Atom Building Game Investigations

Level A Investigations

A-1 Building Atoms

What is an atom?

By using the Atom Building Game to build atoms, students learn about the parts of the atom and the periodic table of the elements. Students learn how to calculate the charge on an atom, and figure out the number of protons, neutrons, and electrons in an atom. The term isotope is also introduced.

A-2 Atomic Challenge

What holds an atom together?

Students learn that atomic forces hold an atom together. They also learn about ions and isotopes. Using their understanding of these concepts, students play a game called Atomic Challenge using the Atom Building Game.

A-3 Building Molecules

What is a molecule?

Students learn about the role of energy levels in the bonding of atoms by building atoms using the Atom Building Game. From their work, students figure out that there are patterns in how atoms bond with each other. Students learn why and how atoms form molecules.

Level B Investigations

B-1 Comparing Atoms

How are elements different from each other?

Students play a game called Atomic Challenge using the Atom Building Game. By playing the game, students learn about the structure of the atom, and what makes elements different from each other. Students also learn about isotopes and radioactivity.

B-2 Nuclear Reactions Game

How are elements organized on the periodic table?

Students learn how atomic structure is related to the placement of elements on the periodic table. Students practice their knowledge and learn about nuclear reactions by playing a game called Nuclear Reactions using the Atom Building Game.

B-3 Bonding and Molecules

Why do atoms form chemical bonds?

Students build models of atoms to learn how electrons are arranged around the nucleus of an atom. Students learn about the role of electrons in bonding, and model the formation of a sodium chloride molecule. Students learn about oxidation numbers.

Level C Investigations

C-1 Electrons and the Periodic Table

What can the periodic table tell you about an atom?

In this Investigation, students learn about the placement of atoms on the periodic table. They learn about electron orbitals and electron configurations. As they build atoms of hydrogen through krypton, students see the order in which electrons fill the energy levels around the nucleus. From their electron configurations, they deduce the relationship between placement of elements on the periodic table, and arrangement of electrons.

C-2 Photons and Lasers

How do atoms make light?

The Photons and Lasers game simulates how light is absorbed and emitted by atoms. In this Investigation, students learn that atoms emit light when some of their electrons gain enough energy to jump to a higher energy level. When these electrons fall back to a lower energy level, they emit electromagnetic radiation, sometimes in the form of visible light. Students also learn how this phenomenon applies to lasers and fireworks.

C-3 Valence Electrons and Molecules

What is the role of electrons in forming molecules?

In this Investigation, students learn why atoms form bonds. They model the formation of a molecule using the Atom Building Game. They learn the role of valence electrons and oxidation numbers in forming molecules. Using their understanding of atomic structure, students figure out basic rules for predicting the ratios of elements in molecules. In a final activity, students learn the difference between atomic mass and mass number, and figure out how the atomic mass of an element is determined.

Question: How are elements organized on the periodic table?

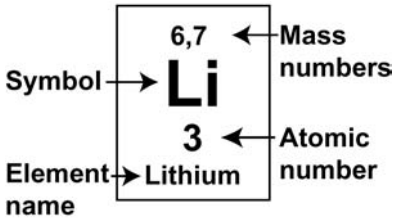
In this Investigation, you will:

1. Describe how atomic structure is related to the placement of elements on the periodic table.
2. Use your understanding atomic structure to play a game called Nuclear Reactions.
3. Discuss what happens during nuclear reactions.

In this Investigation, you will play a game called Nuclear Reactions using the Atom Building Game and the periodic table that comes with the game. By playing this game, you will learn about the organization of the periodic table.

For example, the elements on the periodic table are arranged by **atomic number**, from lowest to highest. The atomic number equals the number of protons in the nucleus of an atom. The atomic number also indicates the number of electrons in an atom. Each element has a unique atomic number.

Isotopes are atoms with the same number of protons, but different numbers of neutrons. Isotopes of an element have a different **mass numbers**. The mass number of an isotope indicates how many protons and neutrons are in the nucleus of the isotope. The periodic table shows the mass numbers of the stable isotopes of each element.



Playing Nuclear Reactions involves simulating nuclear reactions. To win the game, you will need to quickly figure out which nuclear reactions will make real atoms. The game is similar to the processes by which the elements of the periodic table were created inside stars. At the center of a star, nuclear reactions combine atoms to make new elements. We believe all the elements of the periodic table that are heavier than lithium were created inside stars through nuclear reactions. The process gives off a huge amount of energy that we experience as sunshine. The energy from nuclear reactions in the sun is what makes life on Earth possible.

1 Introduction to Nuclear Reactions

If you were to add one, two, or four more neutrons to lithium-7 you would have created lithium-8, lithium-9, and lithium-11, respectively. Each of these isotopes of lithium is **radioactive**, which means that the atomic force in the nucleus (called **strong nuclear force**) is not strong enough to hold these atoms together. The nuclei of these atoms fly apart.

The goal of Nuclear Reactions is to earn points by creating atoms that are stable (not radioactive) and neutrally charged (not ions). Remember that **ions** are atoms that have different numbers of protons and electrons and so have a charge.

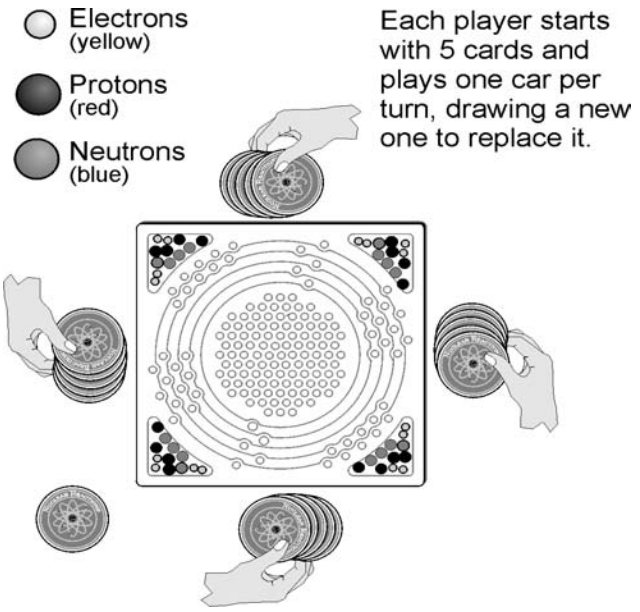
Each player starts with 8 protons, 8 electrons, and 8 neutrons in his or her pocket of the Atomic Building Game board. The game will last for about half an hour. The first player to gain 20 points wins.

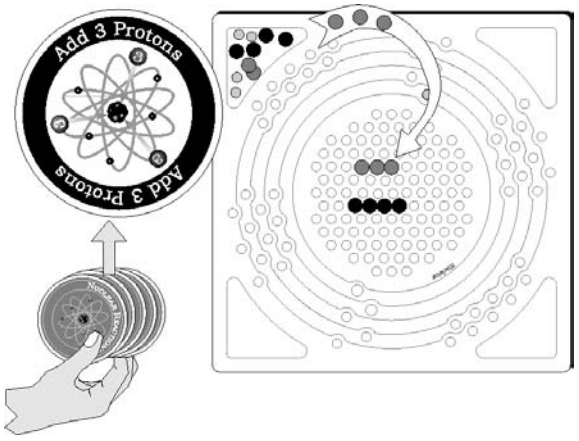
2 Playing Nuclear Reactions

To begin, each player is dealt five cards from the deck of Nuclear Reactions cards. These are held and not shown to anyone else.

Players take turns, choosing which card to play each turn, and adding or subtracting particles from the atom as instructed on the card. For example, playing an "Add 2 Electrons" card would mean you place two yellow marbles in the atom.

Subatomic particles that are added or subtracted from the atom must come from or be placed in your own pocket. You may not play a card for which you do not have the right marbles. For example, a player with only 2 protons left cannot play an “Add 3 Protons” card.

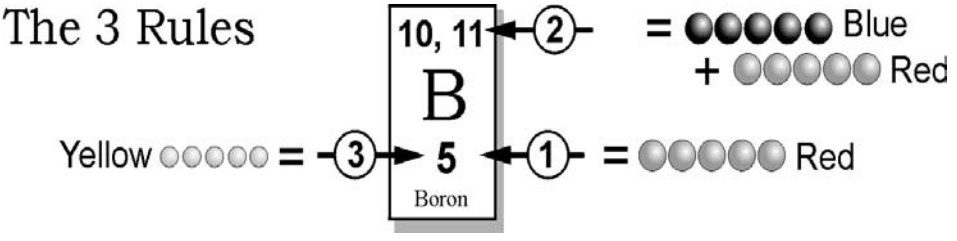




Each time you play a card, draw a new card from the deck so that you always have five. Played cards can be shuffled and reused as needed.

3 Scoring points

1. Points are scored depending on the atom you create. You will need to use the periodic table to determine your strategy and points earned. In particular, it is useful to know which cards to play to get to stable atoms, neutral atoms, or stable and neutral atoms. The diagram below illustrates the three rules for playing the game. These rules are described on the next page.



Rule #1: The number of protons (red marbles) matches the atomic number.
Rule #2: The number of protons (red marbles) plus the number of neutrons (blue marbles) equals one of the correct mass numbers for the element of Rule #1. This move creates a stable atom.
Rule #3: The number of electrons (yellow marbles) equals the number of protons (red marbles). This move creates a neutral atom.

You score 1 point if your move creates or leaves a stable atom. For example, you score 1 point by adding a neutron to a nucleus with 6 protons and 5 neutrons. The resulting atom is carbon-12 which is stable. The next player can also score a point by adding another neutron, making carbon-13. To get the nucleus right you need to satisfy rules #1 and #2.

You score 1 point for adding or taking electrons or protons from the atom if your move creates or leaves a neutral atom. A neutral atom has the same number of electrons and protons. Getting the electrons and protons to balance satisfies rule #3.

You score 3 points (the best move) when you add or take particles from the atom and your move creates a stable and neutral atom. For example, taking a neutron from a stable, neutral carbon-13 atom leaves a stable, neutral carbon-12 atom, scoring 3 points. In other words, you get 3 points if your turn makes an atom that meets all three rules.

4 Additional rules

Taking a turn

When it is your turn, you must either play a card and add or subtract marbles from the atom, or trade in your cards for a new set of five.

Trading in cards

You may trade in all your cards at any time by forfeiting a turn. You have to trade all your cards in at once. Shuffle the deck before taking new cards.

Using the periodic table

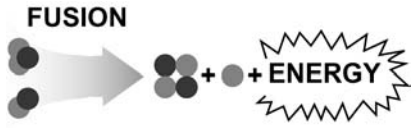
All players should use a periodic table to play the game.

The marble bank

You may choose to play two versions of the marble bank. In version 1, players take marbles from the bank at any time so that they have enough to play the game. In version 2, players must lose a turn to draw marbles from the bank, and may draw no more than 5 total marbles (of any colors) in one turn.

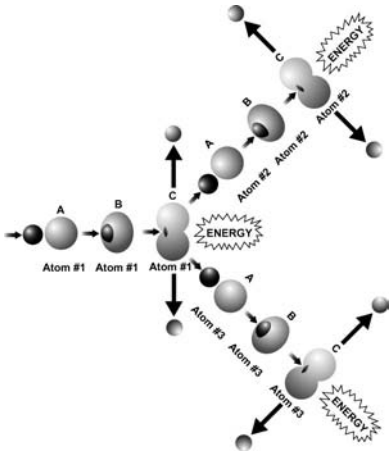
There are two kinds of nuclear reactions, **fusion** and **fission**. These kinds of reactions only involve the nuclei of atoms. The word nuclei is the plural form of the word nucleus.

Fusion involves the combination of two elements with small mass numbers to make an element with a larger mass number.



In the diagram to the right, nuclei are fused, a particle is emitted, and a lot of energy is released. The reaction in the diagram involves the fusion of hydrogen-3 (1 proton + 2 neutrons) with hydrogen-2 (1 proton + 1 neutron) to make a helium-4, a neutron, and energy. In the diagram, the dark green dots are protons; the lighter green dots are neutrons.

Fission involves the splitting of an element with a large mass number into elements with smaller mass numbers. Both nuclear reactions release energy.



The diagram to the right shows a nuclear fission chain reaction. Nuclear fission can be started when a neutron (dark ball) bombards a nucleus (green ball). A chain reaction results. A free neutron (step A) bombards a nucleus (step B) and the nucleus splits into nuclei with smaller mass numbers. More neutrons are also released (step C). These neutrons then bombard other nuclei. Nuclear reactors control fission (and energy production) by capturing neutrons to start, slow, or stop the chain reaction.

The questions below will help you better understand fission and fusion. Use the Atom Building Game to work through the questions.

a. Demonstrate the fusion reaction diagram using the Atom Building Game board. Collect enough marbles (protons, neutrons, and electrons) to build a hydrogen-3 atom (this is a radioactive isotope). Then collect enough marbles to build a hydrogen-2 atom. Place all these marbles in the correct places on the Atom Building Game board. Remove one neutron and hold it in your hand. What element is represented on the board? Why was it important to take away one neutron?

b. Collect enough marbles (protons, neutrons, and electrons) to build lithium-6. Then collect enough marbles to build boron-11. Place all these marbles in the correct places on the Atom Building Game board. What element is represented on the board? Was this activity an example of fusion or fission?

c. Is the atom that results from the combination of lithium-6 and boron-11 a stable or a radioactive isotope? Is the atom an ion or neutral?

d. Now build boron-10 on the Atom Building Game board. How many protons, neutrons, and electrons did you need to add to the board to make fluorine-19? If you were to add these subatomic particles to boron-10, would this represent fusion or fission?

e. Suppose you split a uranium-238 atom. If you have to break it into two pieces, name two elements that could be formed. Be sure that your two elements use up all the neutrons and protons in the uranium. Is either of your two elements a stable isotope or is one (or are both) radioactive?

Name:

B-2 Nuclear Reactions Game

B-2

Question: How are elements organized on the periodic table?

There are no questions to answer for parts 1 through 4 of the Investigation.

1 Introduction to Nuclear Reactions

2 Playing Nuclear Reactions

3 Scoring points

4 Additional rules

5 Nuclear reactions

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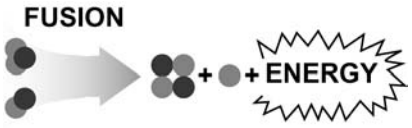

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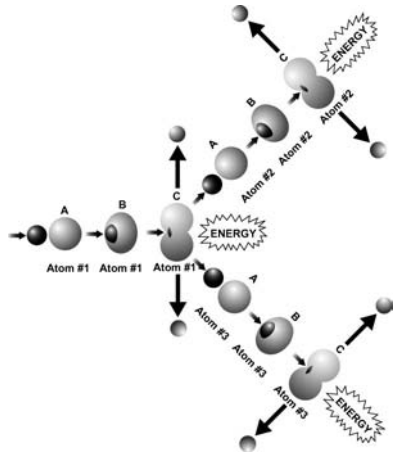

Questions

B-2

1. Identify the mystery atoms that go with the clues. Some clues may have more than one right answer.

a. An atomic number of 29.

b. A mass number of 54.

c. The element has four isotopes.

d. Atoms of the element each have 65 protons.

e. Atoms of the element have three neutrons.

2. Describe the organization of the periodic table. How does this organization help you find information about elements?

3. Describe the term "radioactive." Explain why atoms of certain elements undergo radioactive decay.

4. There are two Atom Building Game boards on a table. The first board is set up to represent an atom that has 19 protons, 22 neutrons, and 18 electrons. The second board is set up to represent an atom that has 43 protons, 55 neutrons, and 43 electrons. Which of these atoms is an ion and which is a radioactive isotope? In your answer, justify your answer and explain the difference between the terms "ion" and "isotope."

5. Compare and contrast the terms "fusion" and "fission."

6. Atoms participate in two types of reactions: chemical reactions to form molecules and nuclear reactions. Which particles are involved in each kind of reaction?

7. The statements below describe the way an Atom Building Game board looks during a game of Nuclear Reactions. For each statement, explain the move you would make and how many points you would earn. Remember, you earn one point if your move creates a stable (nonradioactive) atom or a neutral atom. You earn three points if your move creates a stable and neutral atom. For this exercise, you can only add one marble for each statement. For each statement, write the number of points you earned and explain what you did to earn the points. In some cases, you may not be able to earn points by adding or subtracting one marble. In that case, write "no points" and explain why you cannot earn points with your move.

a. The board has one proton, one neutron, and no electrons.

b. The board has two protons, two neutrons, and two electrons.

c. The board has two protons, three neutrons, and three electrons.

d. The board has four protons, five neutrons, and four electrons.

e. The board has no marbles on it.

f. The board has 14 protons, 14 neutrons, and 14 electrons.

g. The board has 9 protons, 10 neutrons, and 10 electrons.

Curriculum Resource Guide: Atom Building Game

Credits

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