nature.
- Atomic masses are typically an average of several numbers, so they are generally not whole numbers. Atomic numbers, on the other hand, are always integers. You can't have a fraction of a neutron!
- Have students calculate the weighted atomic mass for the two principal stable isotopes of chorine in Question 4 on the BLM. Introduce (or review) the GUESS method for solving the problem (optional).
- Chlorine has an average atomic mass of approximately 35.5 and not 36 as would be calculated without taking the weighting into consideration (note: a more accurate mass of ^{35}Cl is 34.968 and ^{37}Cl is 36.965. The relative abundance of ^{35}Cl is actually 75.77% and ^{37}Cl is 24.23%).

IMPLEMENTATION OPTIONS

- Students could THINK, PAIR and SHARE their definitions of the terms with a partner.
- If necessary, review how the number of neutrons can be determined using the rounded atomic mass and the atomic number (i.e. number of neutrons = rounded atomic mass minus atomic number).

action

25 MINUTES

- Provide each student with a copy of the **Understanding Isotopes Investigation BLM**.
- Explain that in this investigation, the students will work together in small groups to find the weighted averages of the masses of two kinds of nickels (old and new) and then use this information to determine the number of each type of nickel in a mystery sample.
- Review the instructions for Part A and Part B of the investigation on the BLM and have students complete the BLMs.

consolidation

20–30 MINUTES

- Questions to consider for class debriefing discussion:
  - » *What are some problems or limitations with the coin/chip isotope model?*
  - » *Could this activity be done with three different "isotopes" or versions of coins/chips? Explain what the challenges would be in identifying the percentages of each of the three types of isotopes within a mystery sample.*
  - » *How can the same types of calculations you did in the isotope investigation allow scientists to determine the percentage of different isotopes of an element within a sample?*
  - » *Review your terms for atomic number, atomic mass, mass number and isotope from the beginning of the lesson. Have your understanding of these concepts changed? If so, use a different colour of pen/pencil to update your answer.*
  - » *How could you explain to someone the difference between mass number and atomic mass?*

DID YOU KNOW?

Chlorine has isotopes with atomic masses ranging from 28 to 40. There are only two principal stable isotopes, ^{35}Cl and ^{37}Cl. Trace amounts of radioactive ^{36}Cl also exist in the environment.

GUESS

Provide students with strategies for solving word problems, such as:

G – What are the Givens?

U – What are the Unknowns?

E – Write the Equation (this includes any manipulation of the equation depending on the unknowns).

S – Substitute the givens.

S – Solve the equation.

extensions

- The students could write a short summary explaining how the coin/chip model illustrates the concept of isotopes.
- The students could complete the practice application questions on the **Understanding Isotopes Application Questions BLM**.
- The Canadian penny has also changed several times over its history. From 1942 to 1996, the penny was 98% copper, hence its familiar colour (2.5–3.24 g). Between 1997 and 1999, pennies were 98% zinc with copper plating (this practice continued into the 2000's for some coins) (2.25 g). From 2000 to 2012 (when they ceased to be in circulation), the majority of the pennies were 94% steel with copper plating (2.35 g). Have the students repeat the investigation using the three "isotopes" of pennies and discuss the challenges of having three isotopes instead of two.

additional resources

CANADIAN NUCLEAR ASSOCIATION WEB PAGES

- **How reactors work**
- **Fusion research**

RELATED TEACHNUCLEAR LESSON PLANS

- **Fission vs. Fusion**
- **It's All Greek to Me: Radioactive Decay**
- **Radioactive Half-Life: The Whole Story**

background information

(Retrieved August 2019)

- **Interactive Chart of Nuclides – National Nuclear Data Center, Brookhaven National Library**
  This chart of nuclides is a simple map that distinguishes the isotopes of the elements. Nuclide charts organize isotopes along the X (horizontal) axis by their numbers of neutrons and along the Y (vertical) axis by their numbers of protons.
- **IUPAC Periodic Table of Elements and Isotopes – International Union of Pure and Applied Chemistry**
  An interactive learning resource that helps students in using interval atomic weights for elements. You can learn about how to use the interactive table here.
- **Atomic Structure – BBC Bitesize Science**
  This series of pages from BBC Bitesize Science has information about atomic structure, mass, mass number and isotopes.