ATOMIC STRUCTURE

Grade Level: Middle School, Science and Math
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Length of Unit: Two weeks

I. ABSTRACT

Students will be exposed to the history of atomic structure. They will also learn about the three basic subatomic particle found in the atom (this should be a review from 5th grade Core Knowledge curriculum). Students will research and present a project on a scientist that was involved in developing atomic structure (three of the scientists studied are included in the 7th grade science biographies). Once this unit is completed, the student will be ready for a in-depth study of the periodic table and will have the background information necessary to study chemical reactions.

II. OVERVIEW

A. Concept Objectives
   1. Student will be able to design, conduct, evaluate, and communicate about a scientific investigation *(Colorado Science State Standard 1)*.
   2. Students will know and understand the structure of matter, the physical and chemical interaction of matter *(Colorado Science State Standard 2)*.

B. Content from the *Core Knowledge Sequence*
   1. Structure of atoms: protons, neutrons, electrons
      a. Molecules
      b. Compounds are formed by combining two or more elements and have properties different form the constituent elements.
   2. Early theories of matter
      a. The early Greek theory of four elements: earth, air, fire, and water.
      b. Later theories of Democritus: everything is made of atoms and nothing else ("atoms" in Greek means that which can't be cut or divided); atoms of the same kind form a pure "element."
      c. Alchemy
   3. Start of modern chemistry
      a. Lavoisier and oxygen: the idea that matter is not gained or lost in chemical reactions.
      b. John Dalton revives the theory of the atom.
      c. Mendeleev develops the Periodic Table, showing that the properties of atoms of elements come in repeating (periodic) groups.
      d. Niels Bohr develops a model of the atom in shells that hold a certain number of electrons. Bohr's model, plus the discovery of the neutrons, helped explain the Periodic Table: atomic number, atomic weight, and isotopes.
   4. Science Biographies
      a. Antoine Lavoisier
      b. Lise Meitner
      c. Dmitri Mendeleev

C. Skill Objectives
1. Students will identify and know where the current atomic theory came from.
2. Students will become familiar with outline format for note taking.
3. Students will use indirect observations to make predictions.
4. Students will learn contributions of early scientists.
5. Students will research, organize, and presents information on a given scientist.
6. Students will learn how scientists have come to the conclusion that an atom looks the way it does.
7. Students will be able to name and give the charge, relative weight, and know where each of the three main subatomic particles are found within the atom.
8. Students will be able to visually picture the structure of an atom.
9. Students will create a mind map that relates information given in today's lecture.
10. Students will be able to identify and find an element's atomic number.
11. Students will understand and demonstrate how to find mass number and atomic mass of and element.
12. Students will be able to define and identify isotopes of an element.
13. Students will understand the origins of the periodic table.

III. BACKGROUND KNOWLEDGE

A. For Teachers
None

B. For Students
None

IV. RESOURCES

A. Matter Building Block of the Universe, Annotated Teacher's Edition. © 1997 Prentice Hall Science. ISBN 0-13-42-3138-4.
B. Brown, Theodore L.; Bursten, Bruce E.; LeMay, H. Eugene Jr. *Chemistry the Central Science, Sixth Edition*. © 1994 Prentice-Hall.
C. Phil Parratore. *Matter*. © 1995, Creative Teaching Press Inc.
D. http://www.treasure-troves.com/bios/Lavoisier.html
E. Ruben, Samuel. *Handbook of the Elements*. © 1985, Open Court Publishing Company. IBSN 0-87548-399-2.
F. Stwertka, Albert. *A Guide to the Elements*, *Revised Edition*. © 1998, Oxford University Press. IBSN 0-19-512708-0.

V. LESSONS

Lesson One: Early Theories of Matter

A. *Daily Objectives*
1. Concept Objective(s)
    a. Student will be able to design, conduct, evaluate, and communicate about a scientific investigation.

b. Students will know and understand the structure of matter.

2. Lesson Content
    a. Lecture overview of history of atomic theory.
3. Skill Objective(s)
    a. Students will identify and know where the current atomic theory came from.
    b. Students will become familiar with outline format for note taking.

B. *Materials*
    1. Appendix A – *Student Outline, Early Theories of Matter*
    2. Graph paper (optional)

C. *Key Vocabulary*
    1. Matter: anything with mass and volume
    2. Atom: the smallest piece of matter

D. *Procedures/Activities*
    1. In Lesson Three, a scientist research project will be assigned. It is recommend that computer time is scheduled for this day. Having text recourses for students to use on hand will also be very helpful.
    2. Have enough copies of Appendix A – *Student Outline, Early Theories of Matter* to give one to each student. Appendix A is a lecture outline for student use. Currently at the end of each line in the outline, is the word or phrase that should be inserted in the blank. Be sure to these are not included in student handouts.
    3. Scientists have been interested in chemistry for a very long time! Early Greeks believed that the earth and everything in the universe was made up of four basic elements: earth, air, fire, and water. In the Middle Ages, scientists preformed experiments in Alchemy to try and find the perfect element.
    4. Scientists have always known that matter exists. Matter is anything that has mass and volume. Scientists have been searching to find what matter is made of for thousands of years.
    5. Take a piece of paper; rip it in half. Rip it in half again. Repeat until you can rip no more. Now use a scissors to cut the paper in half. Ask the students if you will reach a point where a scissors won't cut the paper anymore. Can the paper still be cut? How? (Accept all logical answers.) You could use a very fine blade and a microscope to assist you in cutting the paper. Could you every reach a point where this method will no longer work to cut the paper? Will there come a point where we get to the smallest piece of paper?
    6. Scientists have been looking for the smallest piece for a long time! They are still looking for the smallest piece of matter. What is matter? Matter is anything that has weight and volume.
    7. Today we are going to try and find out what the smallest "piece" of any substance is. Scientists have been searching for this answer for more than 2000 years!

8. The early Greeks were the first to come up with a theory. They said that the earth is made up of four basic elements (earth, air, fire, and water). This started scientists' search for the smallest piece of matter.
9. Today scientists know that they early Greek theory is not true. How did we get to this point?
10. Another Greek, a philosopher named Democritus (460 – 370 B.C.), was the first person to come up with a reasonable answer.
11. After a lot of observation Democritus concluded that matter could not be divided into smaller pieces forever. He said that eventually a "smallest" piece would be reached – he called this piece the atom. Democritus' theory was widely ignored for over 2000 years!
12. In the late 1700's, a French chemist, Antoine Lavoisier, did many experiments with oxygen. Through his experiments he came up with the idea that matter cannot be gained nor lost in a chemical reaction. From this, we have the Law of Conservation of Mass, which states that matter is neither created nor destroyed during any chemical reaction.
13. In the early 1800's the first meaningful atomic theory was published by an English schoolteacher named John Dalton (1776 – 1844). Dalton's theory had four main points: (1) All elements are made of very small particles called atoms -*Democritus was right*, (2) Atoms of the same element are identical - *Lavoisier's Law of Conservation of Mass*, (3) Atoms are neither created not destroyed in a chemical reaction, and (4) Compounds are formed when atoms of two or more elements combine.
14. Have the students create a cross would puzzle using key terms, people, and other pieces of information from today's lesson. Some terms that student crossword puzzles could include are the following: matter; earth, air, fire, or water (one of the Greeks four basic elements); Democritus; Lavoisier; something about the Law of Conservation of Mass; John Dalton; atom. Have graph paper to assist the students in making their crossword puzzle.

E. *Assessment/Evaluation*
   1. Crossword puzzles

Lesson Two: Indirect Observation Activity

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students will know and understand the structure of matter.
   2. Lesson Content
      a. Lab activity about indirect observations.
   3. Skill Objective(s)
      a. Students will use indirect observations to make predictions.

B. *Materials*
   1. Shoe boxes (one box for every two students)
   2. Various small object (3-5 objects for every shoe box)
   3. Appendix B – *Mental Models*

C. *Key Vocabulary*
   1. Indirect evidence: evidence that is gained based on observation

D. *Procedures/Activities*
   1. Before class, create sealed shoeboxes filled with 3 – 5 small items such as paper clips, erasers, pens, pencils, rocks, etc. You should have one shoebox for each group of two students. It is recommended that you keep a record of what each box contains in case there is any question at the end of the activity.
   2. Have enough copies of Appendix B – *Mental Models* to give one to each student. Currently Appendix B contains answers to some lab questions. Be sure to these are not included in student handouts.
   3. Collect crossword puzzles.
   4. Pass out a copy of Appendix B - *Mental Models* to each student.
   5. Read through the activity as a class.
   6. Check to be sure the students understand what indirect evidence is and why it is helpful when examining extremely small object like matter.
   7. Have the students do a written lab report when they have completed the lab. This report should include an introduction, the procedures followed, observations, questions that need to be answered, and a conclusion. (In my class these are to be typed and I allow about one week for completion.) If your class goes the computer lab tomorrow to work on their research projects, you may want to show them what you expect for their lab reports.

E. *Assessment/Evaluation*
   1. Collect and grade lab reports.

Lesson Three: Research Paper Work Day

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students will know and understand the structure of matter.
   2. Lesson Content
      a. Students will research scientist we are studying and put together a project that gives information about these scientists.
   3. Skill Objective(s)
      a. Students will learn contributions of early scientists.
      b. Students will research, organize, and presents information on a given scientist.

B. *Materials*
   1. Appendix C – *Early Chemist Research Project*
   2. Research materials, books, encyclopedias, etc.

C. *Key Vocabulary*
   None

D. *Procedures/Activities*
   1. Collect books and related material on Democritus, John Dalton, Niels Bohr, Ernest Rutherford, Antoine Lavoisier, Dmitri Mendeleev, J.J. Thomson, and Lise Meitner.

2. Have one copy of Appendix C – *Early Chemist Research Project* for each student.
3. Pass out Appendix C – *Early Chemist Research Project* to each student. Assign the on-going research project on one of the scientists listed in Appendix C. Appendix C also provides a grading rubric and instructions.
4. You may want to assign each student a scientist to research to be sure that all scientists receive equal coverage.
5. Appendix C contains a list of suggestions for research projects, but allow your students to come up with their own project as long as it meets all qualifications.
6. It may be beneficial to have computer time with Internet access and word processing capabilities or the library reserved to take your students to on this day.
7. This day is to give students class time to work on their scientist report.
8. Research projects will be due in Lesson Nine.

E. *Assessment/Evaluation*
1. Research paper will be due on Lesson Nine.
2. Use the provided rubric (contained in Appendix C) to grade student projects.

Lesson Four: Structure of the Atom – Day 1

A. *Daily Objectives*
1. Concept Objective(s)
   a. Students will know and understand the structure of matter.
2. Lesson Content
   a. Lecture on the experiments and observations that led to the discovery of what an atom is made of.
3. Skill Objective(s)
   a. Students will learn how scientists have come to the conclusion that an atom looks the way it does.
   b. Students will become familiar with outline format for note taking.

B. *Materials*
1. Paper
2. Markers, color crayons, or colored pencils
3. Appendix D – *Pictures of Atomic Models*
4. Appendices E & F – *Student Outline-Structure of the Atom*

C. *Key Vocabulary*
1. Corpuscle: negative subatomic particle in the atom discovered by J.J. Thomson; today the corpuscle is known as an electron
2. Nucleus: the center of positive charge in the nucleus; the nucleus was discovered by Ernest Rutherford

D. *Procedures/Activities*
1. Appendix D is included for a reference of the different atomic models. You may want to make this into an overhead transparency to use in class.
2. Appendices E and F contain a student outline of today’s lecture. Make one copy for each student. Currently at the end of each line in the outline,

is the word or phrase that should be inserted in the blank. Be sure that these are not included in student handouts.

3. Appendix G contains a quiz over today's material that may be given whenever convenient (I'll use it in the start of Lesson Five).
4. We learned yesterday that scientists used indirect evidence to learn what an atom really looks like. But what does an atom look like?
5. Pass out a sheet of blank white paper to each student. Have markers, crayons, or colored pencils available for the students' use. Ask each student to draw a picture of what they think an atom looks like. Have students share their ideas with the class. Hang these pictures up somewhere in the classroom.
6. So what does and atom actually look like? In 1897, English scientist J.J. Thomson gave us the first clue. He ran experiments in which he passed a neutral electric current through a gas. The gas gave off rays with a negative charge. This got Thomson thinking because when he started the gas had a neutral charge. Where did this negative charge come from? Thomson reasoned that it had to come from within the atom itself. He said that atoms must be made up of smaller particles. Thomson had found a negative particle in the atom – he called it a corpuscle. Today we know Thomson's corpuscle as the electron.
7. Thomson's discovery of the electron was a huge breakthrough in science, but it also caused more questions to arise. Scientists knew that atoms were neutral – they did not have a charge. Thomson reasoned that there must also be a positive charge in the nucleus to balance out the negative charge from the electrons. Despite his many efforts, Thomson was unable to find any positive charge in the atom.
8. In addition to discovering the electron, Thomson also proposed a model for the structure of the atom. He said that atoms were small hard balls filled with a positively charged substance with negative electrons floating around in it. Thomson's model is often called the "plum pudding" model of the atom. The pudding is thought to correspond with the positively charged substance and the plums with the electrons. Appendix D contains a drawing of Thomson's model.
9. Thomson's atomic model was a huge step in the discovery of atomic structure, but scientists knew that there was more to the atom than what Thomson had discovered. They were searching for a positively charged particle that would balance out the negative electrons.
10. In 1908 another English scientist, a physicist named Ernest Rutherford brought us another step closer to the true structure of the atom.
11. Rutherford set up an experiment where he fired a tiny stream of positively charged particles at a *very* thin sheet of gold foil. Rutherford was able to record where the positive particles ended up once they passed through the gold foil.
12. Rutherford found that most of the particles passed straight though the gold foil! Knowledge of the time said that atoms were small dense spheres. How was this possible? Rutherford reasoned that atoms are not small

dense spheres but mostly empty space. Atoms, he said, must contain *a lot* of empty space to allow so many particles to pass straight through.

13. Rutherford also noticed that some of the particles bounced away from the sheet of gold as if they had hit something. Rutherford knew that positive charges repel positive charges. He reasoned that the positively charged particles in his particle stream must have run into other positive particles. He had found a positive part of the atom – something Thomson had tried to prove without success. Rutherford reasoned that the positive charge must be concentrated in the middle of the atom, not spread throughout it like in Thomson's model. Rutherford called this center of positive charge the nucleus. This positive center was *very* small compared to the rest of the atom – to picture this mentally, compare the nucleus to a baseball and the whole atom to a baseball stadium. The baseball in the stadium is a good representation of how small the nucleus is in relation to the whole atom.
14. If all the positive charge was centered in the middle of the atom, where is the negative charge discovered by Thomson located? Rutherford thought that the electrons were scattered outside the nucleus, near the edge of the atom. Rutherford noted that the electrons must be held in place by their attraction to the nucleus.
15. A model of Rutherford's atom is included in Appendix D.
16. After Rutherford completed his experiments, scientists were much closer to the answer of what an atom looks like. (Remember they have gotten all their information from indirect evidence!) As Thomson's model brought up the question of a positive charge, Rutherford's model brought up another question. Where exactly are the electrons located?
17. Niels Bohr, a Danish scientist, answered the question brought up by Rutherford's experiment in 1913.
18. Bohr placed each electron in a specific energy level, or shell, around the nucleus. He said that electrons move in definite orbits around the nucleus – kind of like how planets move around the sun.
19. A model of Bohr's atom is included in Appendix D.
20. Today's model of the atom is similar to Bohr's model, but based on wave mechanics. Wave mechanics basically says that electrons don't move in a specific path around the nucleus of the atom, like Bohr predicted. Wave mechanics says that it is impossible to know the exact location of an electron in an atom! Instead, the *probable* location of the electron, based on the amount of energy it has, can be known; the more energy the electron has, the further it is from the nucleus.

E. *Assessment/Evaluation*

1. Appendix G – *Structure of the Atom Notes Quiz* – give tomorrow

Lesson Five: Structure of the Atom – Day 2

A. *Daily Objectives*

1. Concept Objective(s)
    a. Students will know and understand the structure of matter.

2. Lesson Content
    a. Lecture on covering specifics about the three main subatomic particles.
    b. Making 3-dimensional models of the atom.
3. Skill Objective(s)
    a. Students will be able to name and give the charge, relative weight, and know where each of the three main subatomic particles are found within the atom.
    b. Student will be able to visually picture the structure of an atom.

B. *Materials*
1. Appendix G – *Structure of the Atom Notes Quiz*
2. Appendix H – *Model of the Atom*
3. An object with the approximate weight of 1 gram (a paper clip is about 1 gram)
4. Balloons
5. Wire coat hangers, pipe cleaners
6. Wire
7. Marshmallows
8. Toothpicks
9. Glue
10. Markers

C. *Key Vocabulary*
1. Subatomic particle: particle smaller that the atom
2. Proton: subatomic particle with a positive charge located in the nucleus of the atom
3. Neutron: subatomic particle with no charge located in the nucleus of the atom
4. amu: Atomic Mass Unit, the unit used to weigh subatomic particles
5. Electron cloud: the area surrounding the nucleus where electrons are found

D. *Procedures/Activities*
1. Today the students are going to create 3-dimensional models of the atom. The materials listed are options; collect anything that would assist the students in this project.
2. Appendix H is provided as a reference for the teacher, however it will be helpful to draw the structure of the atom with your students. It is also helpful to help the students complete a chart similar to the one in Appendix H.
3. Have enough copies of Appendix G – *Structure of the Atom Notes Quiz* for each student. Be sure to remove answers (in italics at the end of each question) before copying for the students.
4. Give Structure of the Atom Quiz contained in Appendix I on yesterday's material.
5. The quiz may be graded in class and serve as a review of yesterday's material.
6. Today, scientists know of about 200 subatomic particles. A subatomic particle is a particle that is smaller than the atom. Today in class we are

going to look at the three main subatomic particles. After today, you should know the charge on each of these particles, the mass of each particle, and where each particle is found in the atom.

7. Yesterday we talk about how Ernest Rutherford did experiments with gold foil and a positive particle beam and found the atoms nucleus. What Rutherford didn't know is that the nucleus of the atom contains two subatomic particles.
8. One of the particles contained in the nucleus is the proton. The proton has a positive charge. Scientists use a special unit to measure the weight of subatomic particles. It was necessary for them to create this special weight because of the size of the subatomic particles. The are so small that based on all current measures their weight would be zero. A proton has a mass on 1 atomic mass unit, or 1 amu. The amu is the special unit that is used to measure the weight of subatomic particles. To get an idea of how small this actually is think of a paperclip (you may want to pass out some small paperclips so the students have an idea of the actual weight of the paperclip). Each paperclip weighs about one gram. One gram is equal to 6.02×10^{23} amu. That means that 6.02×10^{23} protons (that's 6 followed by 23 zeros!) combined would have the same weight as 1 paperclip.
9. The other subatomic particle contained in the nucleus is the neutron. The neutron is neutral; it doesn't have a charge.   The neutron has the same mass as a proton, 1 amu.
10. Yesterday we learned about the subatomic particle discovered by J.J. Thomson, the electron. The electron is the one main subatomic particle that is not found in the nucleus. Electrons are found in the area that surrounds the nucleus called the electron cloud. The electron cloud is divided into various energy levels. Electrons are always found in pairs. Electrons have a mass much smaller even than a proton! They are so small that their mass is considered to be 0 amu.
11. So…what does an atom look like? Appendix H contains a diagram of an atom and a chart that summarizes the charge, location, and mass of three main subatomic particles.
12. Most atoms are neutral and contain the same number of protons, electrons, and neutrons. That is what we will assume our atoms contain unless told otherwise.
13. For the rest of period, use the collected materials to make 3-dimensional models of atom. It might be beneficial to assign each student an element to make. All you would need to tell them is the element and how many electrons, protons, or neutrons the element has.
14. Tell students that they will have class time tomorrow to work on their research projects and that they need to bring materials.

E. *Assessment/Evaluation*

1. Grade student 3-D models.

Lesson Six: Molecules and Compounds

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students will know and understand the structure of matter, the physical and chemical interaction of matter.
   2. Lesson Content
      a. Lecture on elements and compounds.
   3. Skill Objective(s)
      a. Students will create a mind map that relates information given in today's lecture.

B. *Materials*
   1. Appendix I - *Sample Mind Map*

C. *Key Vocabulary*
   1. Pure substance: a substance in which all particles are alike
   2. Element: the simplest pure substance
   3. Molecule: two or more atoms chemically bonded together

D. *Procedures/Activities*
   1. Mind maps are to be created with this lesson. They may be created as a class or individually. They could be created as the class is discussing the material or after all new material has been discussed.
   2. Yesterday we learned was an atom actually looks like. Atoms make up elements. Elements are the simplest pure substance. A pure substance is a substance in which all the particles are alike.
   3. So what are some elements? Oxygen, hydrogen, and iron are some examples. There are many elements! Scientists have devised a shorthand way to represent elements so when they want to talk about them it is not necessary to write out the whole element name. This system uses chemical symbol to represent the elements. A chemical symbol consists of one or two letters. The first letter is ALWAYS capitalized; the second letter is NEVER capitalized. The chemical symbol for oxygen is O, the chemical symbol for hydrogen is H. Many chemical symbols, like those for hydrogen and oxygen, relate directly to there name, this makes them easy to remember. Others are a little tougher. Take the chemical symbol for iron, for example, Fe. This comes from the Latin for iron, ferrum; iron's chemical symbol comes from the Latin and not the English.
   4. Another type of pure substance is a compound. Some examples of compounds are water and table salt.
   5. The simplest form of a compound is not an atom, but a molecule. A molecule is made of two or more atoms chemically bonded together. A molecule is the smallest part of a compound that has all the properties of the compound.
   6. Create a mind map that relates these concepts as a class or individually. A sample mind map has been included in Appendix I.
   7. Remaining class time may be used to work or research projects.

E. *Assessment/Evaluation*
   1. Collect and grade mind maps. Check for accuracy and to be sure the students are able to relate all the concepts and ideas discussed in class.

Lesson Seven: Protons, Neutrons, and Electrons

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students will know and understand the structure of matter, the physical and chemical interaction of matter.
   2. Lesson Content
      a. Lecture, teacher example, and student practice dealing with how to find the number of protons, neutrons, and electrons an atom has.
   3. Skill Objective(s)
      a. Students will be able to identify and find an element's atomic number.
      b. Students will understand and demonstrate how to find mass number and atomic mass of and element.
      c. Students will be able to define and identify isotopes of an element.

B. *Materials*
   1. Appendix J

C. *Key Vocabulary*
   1. Atomic number: the number of protons in the nucleus of an atom
   2. Mass number: the sum of the number of protons and neutrons contained in an atom's nucleus
   3. Atomic mass: the average of all the mass numbers of all the isotopes of an element that occurs in nature
   4. Isotope: an atom of a given element with a different number of neutrons than protons

D. *Procedures/Activities*
   1. Have one copy of Appendix J for each student. Be sure not to copy the answers with the student handout.
   2. Collect any mind maps still not turned in.
   3. The number of protons in an atom helps us identify what element the atom is. The number of proton of an atom is given a special name. It is called the atomic number. All atoms of the same element have the same atomic number. All atoms of hydrogen, for example, have 1 proton. The atomic number of hydrogen is 1. All atoms of carbon have 6 protons. How many electrons must an atom of hydrogen have in order for it to be a neutral molecule? One – hydrogen needs one negative electron to balance out the 1 positive charge in its single proton. The atomic number of carbon is 6. How many neutrons would an atom of hydrogen have? One – the number of neutrons is usually the same as the number of protons in an atom. How many electrons do you expect an atom of carbon to have? A neutral atom of carbon has 6 electrons. How many neutrons would you expect an atom of carbon to have? If you said 6, you're correct.

4. The number of protons and neutrons in an atom give scientists clues to another characteristic of elements. Atoms of the same element have the same mass number. To find this number, add the number of protons and the number of neutrons in an atom. Let's find the mass number of hydrogen and carbon. We said that hydrogen has 1 proton and 1 neutron. The mass number equals the number of protons plus the number of neutrons: 1 proton + 1 neutron = 2. Carbon has 6 protons + 6 neutrons = a mass number of 12.
5. Sometimes atoms of the same element, which have the same number of protons, have different numbers of neutrons. These two atoms are still the same element (only having different numbers of protons can give a different element). These kind of atoms – one in which the number of neutrons does not equal the number of protons – are called isotopes.
6. For example some atoms of carbon have 6 protons but instead of 6 neutrons, they have 8 neutrons. The mass number of this atom would be 6 protons + 8 neutrons which equals 14, this atom of carbon's mass number. Before we had carbon with a mass of 12. How do they keep these different kinds of carbon straight? Do they always have to specify how many protons and neutrons the carbon atom has? No. Scientists categorize isotopes differently. The isotopes of carbon with eight neutrons are referred to as carbon – 14. That's the element followed by its mass number. For elements that do not have an isotope or atoms of an element with the same number of protons and neutrons, it is not necessary to list the mass number after the element so others know exactly what you are talking about. It's assumed that the protons = the neutrons.
7. Some elements have many naturally occurring isotopes. This means that in nature, you are able to find atoms of the same element with different numbers of neutrons. Scientists need to know the mass of a particular element. When looking for this, the mass number of the atom is not sufficient because atoms with different mass numbers exist. Scientists have created another number to solve this problem. This number is called the atomic mass. The atomic mass is the average mass number of all the naturally occurring isotopes of a given element. An element's atomic mass even takes into consideration how much of each isotope actually exists! You will not be asked to calculate and elements atomic mass in class. But tomorrow we will learn where to find this number.
8. Pass out Appendix J. This sheet asks students to find the atomic number, number of protons, electrons, neutrons, and mass numbers of given elements. The students are supplied with limited information and need to understand the relationship between the information to complete the worksheet. It would be wise to go through the first couple with the students

E. *Assessment/Evaluation*

1. Collect Appendix J tomorrow and correct. Reteach if necessary.

Lesson Eight: The Periodic Table

A. *Daily Objectives*
  1. Concept Objective(s)
     a. Students will know and understand the structure of matter, the physical and chemical interaction of matter.
  2. Lesson Content
     a. Lecture about how the periodic table came to be.
  3. Skill Objective(s)
     a. Students will understand the origins of the periodic table.

B. *Materials*
  1. You may want a sample periodic table to show the students

C. *Key Vocabulary*
  None

D. *Procedures/Activities*
  1. Collect Appendix J.
  2. As of today, scientists know of 109 different elements. Throughout the years many of these elements have been discovered. Knowing that all these elements exist is a major accomplishment for scientists. Scientists also know a great deal about each element. Learning and remembering all the known information about each element is a daunting task. For years scientists searched for a way to organize the elements and group all the data in a meaningful way.
  3. In the mid-1800's, a Russian chemist, Dmitri Mendeleev, took a stab at organizing the 63 elements of his time and all their properties.
  4. He made a card for each known element that included the element and all its known properties. Some of the properties he included were, atomic mass, density, valance, and melting point.
  5. Once he had the cards, Mendeleev searched for a pattern. To help him find a pattern, he arranged the elements in different ways. One way Mendeleev arranged the cards was in order of increasing atomic mass. When the cards were put in this order, Mendeleev noticed that there was a repeating pattern in the elements valance 1 2 3 4 3 2 1. Mendeleev broke his long chain of element arranged according to atomic mass into rows so that the pattern of valance was also grouped. Mendeleev was surprised to note that within each column, elements had the same properties.
  6. There were some elements in Mendeleev's table that seemed to be out of place. The properties of these elements seemed to line up better in a different column placing the element out of order according to its atomic mass. Mendeleev moved those elements and assumed that the known calculated atomic masses were incorrect and soon, correct massed would be found that fit the pattern. Mendeleev also predicted the existence of several elements to help fill the holes in his periodic table. Later, elements with the properties Mendeleev predicted were discovered.
  7. Today's periodic table is arranged just a little differently than the one Mendeleev created. Around 1900, an English scientist, Henry Moseley, used atomic numbers to arrange the periodic table. His periodic table

lined up just about exactly with Mendeleev's. Moseley's advantage over Mendeleev was the discovery of the proton, and he arranged the atoms by increasing atomic number.

8. The rest of the class can be used to work on research projects. They are due tomorrow!

E. *Assessment/Evaluation*

1. Check for student understanding.

Lesson Nine: Research Project Presentation

A. *Daily Objectives*

1. Concept Objective(s)
   a. Students will know and understand the structure of matter.
2. Lesson Content
   a. Presentation of student research projects.
3. Skill Objective(s)
   a. Students will research, organize, and presents information on a given scientist.

B. *Materials*

1. Appendix C
2. Student research projects.

C. *Key Vocabulary*

None

D. *Procedures/Activities*

1. Have students present their research projects to the class.
2. These projects can be grading using the rubric contained in Appendix C.

E. *Assessment/Evaluation*

1. Grade research projects.

VI. CULMINATING ACTIVITY

A. Adopt an Element

1. This is a fun extension that lets students learn more about individual elements.
2. See Appendix K for activity.
3. You will need to have some resources that provide information on the elements for this project. *A Guide to the Elements* and *Handbook of the Elements* are listed in the resources section of the beginning of this unit. These are both good recourses, but there are others that would work well also. The Internet is another place the students could search for information.
4. This activity could also serve as a springboard into how the periodic table is set up.

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Student Outline-Early Theories of Matter

B. Appendix B: Mental Models

C. Appendix C: Early Chemist Research Report

D. Appendix D: Models of the Atom
E. Appendix E: Student Outline-Structure of the Atom (two pages)
F. Appendix G: Structure of the Atom Notes Quiz
G. Appendix H: Model of the Atom
H. Appendix I: Sample Mind Map
I. Appendix J: Element Table
J. Appendix K: Adopt-an-Element

VIII. BIBLIOGRAPHY

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Appendix A-Atomic Structure

Student Outline
Early Theories of Matter

I. _______ Theory *(Greek)*

A. All _________ is made of four ________________. *(matter, elements)*

1. _____________ *(Earth)*
2. _____________ *(Air)*
3. _____________ *(Fire)*
4. _____________ *(Water)*

B. This theory is ____________________. *(incorrect)*

II. ____________________ *(Democritus)*

A. ____________ philosopher *(Greek)*

1. _____________ B.C. *(460 – 370)*

B. Conclusion

1. _____________ could not be divided _____________. *(matter, forever)*
2. A _____________ __________ will be ______________. *(smallest piece, reached)*
3. _______________________ called the smallest piece the __________. *(Democritus, atom)*

C. _________________ results were ignored for over _________ years. *(Democritus', 2000)*

III. ____________ _____________ *(Antoine Laviosier)*

A. ___________ chemist *(French)*

1. late ________ *(1700s)*
2. Conducted ____________ with _____________. *(experiments, oxygen*

B. Conclusion

1. ___________ cannot be _____________ nor _____________. *(Matter, created, destroyed*
2. This became known as the _______ of _________________ of _________. *(Law, Conservation, Mass)*

Appendix B-Atomic Structure

Mental Models

Atoms are too small to be seen without the assistance of very high-powered microscopes. Yet, scientists have a very good idea of what an atom looks like.

How'd they do that????

Scientists use something called *indirect evidence* to support their ideas about atoms. Indirect evidence involves making predictions based on observations. Today we are going to determine the characteristics of something we cannot see.

Materials
Sealed shoe box with objects inside
Triple beam balance

Procedure
1. Obtain a shoebox from your teacher.
2. Use a variety of tests, for example weighing, shaking, tipping, and sliding. After each test record the test and what you observed in a data table.
3. On the basis of your observations, sketch the object(s) in your box. Include as many characteristics as you can.

Observations
Include a data table of the test you used and conclusions you came to when trying to find out about the objects in your box.

Analysis
1. How is this activity similar to what scientists have done to learn about the atom? *(using indirect evidence.)*

Critical Thinking
1. How could you test your model of the box contents to see if you are correct? *(Prepare another box with objects that you think are contained in the original. See if they behave the same way.)*
2. Are there any instruments you could use to assist you? If so, what? *(X-ray machine, magnets, etc.)*
3. Open the box. How does your conclusion compare with the actual contents of the box?
4. What can we learn from this about the current model of the atom?

Conclusion
1. What does this experiment tell us about the current model of the atom? *(It is the scientists' best guess, but could change based on new evidence.)*
2. Share what you liked about this activity and at least one way in which the activity could be improved.

Appendix C-Atomic Structure

Early Chemist Research Project

Your task is to research one of the following scientists.

John Dalton	Ernest Rutherford
Democritus	Antoine Lavoisier
J.J. Thomson	Dmitri Mendeleev
Niels Bohr	Lise Meitner

You may choose to represent you finding in any of the following ways:

- A poster that shares information about the scientist and what their major contribution is.
- Write a letter to the scientist asking them about their work.
- Create and perform a skit that highlights your scientist's discovery.
- Compose a lyrical poem, song, or jingle that represents your scientist.
- Write a research paper on your scientist.

Other project ideas may be done with instructor approval.

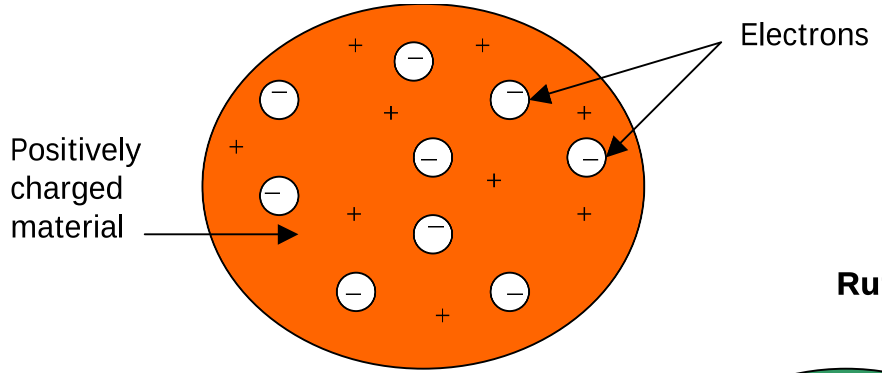
Grading Rubric

Item	Points Possible	Points Received
Presentation		
Class	**10**	
Whole	**10**	
Scientist Background	**10**	
Scientific Contribution	**20**	
Total	**50**	
Percent	**100%**	

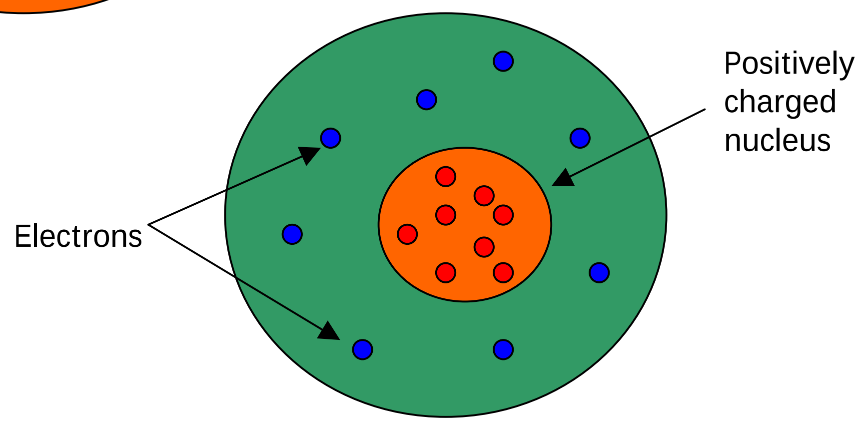
Appendix D-Atomic Structure

Thomson's model

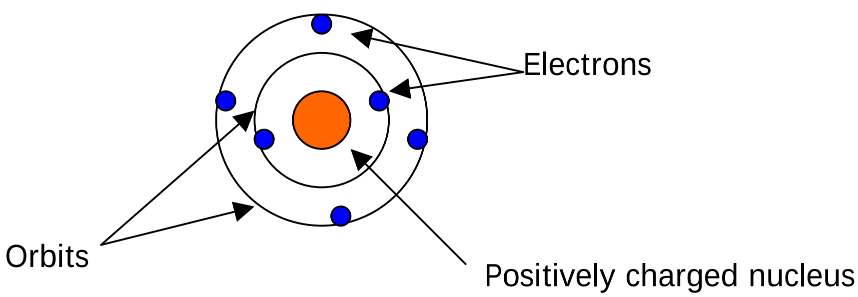
The Plum-Pudding Model



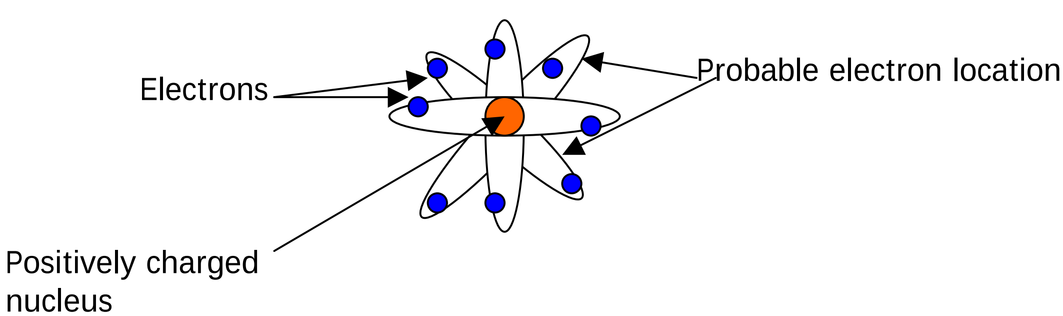
Rutherford's model



Bohr Model



The Wave Model



Appendix E, page 1-Atomic Structure

Student Outline
Structure of the Atom

I. _______ English scientist ______________________. *(1897, JJ Thomson)*

A. Experiment

1. __________ started with ________ gas. *(Thomson, neutral)*
2. He passed an _________ __________ through the gas. *(electric current)*
3. The _______ was now giving off _______ with a ________ _________. *(gas, rays, negative charge)*

B. Conclusions

1. The ________ must contain ________ ___________. *(atom, negative charges)*
2. ____________ called these particles _______________. *(Thomson, corpuscles)*
3. Today, ________________ are known as ______________. *(corpuscles, electrons)*
4. Thomson reasoned that there also must be a _____________ __________ within the atom. *(positive charge)*

C. Thomson's model of the atom.

1. ___________ are _________, ________ balls filled with a _______________ charged substance and ____________. *(atoms, small, hard, positively, electrons)*
2. Called the ________ - ___________ __________. *(Plum - pudding, model)*
3. Drawing

D. More Questions?

1. Where is the _______________ charge? *(positive)*

II. ________ English Scientist __________ __________________ *(1908, Ernest Rutherford)*

A. Experiment

1. Passed __________ __________ particles at a very thin _________ foil. *(positively charged, gold)*
2. Was able to __________ where the _____________ exited the foil. *(record, particles)*
3. __________ particles passed __________ through. *(Many, straight.)*
4. _________ particles bounced __________ from the _______. *(some, away, particles)*

Appendix E, page 1-Atomic Structure

B. Conclusions

1. Atoms must be _______ _________ _________. *(mostly empty space)*
2. _________ charges ________ positive __________. (Prior knowledge.) *(positive, repel, charges)*
    - a. There must be ________ charges in the ________. *(positive, atom)*
    - b. This part is concentrated in the __________ of the atom. *(middle)*
3. _______________ named the _________ part the _____________. *(Rutherford, positive, nucleus)*
    - a. __________ of an atom is similar to a ___________ in a ____________ ____________. *(Nucleus, baseball, baseball stadium)*

C. Atomic Model

1. __________ is very __________ compared to the rest of the __________. *(nucleus, small, atom)*
2. _____________ charges, or ___________, are scattered near the atom's __________. *(Negative, electrons, edge)*
3. Drawing

III. _________ Danish scientist _________ ___________ *(1913, Niels Bohr)*

A. Conclusions

1. Placed __________ in specific ________ _________ around the nucleus. *(electrons, energy levels)*
    - a. _________ move around the _________ like _________ around the _________. *(electrons, nucleus, planets, sun)*

B. Atomic model

1. Drawing

IV. Current Atomic Model - _____________ ____________ *(Wave model)*

A. Based on ______ ____________. *(wave mechanics)*

B. __________ don't have ________ paths. *(electrons, specific)*

1. _________ location of an ________ can ________ be known. *(exact, electron, never)*
2. _________ location of an ________ can be known. *(probable, electron)*

C. Drawing

Appendix G-Atomic Structure

Structure of the Atom Notes Quiz

Name: ___________________________

Using your Structure of the Atom outline, answer the following questions.

1. Who discovered the electron? *(JJ Thomson)*

2. What kind of a charge does an electron have? *(negative)*

3. What is his (the answer to question 1) model of the atom called? Why is it called that? *(The plum – pudding model because the electrons (plums) float around in a positively charged substance (pudding). This model resembles plum – pudding.)*

4. What did Ernest Rutherford discover? *(the nucleus of the atom)*

5. What are atoms mostly? *(empty space)*

6. What kind of charge is on the nucleus? *(positive)*

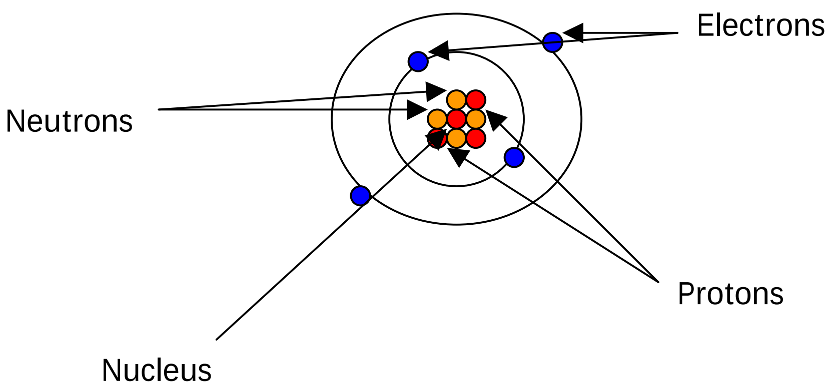
7. Compare the size of the nucleus to the rest of the atom. *(like a baseball in a baseball stadium)*

8. What did Niels Bohr do? *(Bohr put electrons in specific energy levels.)*

9. What is the main difference between the atomic model proposed by Bohr and the current atomic model (the wave model)? *(In the current model, only probable locations of electrons can be known. Bohr placed electrons in specific energy orbits.)*

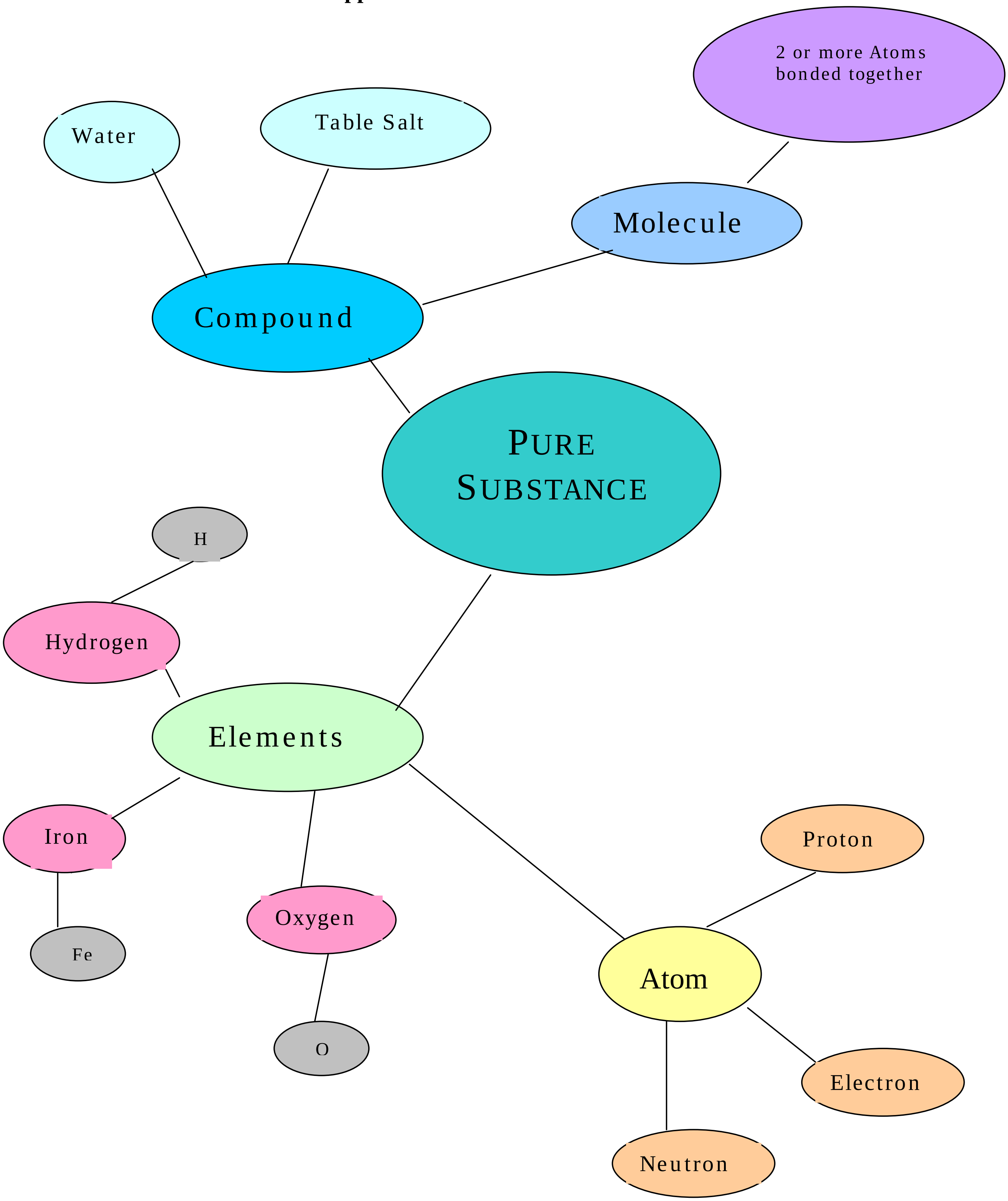
Appendix H-Atomic Structure

Model of the Atom



Subatomic Particle	Charge	Mass	Location
Proton	+	1 amu	Nucleus
Neutron	0	1 amu	Nucleus
Electron	-	0 amu	Electron cloud

Appendix I-Atomic Structure



Appendix J-Atomic Structure

Name: ___________________________________

Fill in the blanks…You *do* have enough information.

Element	Symbol	Atomic #	Mass #	# of Protons	# of Neutrons	# of Electrons
Helium	He	2	4			
Magnesium	Mg				12	12
Silicon	Si		28		14	
Lead	Pb		207			82
Seaborgium	Sg	106	263			
Uranium	U		238			92
Copper	Cu		63	29		
Sodium	Na			11	11	
Nitrogen	N	7			7	
Sulfur	S				16	16
Silver	Ag			47	61	
Krypton	K	36	84			
Neon	Ne				10	10
Barium	Ba				73	56
Calcium	Ca		40			20
Boron	B			5	5	
Francium	Fr	87	223			
Einsteinium	Es		254			99
Platinum	Pt			78	117	
Oxygen	O	8			8	

Key:

Element	Symbol	Atomic #	Mass #	# of Protons	# of Neutrons	# of Electrons
Helium	He	2	4	2	2	2
Magnesium	Mg	12	24	12	12	12
Silicon	Si	14	28	14	14	14
Lead	Pb	82	207	82	125	82
Seaborgium	Sg	106	263	106	157	106
Uranium	U	92	238	92	146	92
Copper	Cu	29	63	29	34	29
Sodium	Na	11	22	11	11	11
Nitrogen	N	7	14	7	7	7
Sulfur	S	16	32	16	16	16
Silver	Ag	47	108	47	61	47
Krypton	K	36	84	36	48	36
Neon	Ne	10	20	10	10	10
Barium	Ba	56	129	56	73	56
Calcium	Ca	20	40	20	20	20
Boron	B	5	10	5	5	5
Francium	Fr	87	223	87	126	87
Einsteinium	Es	99	254	99	155	99
Platinum	Pt	78	195	78	117	78
Oxygen	O	8	16	8	8	8

Appendix K-Atomic Structure

Adopt-an-Element[1]

- Pick and element that you would like to research.
- Have your instructor approve your element.
- The project:
  - Picture
    - You need to include a colored picture or 3-dimensional model of your element.
    - The correct number of protons, electrons, and neutrons must be displayed in your picture or model.
  - History and Background
    - Describe some physical and chemical properties of your element (these should be accurate properties).
    - Tell about your element's chemical family.
    - Explain some common uses for your element.
    - Tell who some of your element's friends are (who it likes to bond with).
    - Give some history on your element.
  - Conclusion
    - State why you would like to adopt this element and why it would fit well in your family.

Items to include	**Points Possible**	**My Score**
Colored picture or 3-dimensional model	10	
Correct number of protons	10	
Correct number of electrons	10	
Correct number of neutrons	10	
Physical and chemical properties	10	
Chemical family characteristics	10	
Common uses	10	
Chemical friends	10	
History of the element	10	
Why you should be allowed to adopt this element	5	
How this element will fit into your family	5	
Total	100	

[1] This activity was adapted from *Matter* by Phil Parratore © 1995, Creative Teaching Press Inc.