2.2 - The Atom & Its Parts Unit, Packet 2

First & Last Name: _____ Course:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: How do we know atoms exist?

Anchoring Phenomenon: Everything is made from atoms. We can physically touch them. But how do we know these tiny particles actually exist? Many scientists have done experiments to determine not only the existence of atoms, but the subatomic particles contained within.

Deeper Questions

1. What evidence do we have for the existence of atoms?
2. What experiments led to the discovery of subatomic particles?
3. How do isotopes help prove atoms and subatomic particles exist?

Schedule

Part 1: Introduction
- Initial Ideas - Changing Ideas About Atoms
- Data Dive - Scientists Contribution to Discovery of the Atom, Obsertainers, Mystery Tube
- Discussion & Developing Explanations

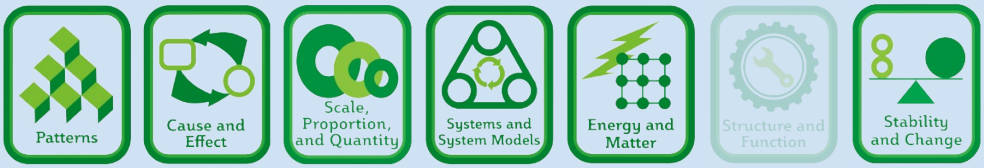
Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Gold Foil Experiment
- Bean Isotopes

Part 4: Review & Assessment
- Ranking Your Readiness
- Formative Assessment & Mastery Check

Part 5: Life Connections
- Life Connections - Seeing Atoms

NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.



Semester Schedule

0. Orientation
0.1 Lab Safety & Scientific & Engineering Practices

1. Conservation of Matter
1.1 - What happens when a substance dissolves?
1.2 - Why do some substances change with heat?
1.3 - Assessment

2. Atoms & Its Parts
2.1 - How can we know what is in substances?
2.2 - What are atoms?
2.3 - Assessment

3. Properties of Electrons
3.1 - Electrons & Energy
3.2 - How do electrons play a role in determining atoms behavior?
3.3 - Assessment

4. Periodic Table
4.1 - What does the periodic table tell us?
4.2 - Assessment

Resource Links: Class Website; Core Ideas; Practice Test; Mastery Check;

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Part 1: Introduction – Changing Ideas About Atoms (2.2.1)

Overview: In this activity, you will begin by discussing your initial ideas about what matter is made from.

Initial Ideas - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Engaging in Argument from Evidence.

Gretchen was cutting an apple into slices. She wondered what would hypothetically happen if an apple slice were cut into increasingly smaller pieces.

1. Three students shared their ideas. Do you agree or disagree with each student's claim?
    a. Gretchen: "The apple could be endlessly cut into smaller and smaller pieces. There is no end to the 'smallness' of an apple." Agree/ Disagree
    b. Karen: "As you cut the apple into smaller pieces you would see that it is made of combinations of unique substances that are unique to the apple" Agree / Disagree
    c. Cady: "There is a limit to how small you could cut up the apple. Eventually you would have particles that cannot be reduced to any smaller pieces." Agree / Disagree

2. Work in your small groups to discuss your ideas. How are your ideas similar or different? Decide as a group whether each statement is correct (and why). Be prepared to present your ideas to the class.

Data Dive - *Read the directions below.*
SEP: Analyzing and Interpreting Data.

In this data dive, you will use reliable internet resources to summarize how our understanding of atoms emerged as a result of the discoveries of specific individuals. You will use this to develop an initial explanation about what atoms are and how we know they exist.

1. **For each of the following, summarize their claims, findings & evidence, and reasoning regarding atoms. Your instructor will determine how to record your ideas.**
    a. Democritus and early ideas about atoms.
    b. Lavoisier & Conservation of Mass
    c. Proust & Law of Definite Proportions
    d. Dalton, Law of Multiple Proportions, and Dalton's Law
    e. Avogadro and Avogadro's Law
    f. Einstein and Brownian Motion

Data Dive Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Asking Questions and Defining Problems.

1. **In the space below, summarize the information for your topic.**

    a. Topic: _____

    b. Key Claim: _____

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c. Evidence & Reasoning to Support Their Claim: _____

_____

_____

2. Atoms are so small that we cannot see them even if we have the most powerful light microscope that exists. **If we can't directly observe atoms, how do we know they exist? Summarize the discoveries that led to our understanding of atoms and molecules.**
3. Often scientific discoveries depend on reaching conclusions about phenomena that cannot be directly observed. **Can you think of other scientific discoveries that occurred without direct observations?**
4. **Does this data support or refute any of the claims from Gretchen, Karen, and/or Kady on the previous page?** If so, explain.

Discussion - *Record your ideas in the spaces below.*

As a class, discuss your ideas about this data. What are the ideas that most agreed on? Where did your ideas differ as a class? Record your ideas in the spaces below.

We generally agree that…	***We disagreed or were unsure if…***

Initial Explanations - *Record your ideas in the spaces below.*
SEP: Constructing Explanations and Designing Solutions; Asking Questions and Defining Problems.

How do we know atoms exist? Record your initial explanation in the space below. It's ok if you aren't completely sure! You will revise this explanation over time.

_____

_____

_____

Throughout this packet, you will be updating this explanation as you gain more information and more experience. When you complete this packet, compare your initial explanation to your final version. You should see clear improvement with each revision.

Part 2: Core Ideas (2.2.2)

Overview: In this activity, you will begin with a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing and Using Models.

1. What impact do protons, neutrons, and electrons have on the properties of every atom (especially type of element)?
2. What is atomic notation? What is included in atomic notation? *Use an example in your explanation*.
3. Practice by writing the atomic notation for the following elements: lithium-7, chlorine-35, calcium-40 and bromine-80.
4. Summarize some of the erroneous ways in which people thought about matter prior to the discovery of atoms. Also address why these ideas were eventually discarded.
5. Summarize five pieces of evidence that led to our understanding that all matter is made from atoms. In each example, summarize the claims, evidence, and reasoning that led to modern understanding of atoms.
6. How did early experiments with vacuum tubes and electrical currents lead to our understanding that atoms are made of smaller subatomic particles?
7. What was the "plum pudding" model of the atom? Defend or refute this idea using evidence.
8. How did experiments by Rutherford's team lead to our understanding of how atoms are structured?
9. How do protons affect the identity (element) of an atom?
10. How do we know that neutrons exist? What evidence & reasoning supports this conclusion?
11. What are isotopes? How did isotopes provide evidence that atoms consist of smaller particles?
12. What is average atomic mass?
13. Practice problem: find the average atomic mass for neon-20 and neon-22.

Revising Explanations - *Record your ideas in the spaces below.*
SEP: Constructing Explanations and Developing Solutions.

How do we know atoms exist?

_____

_____

_____

Throughout this packet, you will be updating this explanation as you gain more information and more experience. When you complete this packet, compare your initial explanation to your final version. You should see clear improvement with each revision.

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Part 3A: Rutherford Simulations (2.2.3) Score: _____/_____

Pre-Investigation Questions - *Work as a group to prepare verbal responses for these questions. When you think you are <u>all</u> ready to provide responses, raise your hand. Your instructor will listen to your explanations, provide feedback, and determine if you are ready to move on to the investigation.*
SEP: Developing and Using Models.

1. *What were the erroneous ideas that were not accepted prior to the discovery of the atom? Why weren't they accepted?*
2. *What are the five pieces of evidence that helped prove the existence of atoms?*
3. *Describe the vacuum tube experiment and how it contributed to the discovery of subatomic particles.*
4. *How do isotopes provide evidence for the existence of subatomic particles?*

This activity was completed _____ (*instructor signature*)

Overview: You will use simulations (computer of physical models) to recreate the experiments Rutherford's team used to determine the structure of the atom. You will use these experiments to deepen your understanding of how we know atoms exist and what atoms are made from.
SEP: Planning and Carrying Out Investigations.

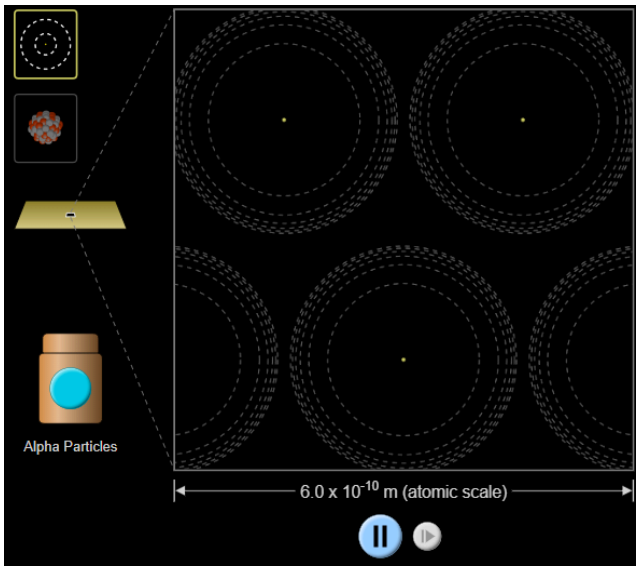
Materials: Use a school-approved device to visit the Rutherford PhET Simulation.

Methods: Check each box as you complete each step.

1. ☐ Open the PhET simulation. Click "Rutherford Atom"
2. ☐ Your screen should look like this image. In this simulation, you can see a "particle gun" in the lower left side of your screen (labeled "Alpha Particles").

   You will be firing positively charged particles at a thin sheet of gold foil. You will then observe how these particles are affected by the gold atoms (which are shown in the large box on the right).

   In the space below, predict what will happen when you fire alpha particles at the sheet of gold atoms.



_____

3. ☐ After you make your predictions, **check the traces check box** in the alpha particle box click the blue button above the label "Alpha Particles". What happens to most of the particles? Do they bounce back, or are they mostly unaffected by the gold atoms?

_____

4. ☐ In the upper left of your screen, you can see an atomic nucleus with red and white protons and neutrons. Click on this icon. What do you notice as the protons come closer and closer to the nucleus?

_____

Why do you think this occurs? _____

_____

5. In the upper right, you should see a box labeled "Legend". Based on this information, how does an alpha particle differ from a proton and a neutron?

_____

6. Based on your understanding of protons, what kind of atom most resembles an alpha particle?

_____

Post-Investigation Questions - *Record your ideas in the spaces below.*
SEP: Analyzing and Interpreting Data; Constructing Explanations and Developing Solutions. Engaging in Argument from Evidence.

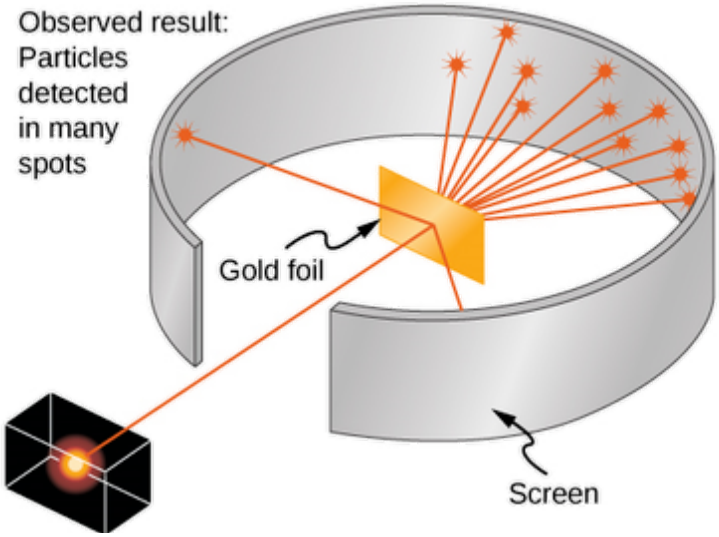
1. An image of Rutherford's gold foil experiment is shown below. Using your knowledge from this packet and from this simulation, briefly explain the significance of Rutherford's findings.

Overview of Experiment: _____

Key finding: _____

Evidence to support this claim: _____

_____



Part 3B: Bean Salad Isotopes (2.2.3) Score: _____/_____

Pre-Investigation Questions - *Work as a group to prepare verbal responses for these questions. When you think you are <u>all</u> ready to provide responses, raise your hand. Your instructor will listen to your explanations, provide feedback, and determine if you are ready to move on to the investigation.*

SEP: Developing and Using Models.

1. *What particle(s) are responsible for the atomic mass?*
2. *Where do you find the atomic mass on the periodic table?*
3. *Why are most of the masses on the periodic table not whole numbers?*
4. *What is meant by percent abundance?*
5. *What is a weighted average?*

This activity was completed _____ (*instructor signature*)

Overview: The mass of an atom is the mass of the proton (1) + mass of a neutron (1). If that is the case, and we know that you cannot have a fractional proton and/or neutron, why are the majority of the masses on the periodic table not whole numbers?

You will use a model of isotopes to determine percent abundance and the atomic mass of a new element. Isotopes are atoms of an element which are chemically the same but have different physical properties. Isotopes have different atomic masses. To model isotopes, we will use beans to represent different isotopes of the element.

In this investigation we will use different types of beans, each type representing a different isotope of the new element Pintonium. We will analyze the beans in our sample to find the average atomic mass of the element Pintonium.

Materials: baggie containing atoms (beans), balance

Directions:

1. ☐ Get your sample of Pintonium from your teacher
2. ☐ Examine the bag and determine how many different isotopes are in the bag (types of beans)
3. ☐ Separate the isotopes and find the total mass for each group of isotopes. **Record in data table**.
4. ☐ Use the number of particles (beans) there are for each isotope by counting the number of beans for each type. **Record in data table**.
5. ☐ Using the total mass of each sample of each isotope and the number of particles in that sample, calculate the average atomic mass of an individual particle of each isotope.
6. ☐ Calculate the percent abundance of each isotope by using the number of particles for each isotope divided by the total number of particles. **Record in data table**.
7. ☐ Calculate the weighted average atomic mass for Pintonium.

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Data Table:

	A	B	C	D	E
	# of particles in bag	Total mass of each isotope	Mass per particle (bean) C = B/A	% Abundance D = A/F	Atomic Mass Contribution of each isotope E = C x D
White Bean Isotope (navy)					
Speckled Bean Isotope (pinto)					
Red Bean Isotope (kidney)					
F = Total Number of particles (sum up the column				Weighted atomic mass of Pintonium (sum up the column)	

Questions:

1. A chemist obtained the following data when measuring a sample of element X, a real element from the periodic table: **(SHOW YOUR WORK)**

Isotope	**# of atoms**	**Mass of sample**
A	40	400
B	160	1760

   a. Calculate the percent abundance of each atom by taking the number of atoms of each type divided by the total number of atoms present.

   b. Calculate the mass of each isotope (atom/particle) by dividing the mass of each sample by the total mass (Mass of Sample A / Number of Atoms A)

   c. Calculate the atomic mass of element X: (% abundance of A x Mass of A) + (% abundance of B x Mass of B)

d. Based on this information and the information on the periodic table, what is the identity of element X?

2. How does the sample of beans represent isotopes?

3. Why do we use a weighted average for atomic mass?

Be prepared to discuss and defend your ideas in small groups and as a class.

Part 4: Review & Assessment (2.2.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as *1,2,3* or *green/yellow/red*, or any other method). Then work in teams to review anything that is still unclear.
Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.
Step 3: Complete the Formative Assessment (*last page of the packet*). Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.
Step 4: Individually complete a Mastery Check (link on pg. 1). If your performance indicates that additional support is needed, your instructor will determine how to help you move forward.

How do we know atoms exist?

Note: At this point, you may still be uncertain about your answer. That is ok! We still have unanswered questions about this topic. If time allows, discuss when information is still needed to answer this question.

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Part 5: Life Connections - Seeing Atoms (2.2.5)

Background - *Complete the reading before answering the questions below.*
SEP: Asking Questions and Defining Problems.

Directions: For this activity, you will consider a real-world scenario related to our topics this packet. You will use your understanding of this packet's content to develop an explanation based on the evidence provided.

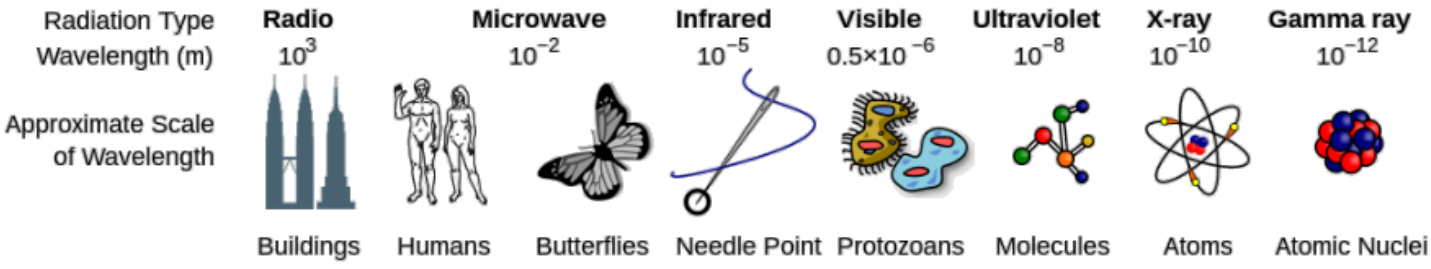
Background: We all know that it is impossible to directly see atoms. However, scientists have developed other methods to create indirect images of atoms. Read the excerpt below. This may be a challenging text. As you read the texts, underline any words that are confusing or unfamiliar. Complete an initial read-through, and check with your group to reach an initial consensus about the key points. Then use an internet search engine to look up unfamiliar terms and/or find additional information to help you make sense of these readings. Be prepared for a class discussion about the key points and main takeaways from this reading.

(Text & Images Source: Woodford, 2020)

Introduction. *What's the smallest thing you've ever seen? Maybe a hair, a pinhead, or a spec of dust? If you swapped your eyes for a couple of the world's most powerful microscopes, you'd be able to see things 100 million times smaller: bacteria, viruses, molecules—even the atoms in crystals would be clearly visible to you! Ordinary optical microscopes (light-based microscopes), like the ones you find in a school lab, are nowhere near good enough to see things in such detail. It takes a much more powerful electron microscope—using beams of electrons instead of rays of light—to take us down to nano-dimensions. Let's take a closer look at electron microscopes and how they work!*

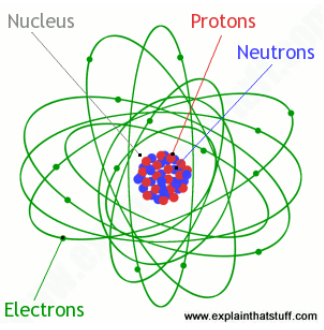
Seeing With Light. *We can see objects in the world around us because light rays (either from the sun or from another light source, like a desktop lamp) reflect off them and into our eyes. You can read these words on your paper or computer screen because light particles are streaming out of the display into your eyes. We call these individual particles of light photons: each one is a tiny packet of energy.*

Seeing with photons is fine if you want to look at things that are much bigger than atoms. But if you want to see things that are smaller, photons turn out to be pretty clumsy and useless. Just imagine if you were a master wood carver - if all you had were a sledgehammer and a spade, carving intricate furniture would be impossible. In short, the tools you use have to be smaller than the things you're using them on.



(Image Source)

The smallest thing you can see with a microscope is partly determined by the light that shines through it. If you want to see finely detailed things that are smaller than the wavelength of light, you need to use particles that have an even shorter wavelength than photons; in other words, you need to use electrons.



Seeing With Electrons. *As you probably know, electrons are the tiny charged*

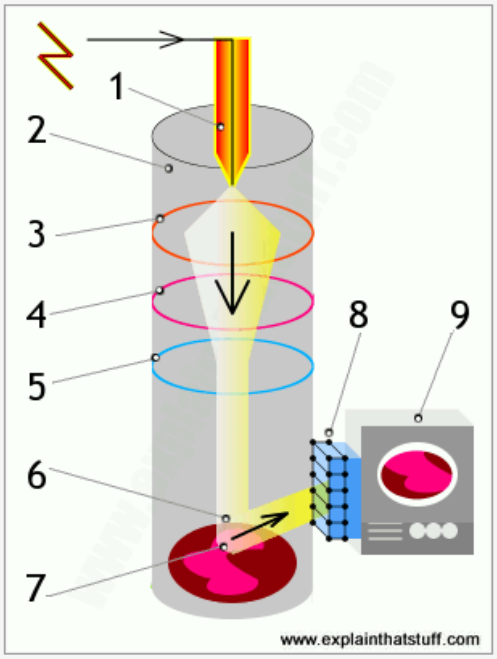
particles that occupy the outer regions of atoms. (These are also the particles that carry electricity around in wires.) In an electron microscope, a stream of electrons takes the place of a beam of light. An electron has an equivalent wavelength of just over 1 nanometer, which allows us to see things smaller even than light itself (smaller than the wavelength of light's photons).

If you've ever used an ordinary microscope, you'll know the basic idea is simple. There's a light at the bottom that shines upward through a thin slice of the specimen. You look through an eyepiece and a powerful lens to see a considerably magnified image of the specimen (typically 10–200 times bigger). There are four important parts to an ordinary microscope: 1) The source of light. 2) The specimen you're viewing. 3) The lenses that magnify the specimen. 4) The magnified image of the specimen that you see.

In an electron microscope, these four things are slightly different.

1. *The light source is replaced by a beam of very fast moving electrons.*
2. *The specimen usually has to be specially prepared and held inside a vacuum chamber from which the air has been pumped out (because electrons do not travel very far in air).*
3. *The lenses are replaced by a series of coil-shaped electromagnets through which the electron beam travels. In an ordinary microscope, the glass lenses bend (or refract) the light beams passing through them to produce magnification. In an electron microscope, the coils bend the electron beams the same way.*
4. *The image is formed as a photograph (called an electron micrograph) or as an image on a TV screen.*

A **scanning electron microscope** scans a beam of electrons *over* a specimen to produce a magnified image of an object. That's completely different from a TEM, where the beam of electrons goes right through the specimen.



1. Electrons are fired into the machine.
2. The main part of the machine (where the object is scanned) is contained within a sealed vacuum chamber because precise electron beams can't travel effectively through air.
3. A positively charged electrode (anode) attracts the electrons and accelerates them into an energetic beam.
4. An electromagnetic coil brings the electron beam to a very precise focus, much like a lens.
5. Another coil, lower down, steers the electron beam from side to side.
6. The beam systematically scans across the object being viewed.
7. Electrons from the beam hit the surface of the object and bounce off it.
8. A detector registers these scattered electrons and turns them into a picture.
9. A hugely magnified image of the object is displayed on a TV screen.