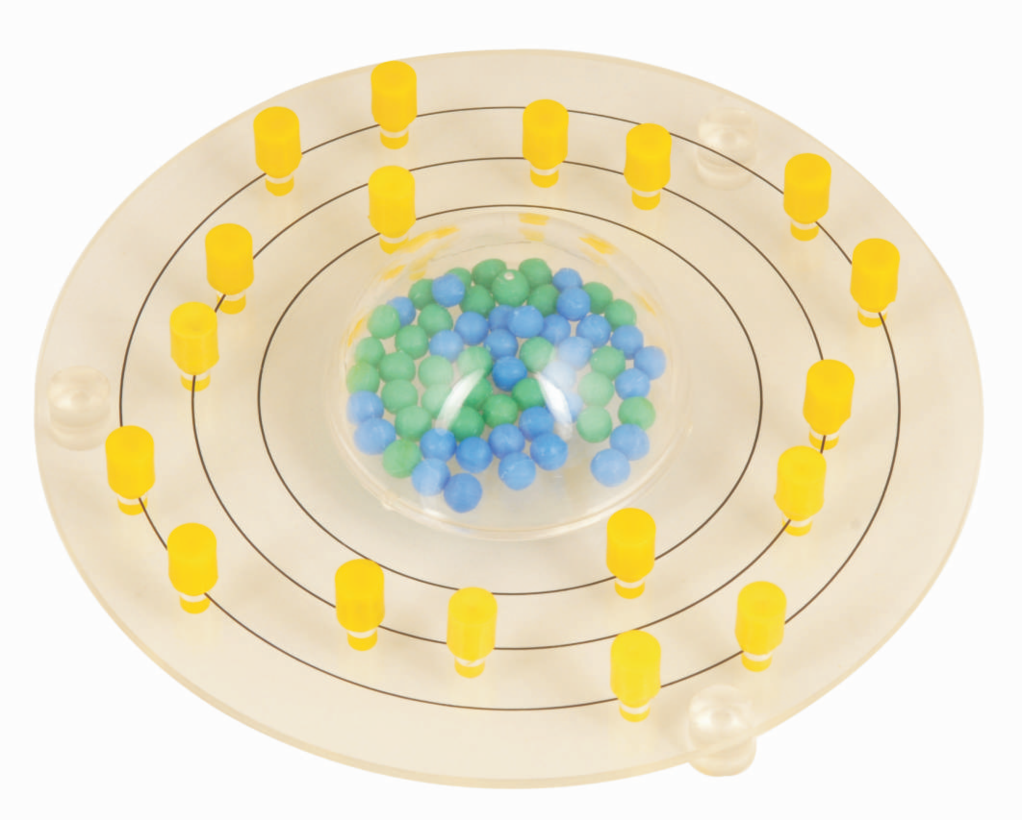
# ATOM MODEL
## CAT NO. ATM13



Experiment Guide

## GENERAL BACKGROUND OR THEORY ON THE EXPERIMENT:

### Atoms:

An atom is the smallest amount of mass that matter can be broken up into and still retain its properties. Atoms are the building blocks of everything we see around us.

Atoms themselves are made up of three smaller particles, protons, electrons, and neutrons. The number of protons in an atom give each atom its unique characteristics. An atom with two protons is called Helium and it has certain properties associated with it such as how reactive it is to other elements, its phase at room temperature, etc. Add just one more proton to the nucleus and an inert gas is changed into a very reactive metal that will produce a fantastic heat and light display if brought in contact with water.

The mass of a proton and a neutron are the same. To make the math easier, we usually measure the mass in amu (atomic mass units) when talking about atoms. 1 amu is the mass of one proton. Electrons are so much smaller than protons and neutrons that even though they have mass, we can assume that the mass of an electron is 0 amu.

### Ions:

There are two types of charge. One is called positive and the other is called negative. Protons carry a +1 positive charge and electrons carry a -1 negative charge. Neutrons are neutral, meaning that they have no charge. If an atom is neutral, as most atoms are, then then number of protons and electrons in an atom must be the same. If the number of protons and electrons are not the same then the atom is called an ion, mean that it is either positively charged, or negatively charged. A positively charged atom or positive ion has more protons than electrons. If there are two more protons than electrons that means it has a +2 (plus two) charge. If there are more electrons than protons, then we call this a negative ion. If there are three more electrons than protons then the charge is -3 (negative three, minus three).

The short hand way for writing an ion is by using the one or two letter atomic symbol for the element followed by the charge of the ion. If the charge is +1 or -1, usually the one is just left off.

### EXAMPLES:

Hydrogen with no electrons : $H^{+}$

Oxygen with two extra electrons : $O^{-2}$

Iron having lost two electrons: $Fe^{+2}$

### The Bohr Model:

Although there are some errors in the Bohr Model of the atom, it is simple, straight forward and mostly correct. This is why we still study this model and teach it in schools.

In the Bohr Model of the atom, protons and neutrons reside in the center of the atom in a place called the nucleus. While the electrons orbit around the nucleus at certain energy levels. Each level is given by the distance the electrons are from the nucleus.

The Bohr Model says that each orbital has a certain amount of energy associated with it. If an electron is given a certain amount of energy, it can jump to a higher orbital. As the electron jumps back down, it releases that energy in the form of a photon of light. There are flaws with this model that the currently accepted quantum theory accounts for.

**Isotopes:**

Although each element has a set number of protons, the number of neutrons can vary from atom to atom. An isotope is an atom that has the same number of protons, but a different number of neutrons. We name isotopes by their atomic mass number, which is simply the number of protons plus the number of neutrons in an atom. For example, most carbon atoms have 6 protons and 6 neutrons. This isotope of carbon is called carbon-12, however a commonly known isotope of carbon has 6 protons and 8 neutrons and is called carbon-14.

**Average Atomic Mass:**

Atoms of an element have the same atomic number always, but there are naturally differences in atomic mass between atoms in the element. This is naturally occurring, and so we can calculate an average atomic mass.

**FOR EXAMPLE:**

A sample of Hydrogen has three isotopes. Hydrogen-1, Hydrogen-2, and Hydrogen-3. In a given sample 99.9844% of the isotopes are Hydrogen-1, Almost all the other 0.0156% of the atoms are Hydrogen -2. The average atomic mass can be found by the following method:

Percent of sample written in decimal form x mass of isotope in amu for isotope 1

Percent of sample written in decimal form x mass of isotope in amu for isotope 2

Percent of sample written in decimal form x mass of isotope in amu for isotope 3

… etc.

+______________________________________________

Average Atomic Mass in amu

Example:

0.999844 x 1 = 0.999844

0.000156 x 2 = 0.000312

+______________________

1.000156 amu

So the average atomic mass of hydrogen is 1.000156 amu

## REQUIRED COMPONENTS (INCLUDED)

| *Name of Part* | *Quantity* |
|---|---|
| Clear plastic model base | 1 |
| Yellow electron pegs | 25 |
| Green proton balls | 30 |
| Blue neutron balls | 70 |

The plastic dome can easily be removed by turning the model over and gently pushing on the three posts that hold the dome in place as shown in diagram 1.

When building your atom it is recommended to fill the nucleus first with the appropriate number of protons and neutrons. Keep the dome representing the nucleus upside down and then add the plastic disc that holds the electrons over top of the dome. Push the three pegs gently into place forming a tight seal, and then flip the clear plastic base over so that the dome is facing up before adding the electron pegs to the apparatus.

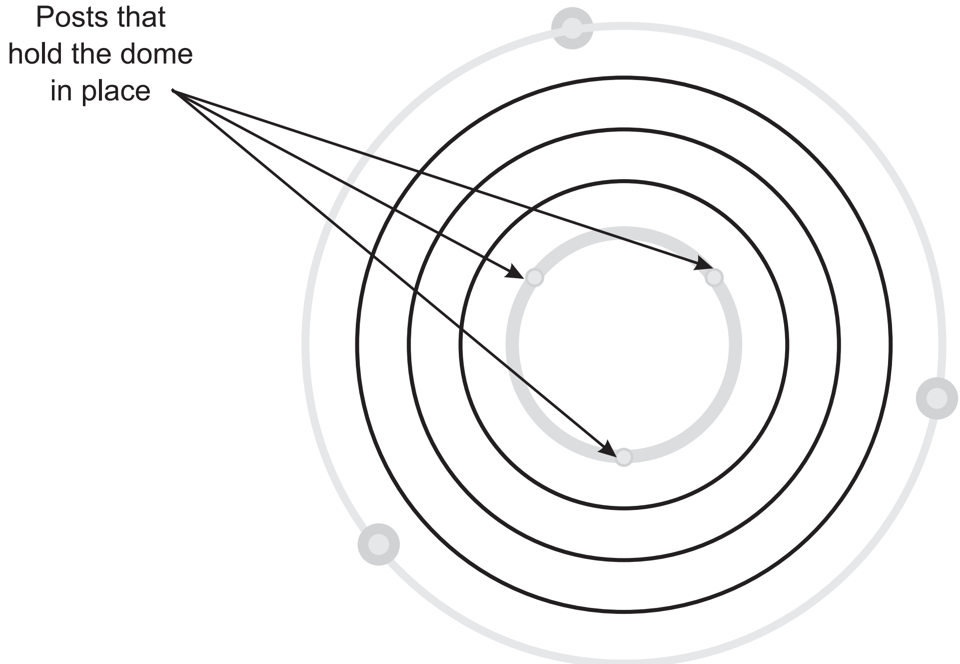



*Diagram 1*

## ACTIVITY 1: MODELING THE ATOM (TEACHER NOTES)

Print out and cut up the cards with the atomic symbols on them so that each student can get a different element to model.

Give each student an EISCO atom model and periodic table.

Tell students to round the mass number to the nearest whole number to determine the number of protons and neutrons combined. Subtract the atomic number from the mass number to get the number of neutrons. Assume that all atoms are neutral (therefore the number of protons and electrons are the same.)

To make cards that the students can handle, cut out each sheet along the outside black line on each page and then fold the sheet lengthwise down the middle black line so that the front of the cards have the name of the element and the backs of the cards have the picture of the model. Use a glue stick to fasten the front and back together and after the glue dries, cut each individual card apart. If a teacher does not wish for the students to have the answers, simply print and cut out the left hand side of the answer sheet. The cards will last longer if you have access to a laminator and can laminate the cards.

**Key :**

- ● Protons (green)
- ○ Neutron (Blue)
- ● Electron (Yellow)

## TEACHER QUICK REFERENCE GUIDE :

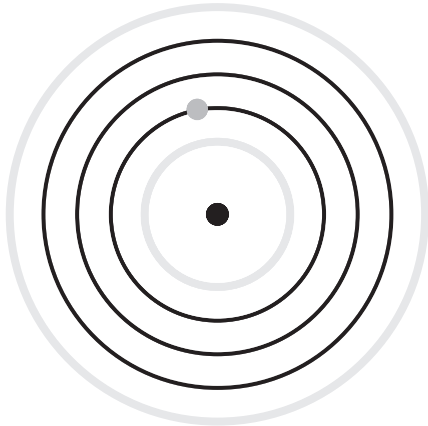
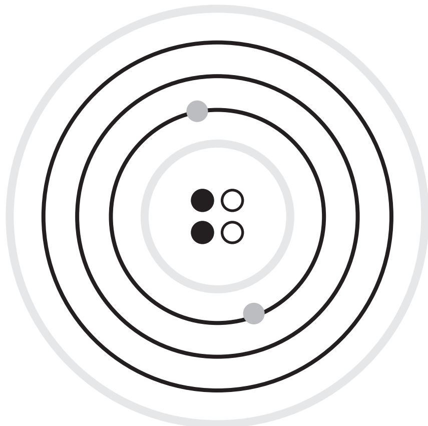
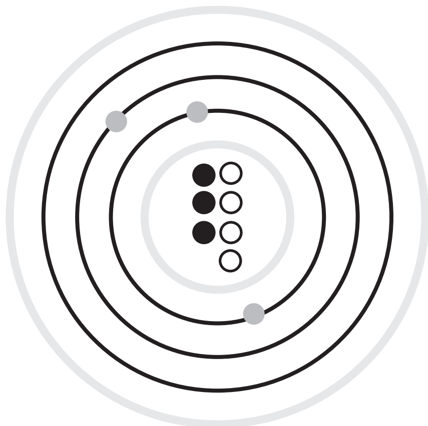
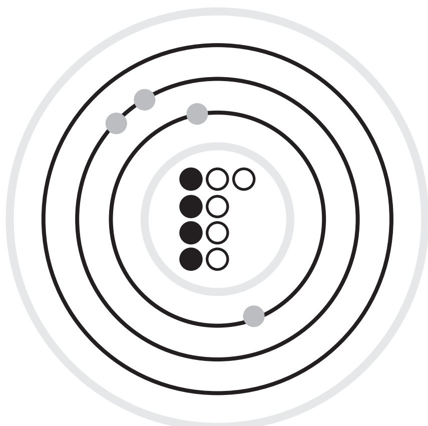
| Element (The most common isotope is used) | Number of green balls in the smallest grey circle | Number of blue balls in the smallest grey circle | Number of yellow dots on the smallest black ring | Number of yellow dots on the middle size black ring | Number of yellow dots on the largest black ring |
|---|---|---|---|---|---|
| Li (Lithium) | 3 | 4 | 2 | 1 | 0 |
| Be (Bervllium) | 4 | 5 | 2 | 2 | 0 |
| B (Boron) | 5 | 6 | 2 | 3 | 0 |
| C (Carbon) | 6 | 6 | 2 | 4 | 0 |
| N (Nitrogen) | 7 | 7 | 2 | 5 | 0 |
| O (Oxygen) | 8 | 8 | 2 | 6 | 0 |
| F (Fluorine) | 9 | 10 | 2 | 7 | 0 |
| Ne (Neon) | 10 | 10 | 2 | 8 | 0 |
| Na (Sodium) | 11 | 12 | 2 | 8 | 1 |
| Mg (Magnesium) | 12 | 12 | 2 | 8 | 2 |
| Al (Aluminum) | 13 | 14 | 2 | 8 | 3 |
| Si (Silicon) | 14 | 14 | 2 | 8 | 4 |
| P(Phosohorus) | 15 | 16 | 2 | 8 | 5 |
| S (Sulfur) | 16 | 16 | 2 | 8 | 6 |
| CI (Chlorine)* | 17 | 18 | 2 | 8 | 7 |
| Ar (Argon) | 18 | 22 | 2 | 8 | 8 |

* The most common isotope of Chlorine is Chlorine - 35, rounding the atomic mass to the nearest whole number on some reference tables may give students the impression that Chlorine - 36 is the most common isotope.

# Periodic Table of the Elements

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.01 | | | | | | | | | | | | | | | | | 2 He 4.00 |
| 3 Li 6.94 | 4 Be 9.01 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 |
| 11 Na 22.99 | 12 Mg 24.30 | | | | | | | | | | | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 |
| 19 K 30.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.88 | 23 V 50.94 | 24 Cr 52.00 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.69 | 29 Cu 63.55 | 30 Zn 65.39 | 31 Ga 69.72 | 32 Ge 72.61 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | 43 Tc (97.91) | 44 Ru 101.07 | 45 Rh 102.91 | 46 Pd 106.42 | 47 Ag 107.87 | 48 Cd 112.41 | 49 In 114.82 | 50 Sn 118.71 | 51 Sb 121.75 | 52 Te 127.60 | 53 I 126.90 | 54 Xe 131.29 |
| 55 Cs 132.91 | 56 Ba 137.33 | 57 La 138.91 | 72 Hf 178.49 | 73 Ta 180.95 | 74 W 183.85 | 75 Re 186.21 | 76 Os 190.23 | 77 Ir 192.22 | 78 Pt 195.08 | 79 Au 196.97 | 80 Hg 200.59 | 81 Tl 204.38 | 82 Pb 207.2 | 83 Bi 208.98 | 84 Po (208.98) | 85 At (209.99) | 86 Rn (222.02) |
| 87 Fr (223.02) | 88 Ra (226.03) | 89 Ac (227.03) | 104 Rf (261.11) | 105 Ha (262.11) | 106 Sg (263.12) | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 Ce 140.12 | 59 Pr 140.91 | 60 Nd 144.24 | 61 Pm (144.91) | 62 Sm 150.36 | 63 Eu 151.97 | 64 Gd 157.25 | 65 Tb 158.93 | 66 Dy 162.50 | 67 Ho 164.93 | 68 Er 167.26 | 69 Tm 168.93 | 70 Yb 173.04 | 71 Lu 174.97 |
| 90 Th 232.04 | 91 Pa 231.04 | 92 U 238.03 | 93 Np (237.05) | 94 Pu (244.06) | 95 Am (243.06) | 96 Cm (247.07) | 97 Bk (247.07) | 98 Cf (251.08) | 99 Es (252.08) | 100 Fm (257.10) | 101 Md (258.10) | 102 No (259.10) | 103 Lr (262.11) |

| | |
|---|---|
| H |  |
| He |  |
| Li |  |
| Be |  |

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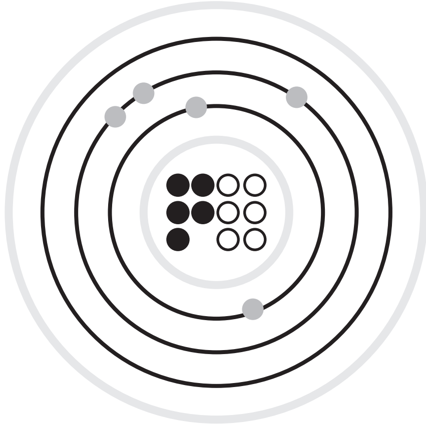
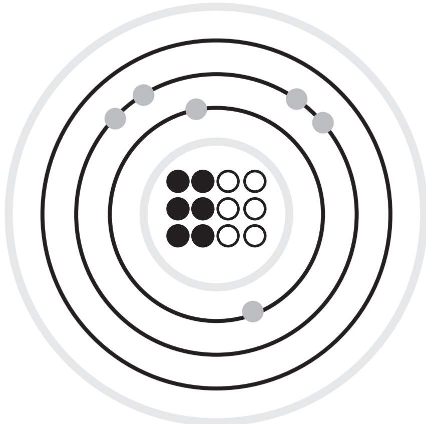
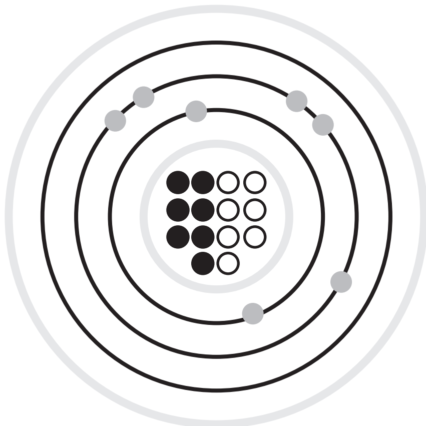
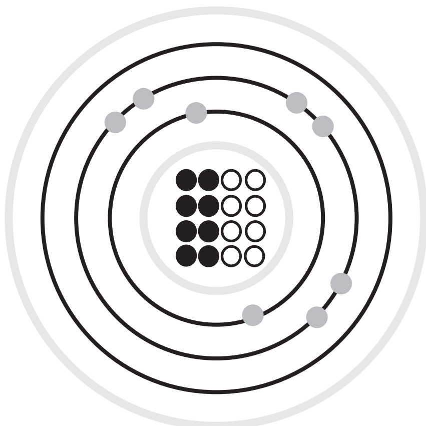
|---|---|
| B |  |
| C |  |
| N |  |
| O |  |

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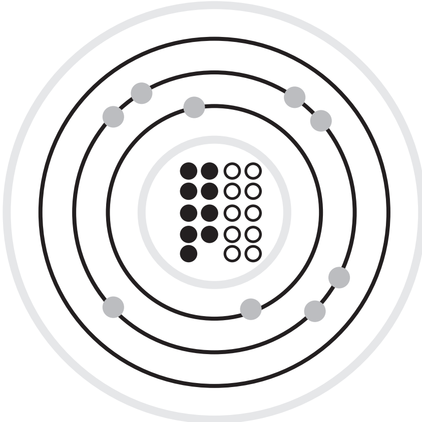
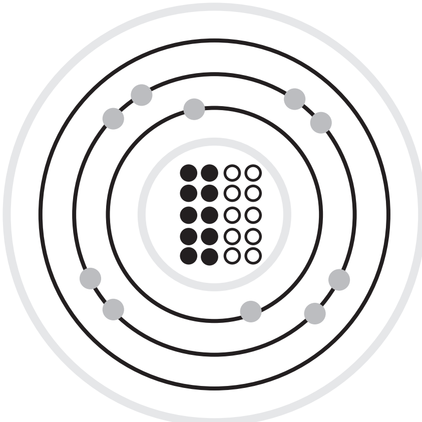
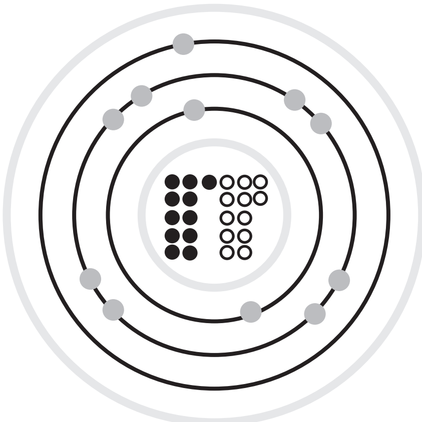
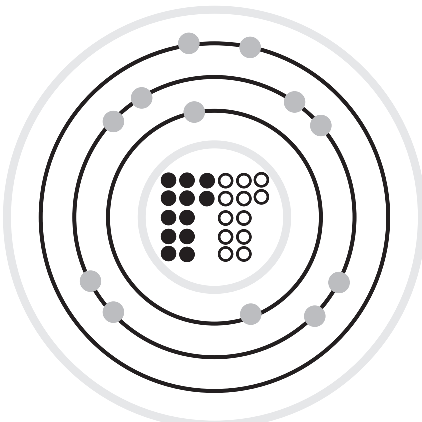
|---|---|
| F |  |
| Ne |  |
| Na |  |
| Mg |  |

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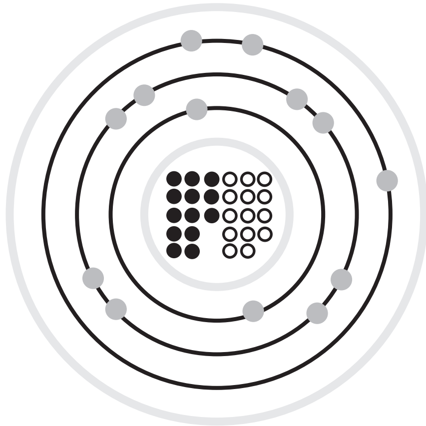
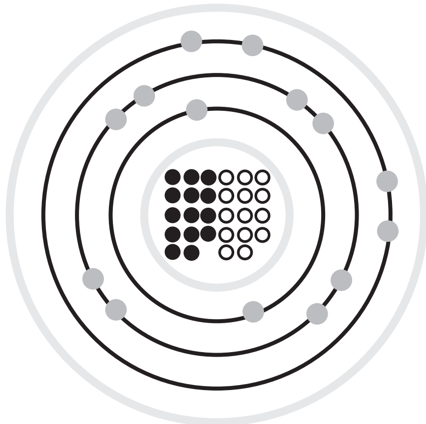
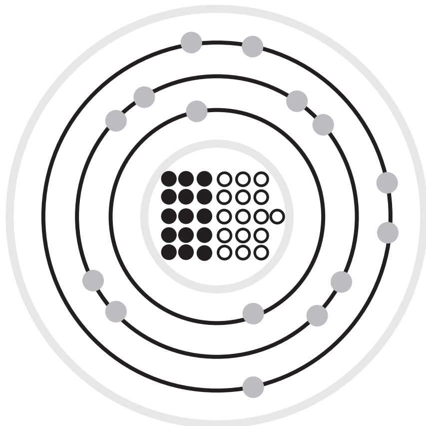
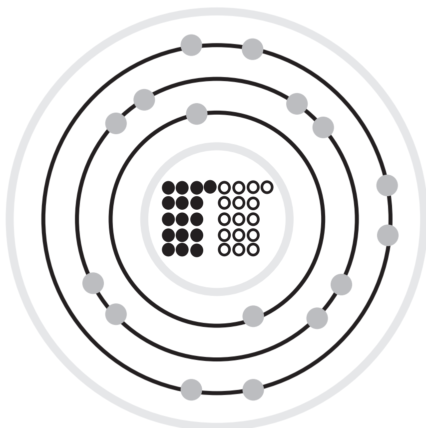
|---|---|
| Al |  |
| Si |  |
| P |  |
| S |  |

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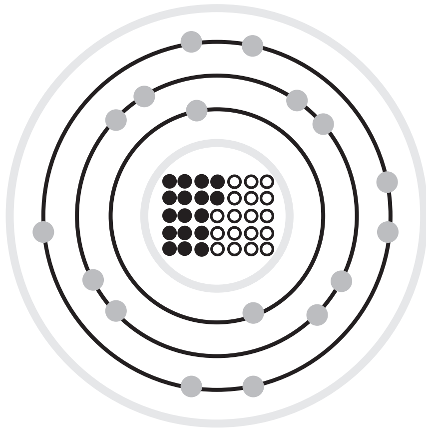
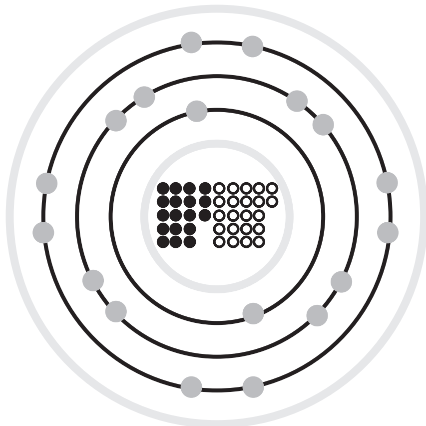
|---|---|
| Cl |  |
| Ar |  |

## ACTIVITY 2: ISOTOPES

This activity will help students to understand exactly what an isotope is as well as familiarize them with notation for isotopes.

**For example a card may say:**

Boron-11

This means that the atom weight of this atom is 11amu.  So the total number of protons and neutrons is 11.  Since the element is boron, it must have 5 protons because 5 is the atomic number of boron.

11-5 = 6 neutrons in this atom.

For the atom to be electrically neutral there must also be 5 electrons.

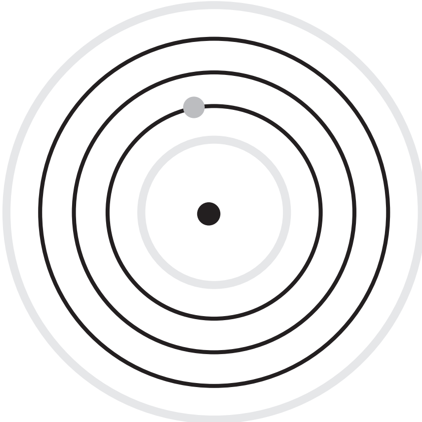
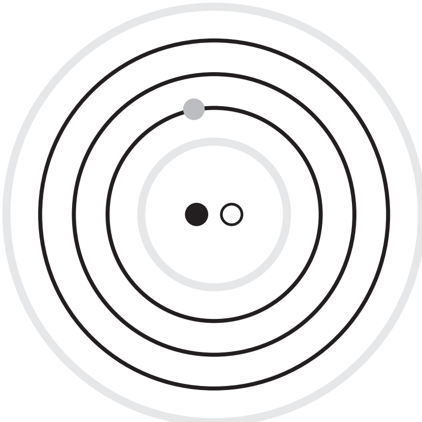
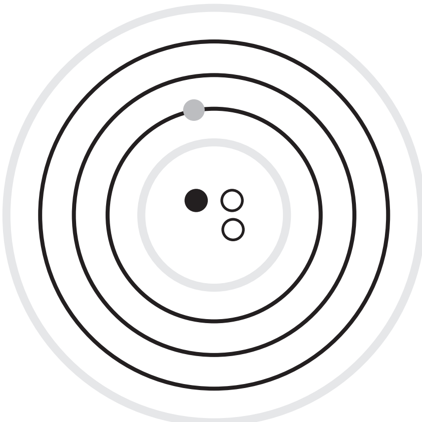
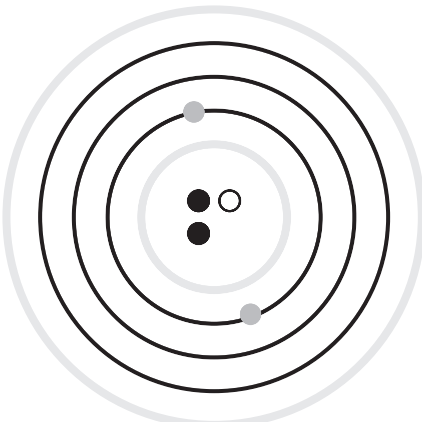
Student will need an atom model, a periodic table and at least one of the cards with the name of an isotope on it.  (See activity 1 for instructions on how to easily make the cards.) Students can work on this on their own and check their answers if the answers are on the back of the card, or the teachers can hand out just the name of the isotope and check it themselves.

In the upper left hand corner of each card is percentage. This tells students the percentage of that particular isotope that is found naturally in a sample of that element.

## TEACHER QUICK REFERENCE TABLE:

| Element (The most common isotope is used) | Number of green balls in the smallest grey circle | Number of blue balls in the smallest grey circle | Number of yellow pegs on the smallest black ring | Number of yellow pegs on the middle size black ring | Number of yellow pegs on the largest black ring |
|---|---|---|---|---|---|
| Hydrogen-1 | 1 | 0 | 1 | 0 | 0 |
| Hydrogen-2 | 1 | 1 | 1 | 0 | 0 |
| Hydrogen-3 | 1 | 2 | 1 | 0 | 0 |
| Helium-3 | 2 | 1 | 2 | 0 | 0 |
| Helium-4 | 2 | 2 | 2 | 0 | 0 |
| Lithium-6 | 3 | 3 | 2 | 1 | 0 |
| Lithium-7 | 3 | 4 | 2 | 1 | 0 |
| Beryllium-7 | 4 | 3 | 2 | 2 | 0 |
| Beryllium-9 | 4 | 5 | 2 | 2 | 0 |
| Beryllium-10 | 4 | 6 | 2 | 2 | 0 |
| Boron-10 | 5 | 5 | 2 | 3 | 0 |
| Boron-11 | 5 | 6 | 2 | 3 | 0 |
| Carbon-12 | 6 | 6 | 2 | 4 | 0 |
| Carbon-13 | 6 | 7 | 2 | 4 | 0 |
| Carbon-14 | 6 | 8 | 2 | 4 | 0 |
| Nitrogen-13 | 7 | 6 | 2 | 5 | 0 |
| Nitrogen-14 | 7 | 7 | 2 | 5 | 0 |

| **Element** (The most common isotope is used) | **Number of green balls in the smallest grey circle** | **Number of blue balls in the smallest grey circle** | **Number of yellow pegs on the smallest black ring** | **Number of yellow pegs on the middle size black ring** | **Number of yellow pegs on the largest black ring** |
|---|---|---|---|---|---|
| Nitrogen-15 | 7 | 8 | 2 | 5 | 0 |
| Oxygen-16 | 8 | 8 | 2 | 6 | 0 |
| Oxygen-17 | 8 | 9 | 2 | 6 | 0 |
| Oxygen-18 | 8 | 10 | 2 | 6 | 0 |
| Fluorine-18 | 9 | 9 | 2 | 7 | 0 |
| Fluorine-19 | 9 | 10 | 2 | 7 | 0 |
| Neon-20 | 10 | 10 | 2 | 8 | 0 |
| Neon-21 | 10 | 11 | 2 | 8 | 0 |
| Neon-22 | 10 | 12 | 2 | 8 | 0 |
| Sodium-22 | 11 | 11 | 2 | 8 | 1 |
| Sodium-23 | 11 | 12 | 2 | 8 | 1 |
| Magnesium-24 | 12 | 12 | 2 | 8 | 2 |
| Magnesium-25 | 12 | 13 | 2 | 8 | 2 |
| Magnesium-26 | 12 | 14 | 2 | 8 | 2 |
| Aluminum-26 | 13 | 13 | 2 | 8 | 3 |
| Aluminum-27 | 13 | 14 | 2 | 8 | 3 |
| Silicon-28 | 14 | 14 | 2 | 8 | 4 |
| Silicon-29 | 14 | 15 | 2 | 8 | 4 |
| Silicon-30 | 14 | 16 | 2 | 8 | 4 |
| Silicon-32 | 14 | 18 | 2 | 8 | 4 |
| Phosphorus-31 | 15 | 16 | 2 | 8 | 5 |
| Phosphorus-32 | 15 | 17 | 2 | 8 | 5 |
| Phosphorus-33 | 15 | 18 | 2 | 8 | 5 |
| Sulfur-32 | 16 | 16 | 2 | 8 | 6 |
| Sulfur-33 | 16 | 17 | 2 | 8 | 6 |
| Sulfur-34 | 16 | 18 | 2 | 8 | 6 |
| Sulfur-35 | 16 | 19 | 2 | 8 | 6 |
| Sulfur-36 | 16 | 20 | 2 | 8 | 6 |
| Chlorine-35 | 17 | 18 | 2 | 8 | 7 |
| Chlorine-36 | 17 | 19 | 2 | 8 | 7 |
| Chlorine-37 | 17 | 20 | 2 | 8 | 7 |
| Argon-36 | 18 | 18 | 2 | 8 | 8 |
| Argon-37 | 18 | 19 | 2 | 8 | 8 |
| Argon-38 | 18 | 20 | 2 | 8 | 8 |
| Argon-39 | 18 | 21 | 2 | 8 | 8 |
| Argon-40 | 18 | 22 | 2 | 8 | 8 |
| Argon-41 | 18 | 23 | 2 | 8 | 8 |
| Argon-42 | 18 | 24 | 2 | 8 | 8 |

| | |
|---|---|
| Hydrogen-1 | 99.9844%  |
| Hydrogen-2 | 0.0156%  |
| Hydrogen-3 | 0%  |
| Helium-3 | 0.000137%  |

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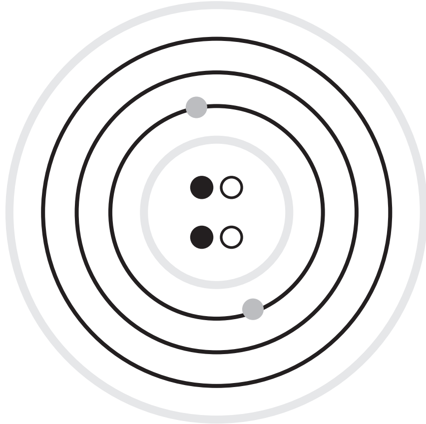
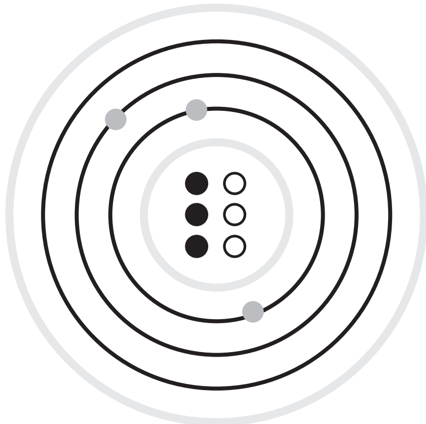
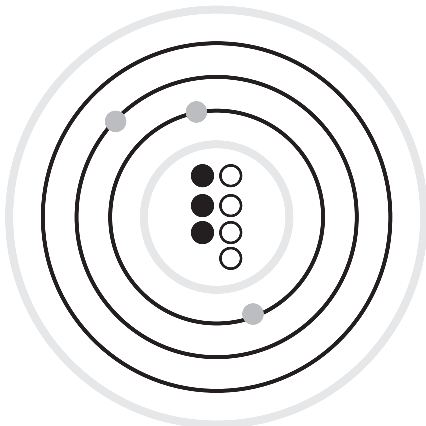
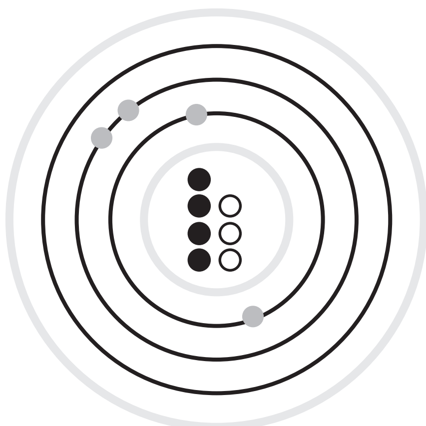
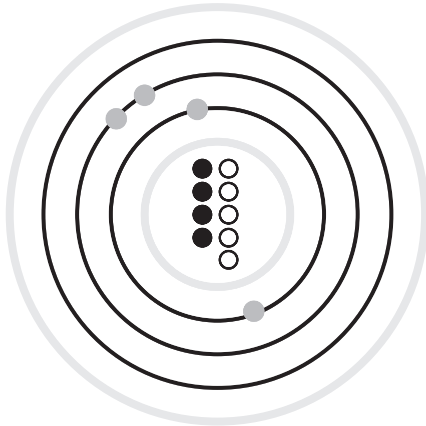
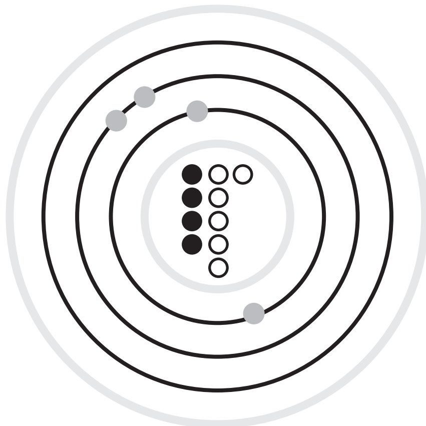
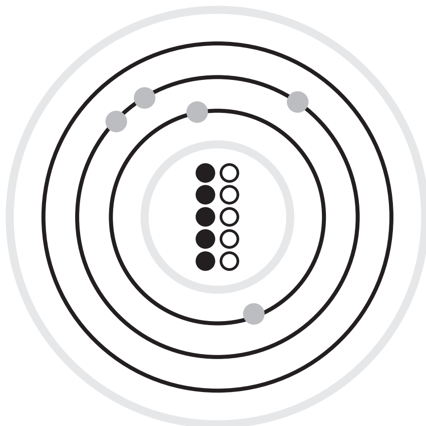
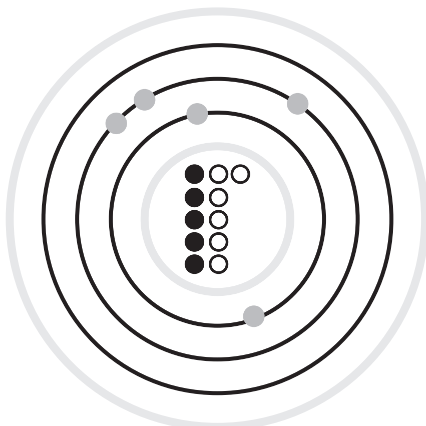
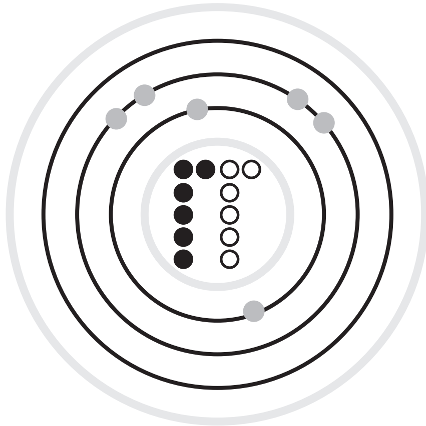
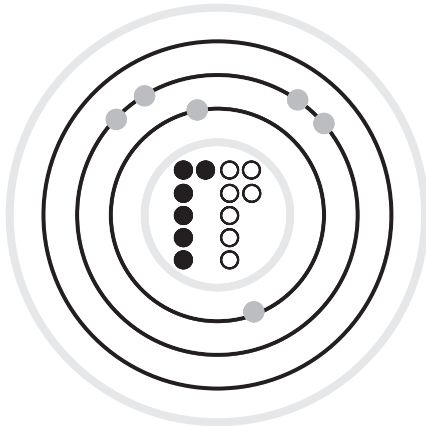
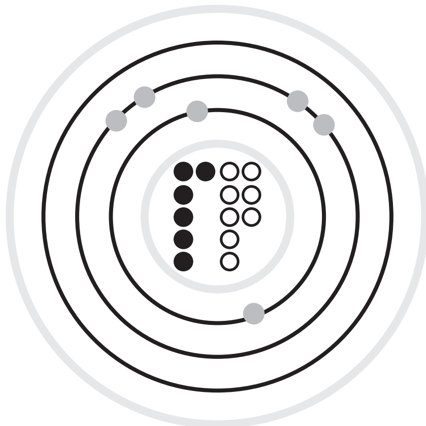
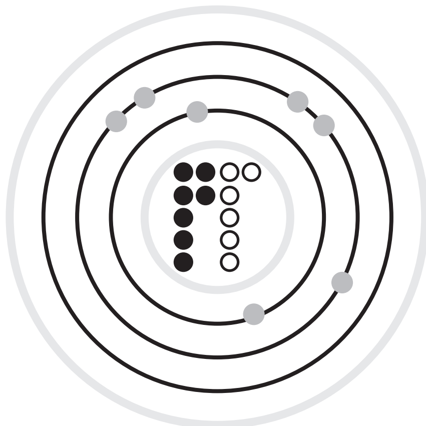
|---|---|
| Helium-4 | 99.9999%  |
| Lithium-6 | 7.59%  |
| Lithium-7 | 92.4%  |
| Beryllium-7 | 0%  |

| | |
|---|---|
| Beryllium-9 | 100%  |
| Beryllium-10 | 0%  |
| Boron-10 | 19.9%  |
| Boron-11 | 80.1%  |

| | |
|---|---|
| Carbon-12 | 98.93%  |
| Carbon-13 | 1.07%  |
| Carbon-14 | 0%  |
| Nitrogen-13 | 0%  |

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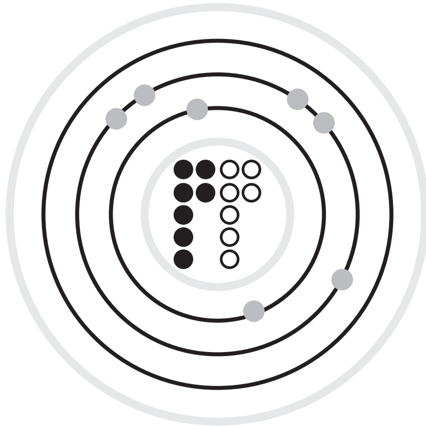
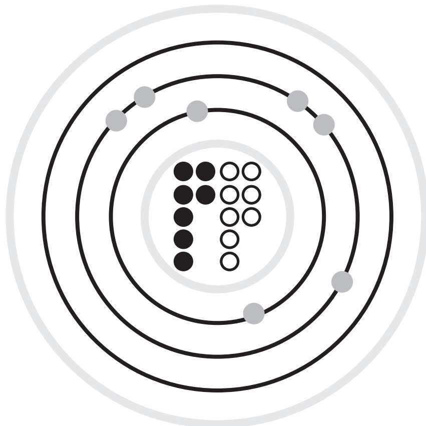
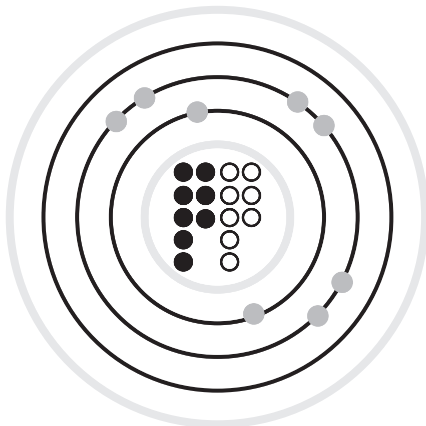
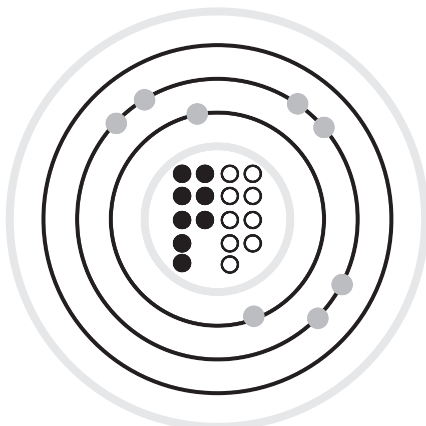
|---|---|
| Nitrogen-14 | 99.632%  |
| Nitrogen-15 | 0.368%  |
| Oxygen-16 | 99.757%  |
| Oxygen-17 | 0.038%  |

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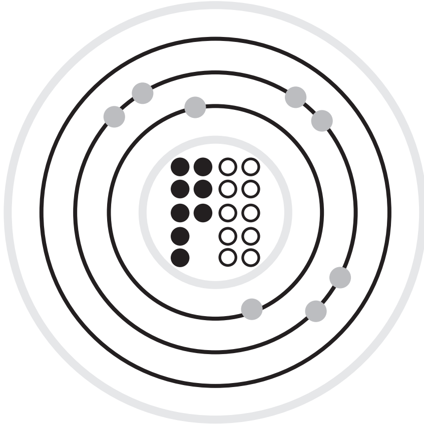
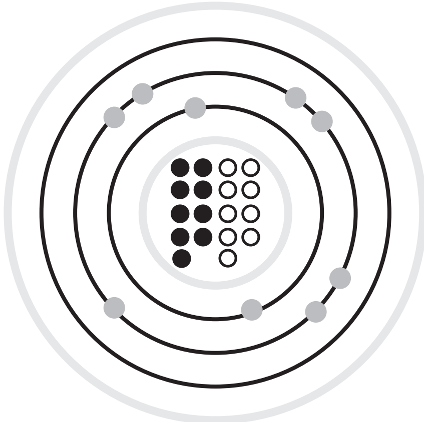
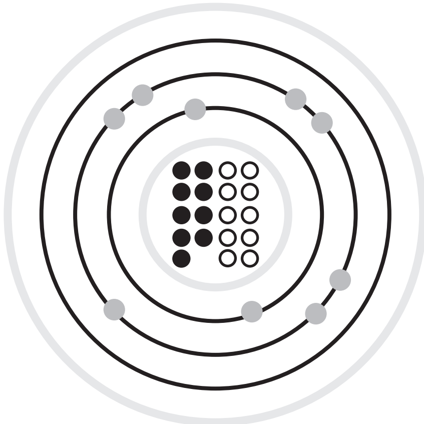
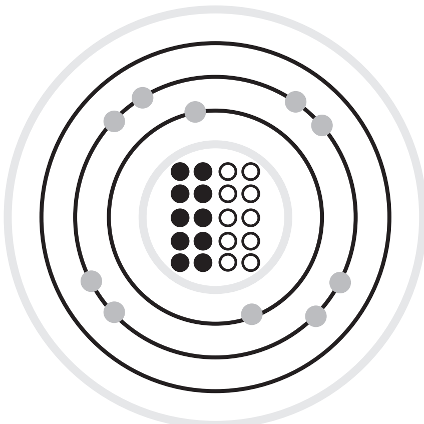
|---|---|
| Oxygen-18 | 0.205%  |
| Fluorine-18 | 0%  |
| Fluorine-19 | 100%  |
| Neon-20 | 90.40%  |

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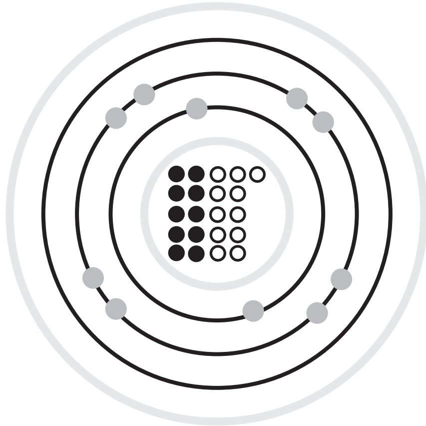
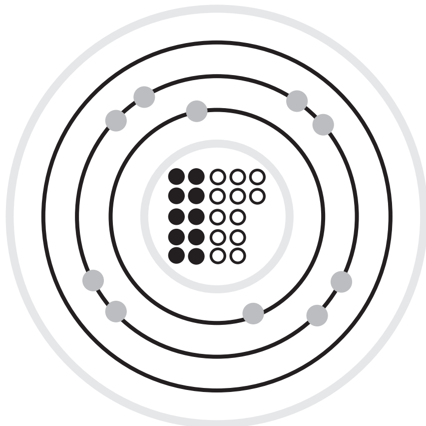
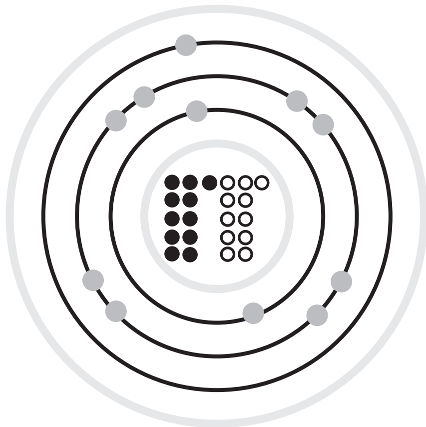
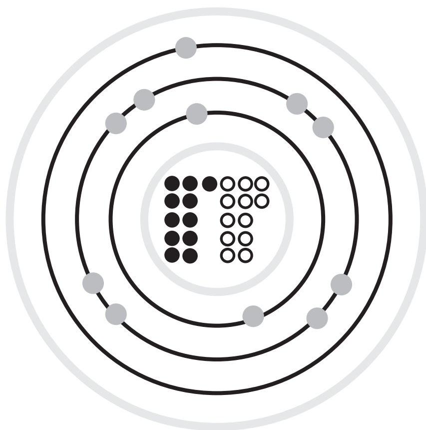
|---|---|
| Neon-21 | 0.27%  |
| Neon-22 | 9.25%  |
| Sodium-22 | 0%  |
| Sodium-23 | 100%  |

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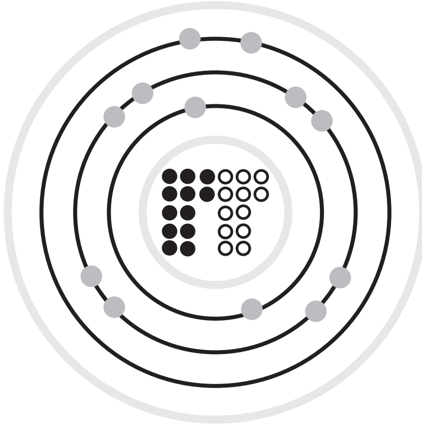
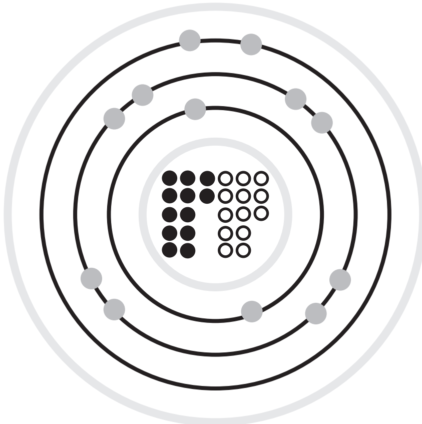
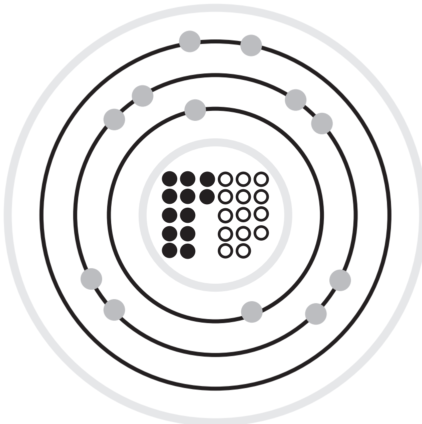
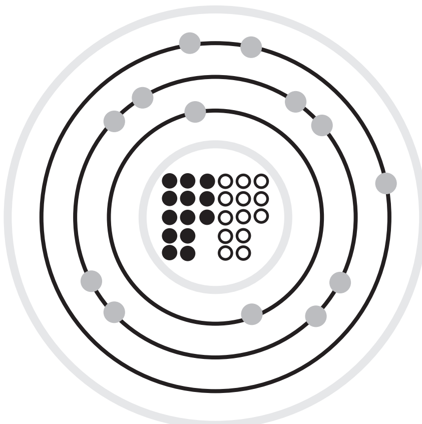
|---|---|
| Magnesium-24 | 78.99%  |
| Magnesium-25 | 10%  |
| Magnesium-26 | 11.01%  |
| Aluminum-26 | 0%  |

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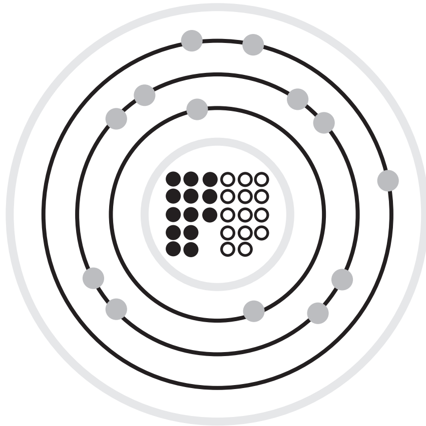
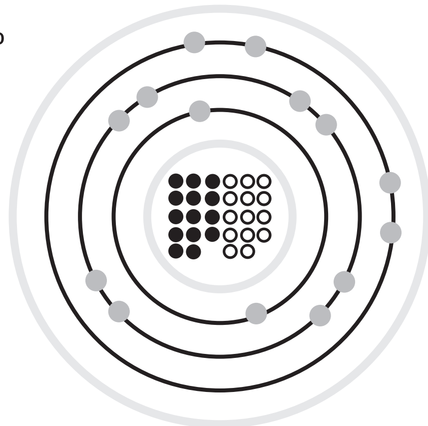
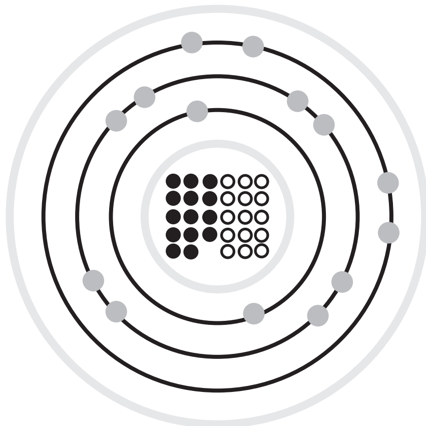
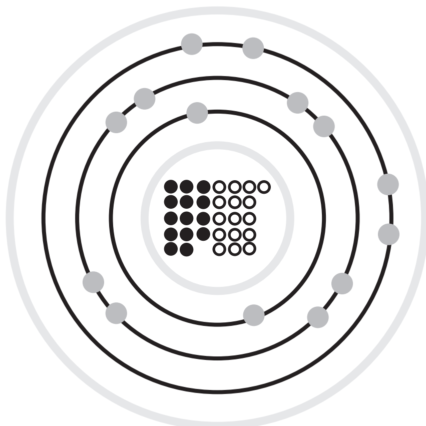
|---|---|
| Aluminum-27 | 100%  |
| Silicon-28 | 92.2297%  |
| Silicon-29 | 4.6832%  |
| Silicon-30 | 3.0872%  |

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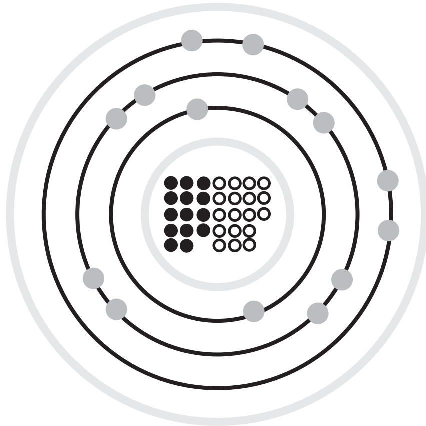
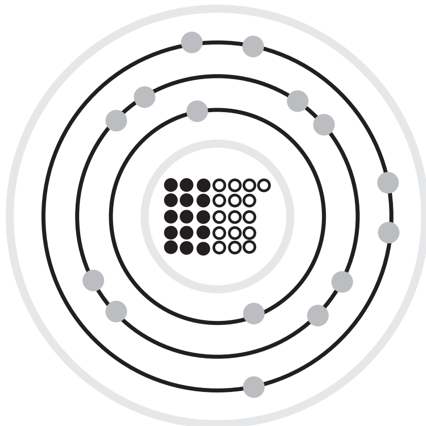
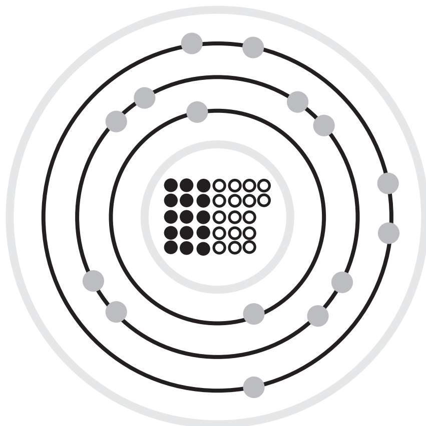
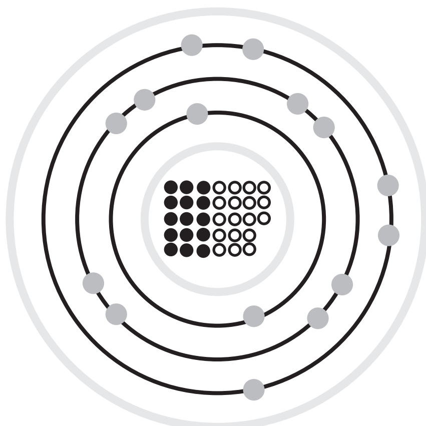
|---|---|
| Silicon-32 | 0%  |
| Phosphorus-31 | 100%  |
| Phosphorus-32 | 0%  |
| Phosphorus-33 | 0%  |

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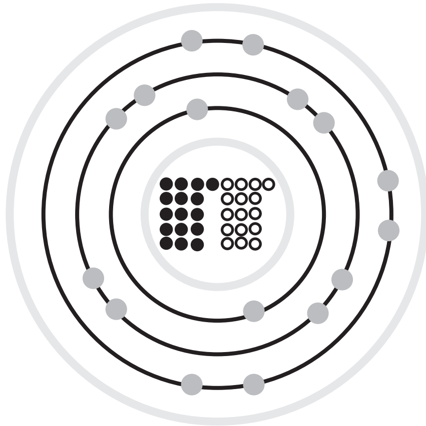
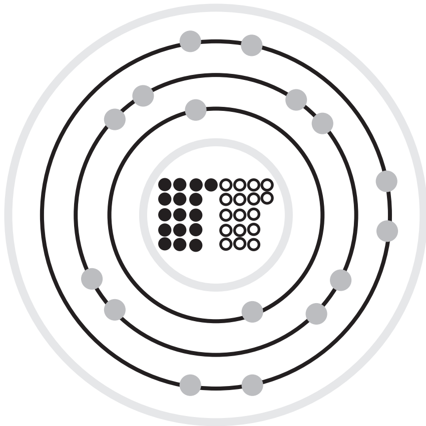
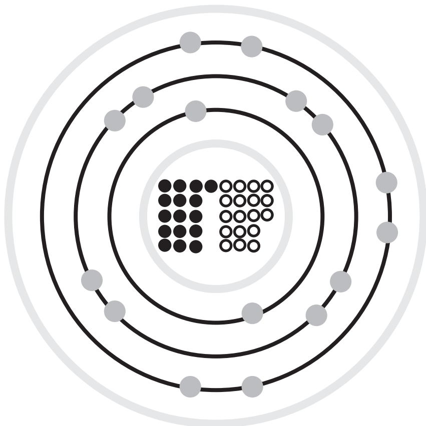
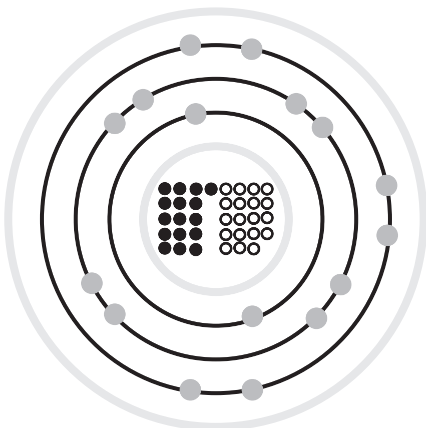
|---|---|
| Sulfur-32 | 94.93%  |
| Sulfur-33 | 0.76%  |
| Sulfur-34 | 4.29%  |
| Sulfur-35 | 0%  |

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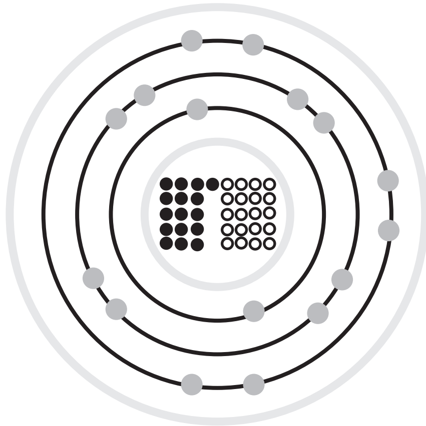
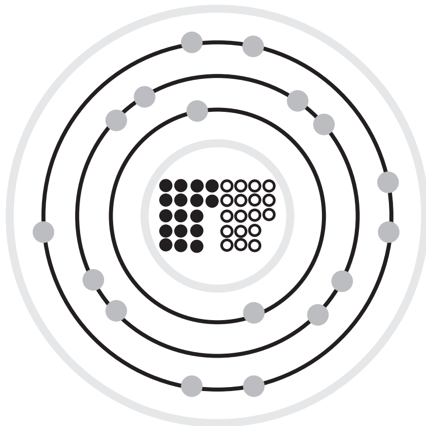
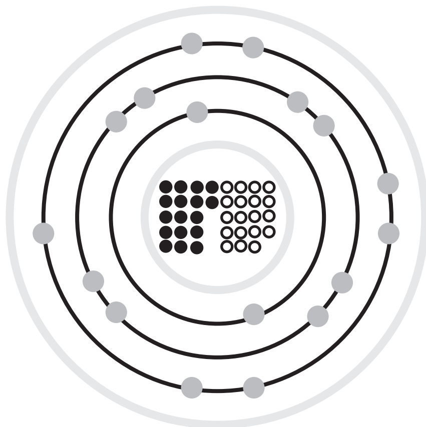
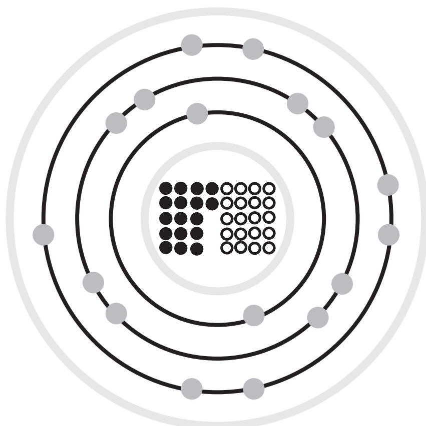
|---|---|
| Sulfur-36 | 0.02%  |
| Chlorine-35 | 75.78%  |
| Chlorine-36 | 0%  |
| Chlorine-37 | 24.22%  |

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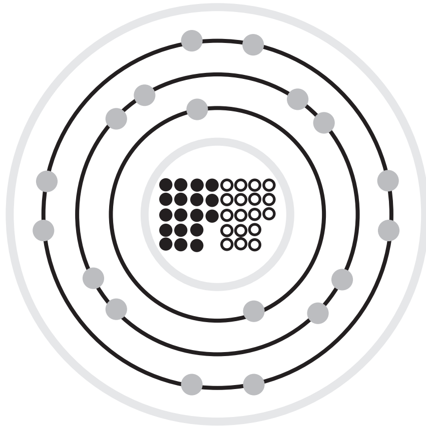
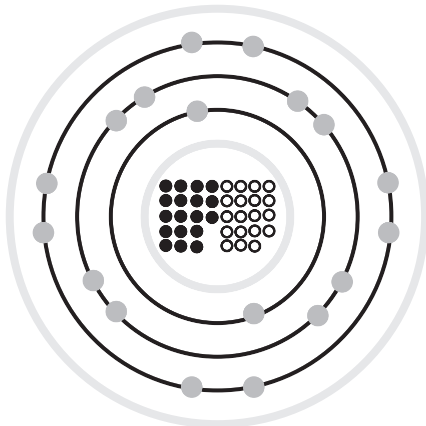
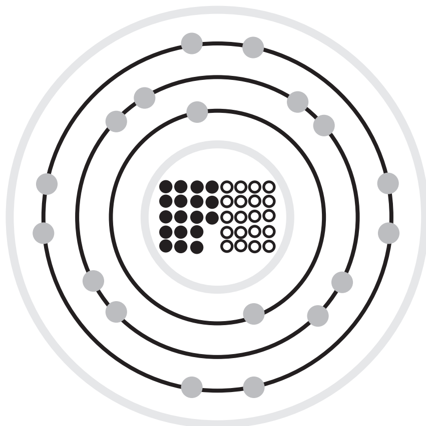
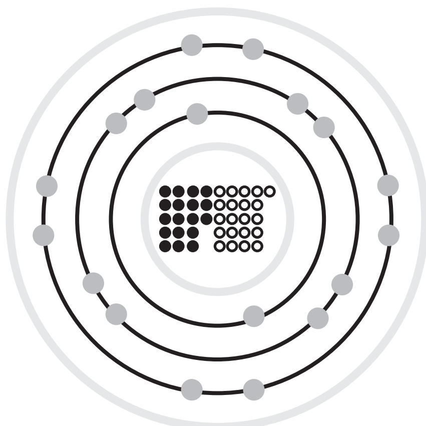
|---|---|
| Argon-36 | 0.3365%  |
| Argon-37 | 0%  |
| Argon-38 | 0.0632%  |
| Argon-39 | 0%  |

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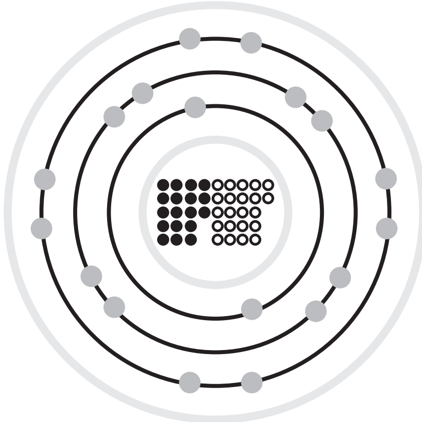
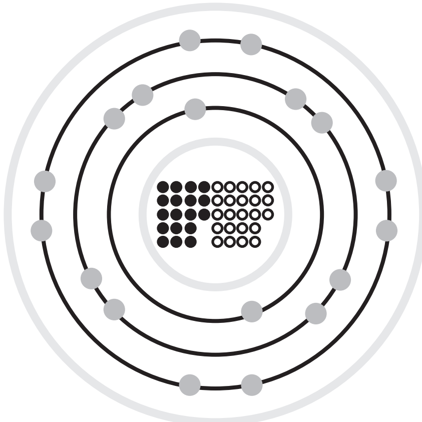
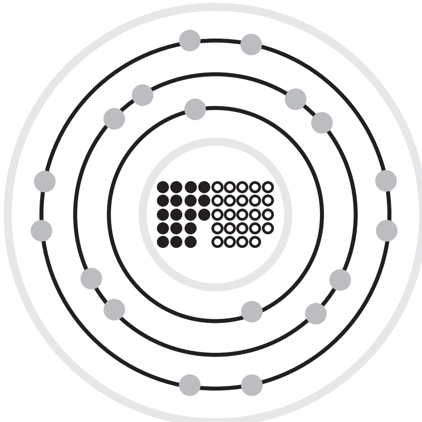
|---|---|
| Argon-40 | 99.6003%  |
| Argon-41 | 0%  |
| Argon-42 | 0%  |

## ACTIVITY 3: CALCULATING ATOMIC MASS

To students it can be confusing that every proton and neutron has a mass of one but that the atomic mass of an element is usually some decimal number. Here students can physically see and estimate the atomic mass of some basic elements. You will need several atom models for this activity, depending on which element(s) you choose to model.

**Boron:**

Set up four models of boron-11 and one model as boron-10

**Neon:**

Set up nine models as neon-20 and one model as neon-22

**Magnesium:**

Set up eight models as magnesium-24, one model as magnesium-25, one model as magnesium-26

**Chlorine:**

Set up three models as chlorine-35 and one model as chlorine-37

## PROCEDURE :

(The teacher answers are written with chlorine as a sample, but any of the four listed above would work well.)

You are given a sample of a certain element. This sample consists of several atoms, but in a real life sample there would be many more. Your job is to study each atom closely by answering the following questions, and then determine the approximate atomic mass of your sample.

**Key:**

Green balls are protons

Blue balls are neutrons

Yellow pegs are electrons

1. What element are you studying? Justify your answer using the term atomic number.

   (The atomic number of an element is the same as the number of protons and the atomic number is the same for every atom of that element. Our sample is Chlorine because it has seventeen green balls or seventeen protons.)

2. What are the number of protons, neutrons and electrons of each atom in your sample? Make a small data table and record your findings below.

| Sample number | Number of Protons | Number of Electrons | Number of Neutrons | Atomic Weight in amu |
|---|---|---|---|---|
| 1 | 17 | 17 | 18 | 35 |
| 2 | 17 | 17 | 18 | 35 |
| 3 | 17 | 17 | 20 | 37 |
| 4 | 17 | 17 | 18 | 35 |

3. Add another column to your data table in question 2 and find the atomic weight of each sample.

4. What is the average atomic weight of your sample in amu? Show your work in the space provided below.

$$\frac{35+35+37+35}{4} = \frac{142}{4} = 35.5 \text{ amu}$$

5 Look up the atomic mass of the element your sample is made out of on the periodic table and record that value here.
*35.45*

6. How does your average atomic weight compare to your given atomic mass?
*(The two values are very similar. The percent error is less than 1%.)*

Name:________________________________________ Date:___________________

## ACTIVITY 3: ATOMIC MASS

You are given a sample of a certain element. This sample consists of several atoms, but in a real life sample there would be many more. Your job is to study each atom closely by answering the following questions, and then determine the approximate atomic mass of your sample.

**Key:**

Green balls are protons

Blue balls are neutrons

Yellow pegs are electrons

1. What element are you studying? Justify your answer using the term atomic number.

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

2. What are the number of protons, neutrons and electrons of each atom in your sample? Make a small data table and record your findings below.

3. Add another column to your data table in question 2 and find the atomic weight of each sample.

4. What is the average atomic weight of your sample in amu? Show your work in the space provided below.

5. Look up the atomic mass of the element your sample is made out of on the periodic table and record that value here.

____________

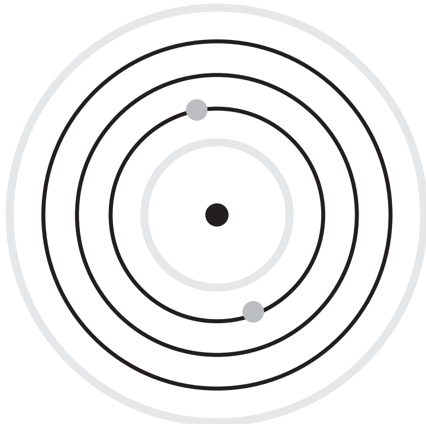
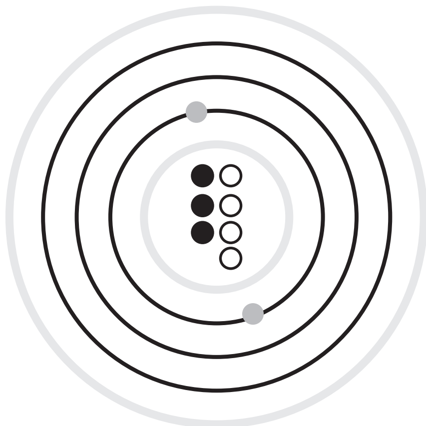
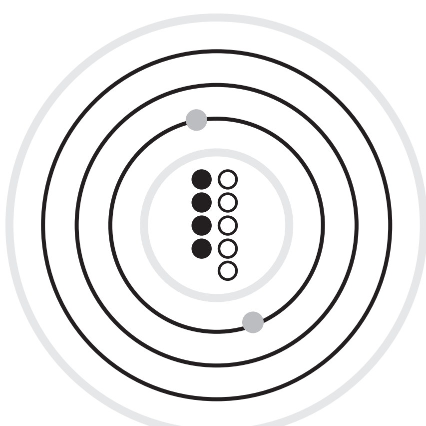
6. How does your average atomic weight compare to your given atomic mass?

## ACTIVITY 4: IONS

This model can also help students to learn about ions. The cards below show some common ions of some of the first 18 elements on the periodic table. Prepare the cards as suggested in activity one. If the teacher chooses, the answers can be left on the back of the card so students can check their own answers.

It is important to note that the ions on the cards are not all ions that would normally appear in solution. Some of the ions listed are oxidation states, which means they are the number of electrons that would be present when that element combined with other atoms to make a molecule. It is beneficial for students to practice counting the numbers of protons verses electrons before they study more complex topics.

Students will begin to notice patterns as they begin to figure out the electron configurations, such as a preference for even numbers of electrons in ions and preference for making complete orbital shells.

| | |
|---|---|
| $H^+$ |  |
| $H^-$ |  |
| $Li^+$ |  |
| $Be^{+2}$ |  |

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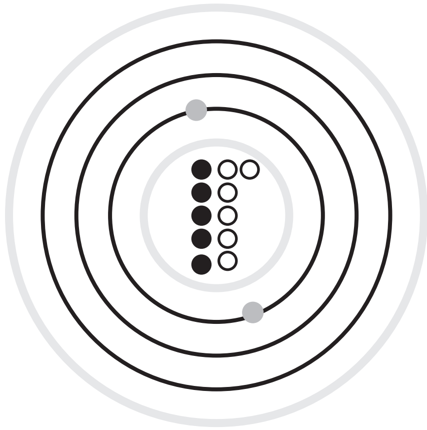
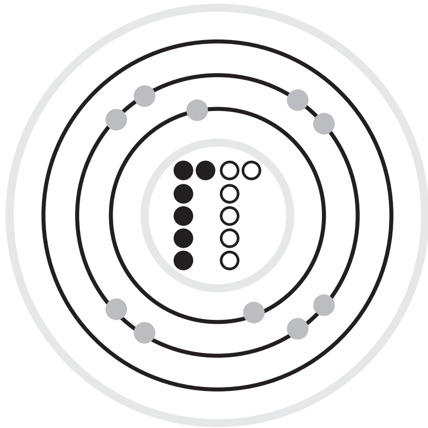
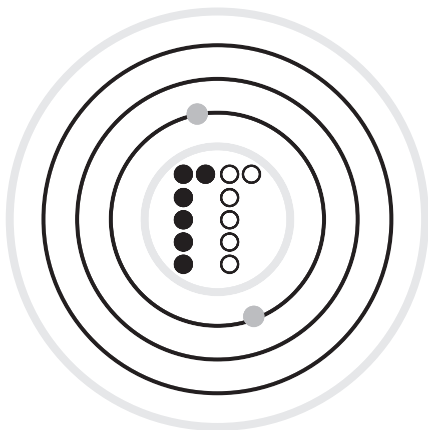
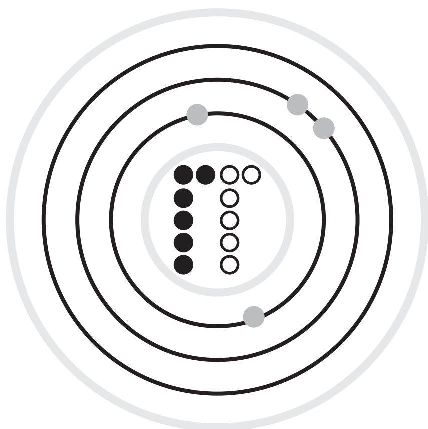
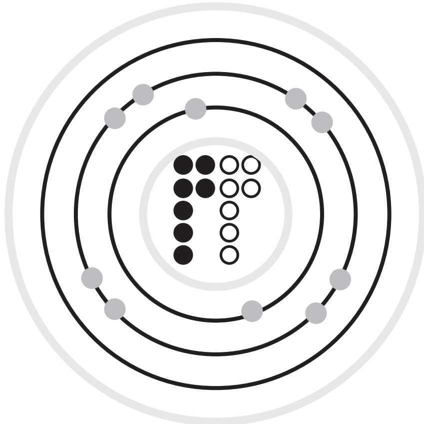
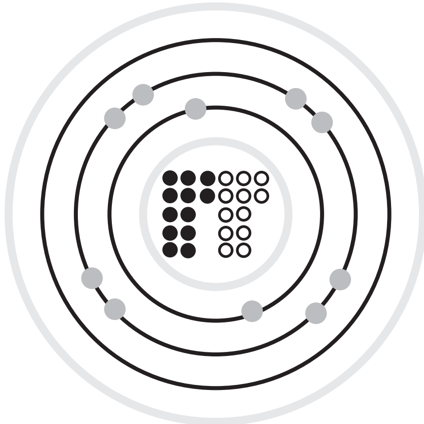
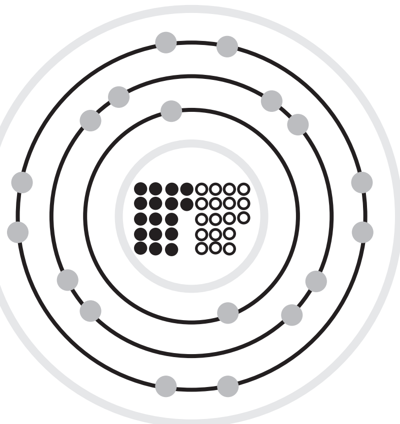
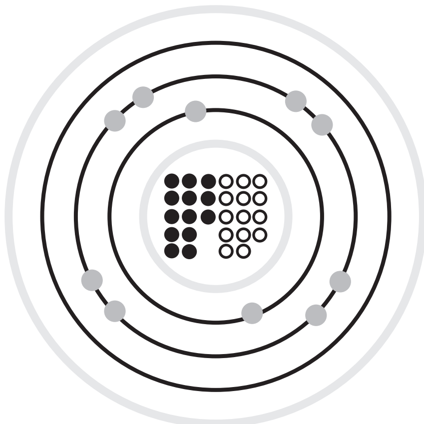
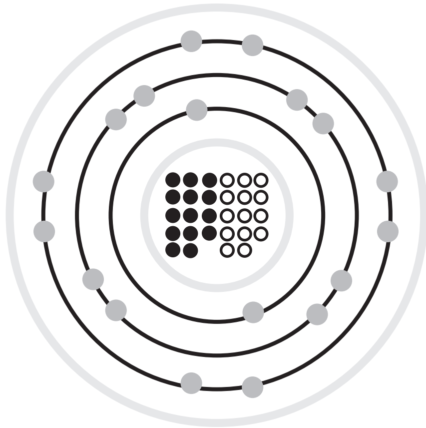
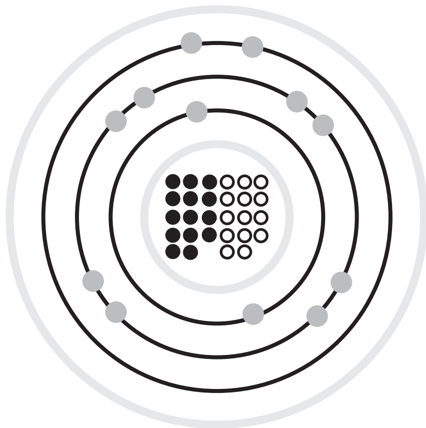
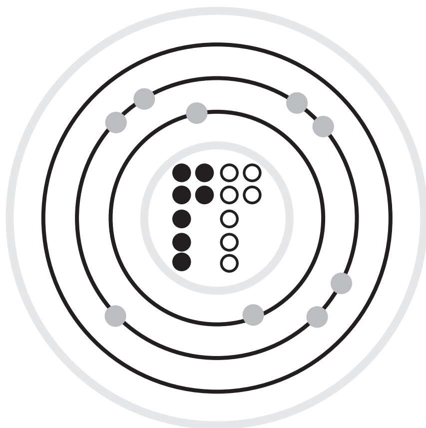
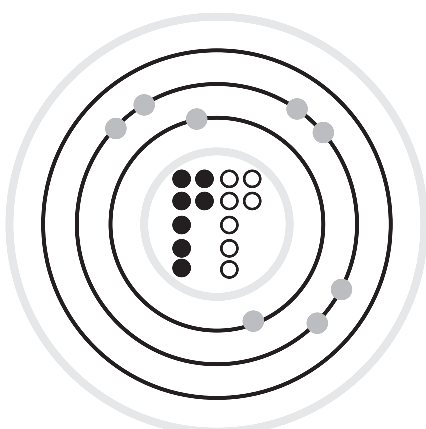
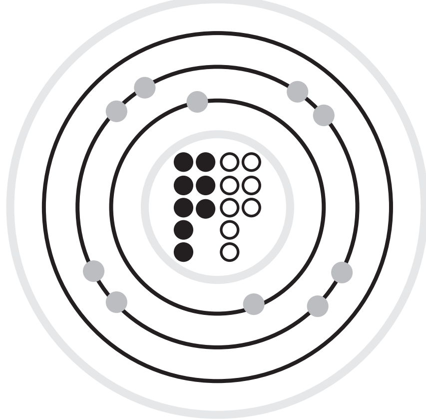
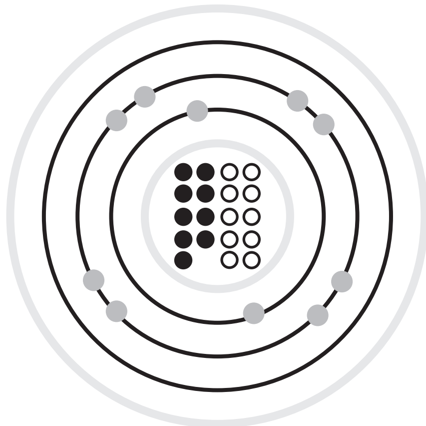
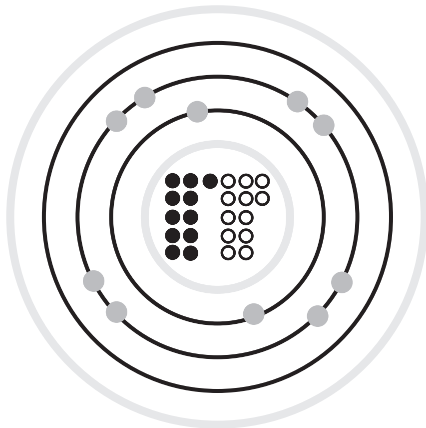
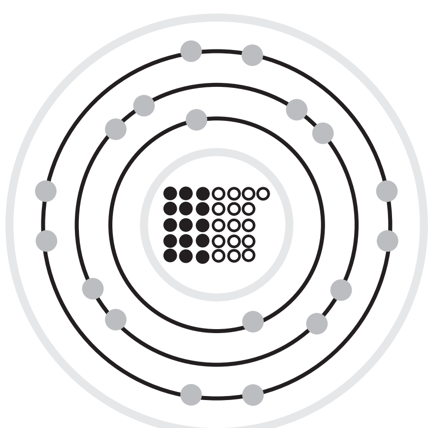
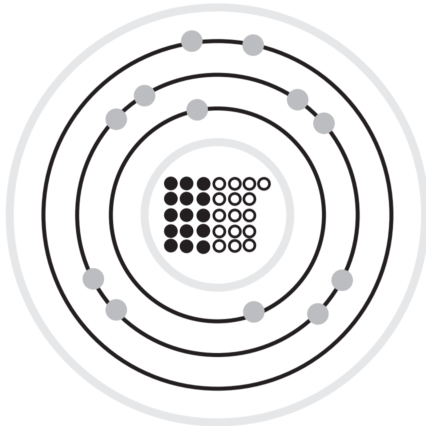
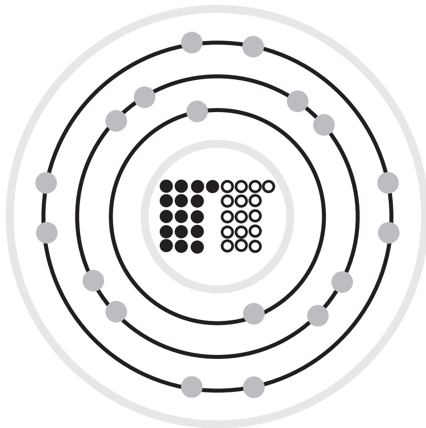
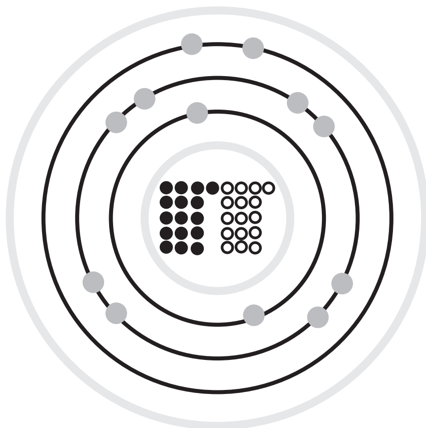
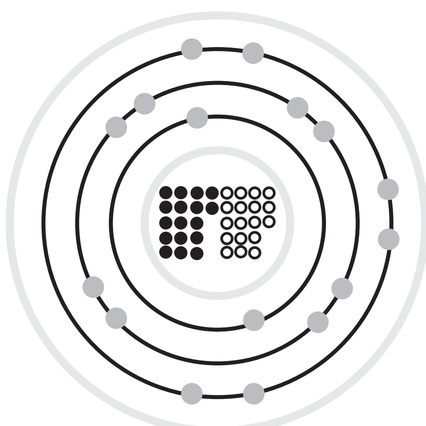
|---|---|
| $B^{+3}$ |  |
| $C^{-4}$ |  |
| $C^{+4}$ |  |
| $C^{+2}$ |  |

| | |
|---|---|
| $N^{-3}$ |  |
| $Mg^{+2}$ |  |
| $Cl^{-}$ |  |
| $Al^{+3}$ |  |

| | |
|---|---|
| $Si^{-4}$ |  |
| $Si^{+2}$ |  |
| $N^{-2}$ |  |
| $N^{-1}$ |  |

| | |
|---|---|
| $O^{-2}$ |  |
| $F^{-}$ |  |
| $Na^{+}$ |  |
| $P^{-3}$ |  |

| | |
|---|---|
| $P^{+3}$ |  |
| $S^{-2}$ |  |
| $S^{+4}$ |  |
| $Cl^{+1}$ |  |

## TEACHER QUICK REFERENCE GUIDE :

| Ion | Green dots in smallest circle | Blue dots in smallest circle | Yellow pegs on smallest black circle | Yellow pegs on second smallest black circle | Yellow pegs on largest black circle |
|---|---|---|---|---|---|
| $H^{+}$ | 1 | 0 | 0 | 0 | 0 |
| $H^{-}$ | 1 | 0 | 2 | 0 | 0 |
| $Li^{+}$ | 3 | 4 | 2 | 0 | 0 |
| $Be^{+2}$ | 4 | 5 | 2 | 0 | 0 |
| $B^{+3}$ | 5 | 6 | 2 | 0 | 0 |
| $C^{-4}$ | 6 | 6 | 2 | 8 | 0 |
| $C^{+4}$ | 6 | 6 | 2 | 0 | 0 |
| $C^{+2}$ | 6 | 6 | 2 | 2 | 0 |
| $N^{-3}$ | 7 | 7 | 2 | 8 | 0 |
| $Mg^{+2}$ | 12 | 12 | 2 | 8 | 0 |
| $Cl^{-}$ | 17 | 18 | 2 | 8 | 8 |
| $Al^{+3}$ | 13 | 14 | 2 | 8 | 0 |
| $Si^{-4}$ | 14 | 14 | 2 | 8 | 8 |
| $Si^{+2}$ | 14 | 14 | 2 | 8 | 2 |
| $N^{-2}$ | 7 | 7 | 2 | 7 | 0 |
| $N^{-1}$ | 7 | 7 | 2 | 6 | 0 |
| $O^{-2}$ | 8 | 8 | 2 | 8 | 0 |
| $F^{-}$ | 9 | 10 | 2 | 8 | 0 |
| $Na^{+}$ | 11 | 12 | 2 | 8 | 0 |
| $P^{-3}$ | 15 | 16 | 2 | 8 | 8 |
| $P^{+3}$ | 15 | 16 | 2 | 8 | 2 |
| $S^{-2}$ | 16 | 16 | 2 | 8 | 8 |
| $S^{+4}$ | 16 | 16 | 2 | 8 | 2 |
| $Cl^{+1}$ | 17 | 18 | 2 | 8 | 6 |



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