SNC1D
UNIT 2: CHEMISTRY
CHAPTER 5: UNDERSTANDING THE PROPERTIES OF ELEMENTS

5.2: THE STRUCTURE OF THE ATOM

INSIDE THE ATOM **Page 188**

An atom consists of a **heavy, positively charged nucleus** that contains **protons and neutrons** (both of approximately the same mass), and **negatively charged electrons** orbiting around the nucleus at **specific energy levels.** Electrons are much smaller than protons and neutrons, approximately **1/2000th** the size of a proton.

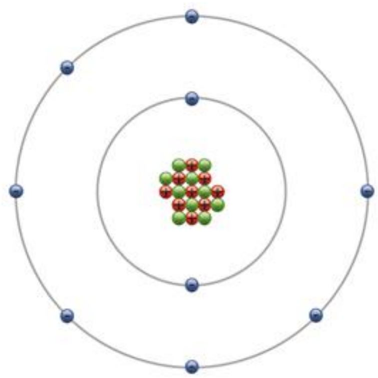


Image courtesy of Wikimedia Commons

Although an electron is a fraction of the size of a proton, it still carries the **same amount of charge**. The only difference is the charge on a **proton is positive** and the charge on an **electron is negative**. In an atom, for each proton (+1 charge) there is an electron (-1 charge), so that the overall charge of an atom is neutral (no charge).

STRUCTURE OF THE ATOM			
Characteristic	**PROTON**	**NEUTRON**	**ELECTRON**
Charge	Positive	No charge	Negative
Location	Nucleus	Nucleus	Energy Levels around nucleus
Relative Mass	1	1	1/2000th

ATOMIC NUMBER

Elements are listed in the Periodic Table in order of atomic number. The ***atomic number*** indicates how many ***protons*** are found in the atomic structure of the element. Potassium, with atomic number 19, contains 19 protons in its nucleus. It is the number of protons that **make elements different,** not the number of electrons or neutrons. If the atom is neutrally charged then the atomic number also equals the number of electrons.

ATOMIC MASS

A second number (often a decimal number), found in the Periodic Table, is the atomic mass shown beneath the element's symbol. By rounding off the number, we obtain the mass number of the element, which equals the **sum of protons and neutrons** in the atom's nucleus:

Mass Number = (Number of Protons) + (Number of Neutrons)

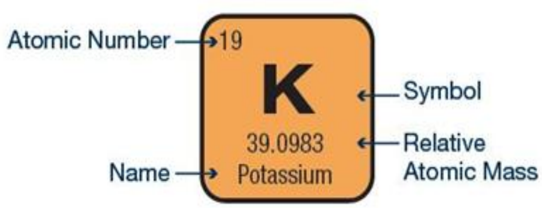
EXAMPLE:
Potassium, with atomic number 19, indicates that there are 19 protons in the nucleus. The atomic mass of potassium is 39.0983, which can be rounded to 39 to obtain the mass number. Therefore, there must be 20 neutrons in the nucleus of the potassium atom.

Mass Number = Number of Protons + Number of Neutrons

$\therefore$ Number of Neutrons = Mass Number – Number of Protons
= 39 – 19
= 20

REPRESENTING ELEMENTS **see page 189**

Element symbols are a **universal language** and although the names of elements may vary from country to country, their symbols are the same. The universal symbol for potassium is K.



Potassium as represented in the Periodic Table

$$^{39}_{19}K$$

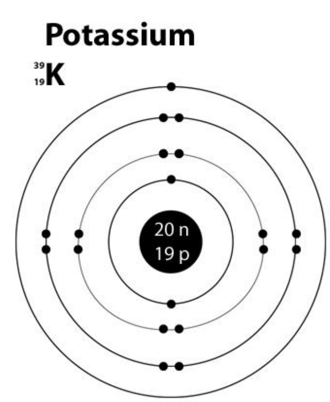
Standard Atomic Notation

REPRESENTING ATOMS **Page 190**

For the purposes of this course, we will be using the classical model, commonly called the **Bohr-Rutherford model**. [See page 190 for more information.]

Energy Shell	Maximum Number of Electrons in the Shell
1	2
2	8
3	8

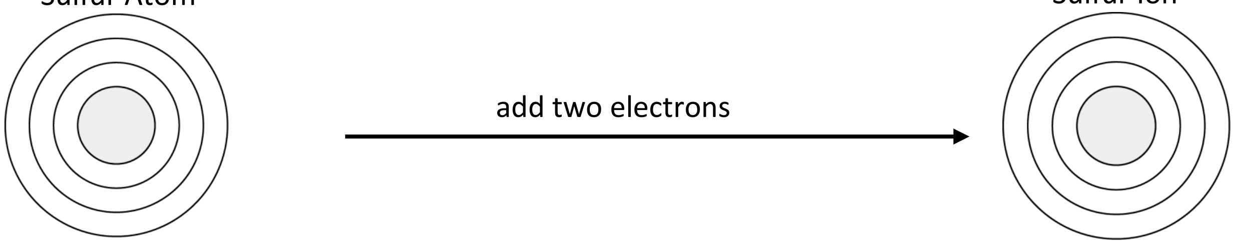
For example, the Bohr-Rutherford Model of Potassium is shown to the right.



REPRESENTING IONS

Most atoms are able to add or lose electrons to create **IONS**, which are particles with a positive or negative charge. The model of an ion is different from the model of its neutral atom.
For example, sulfur *(atomic mass 32 and atomic number 16)* will often add two electrons **to fill the outer shell**. Although the number of electrons has changed, the number of protons has not changed and since the number of protons is the same as the atomic number, the atom is still sulfur. Complete the Bohr-Rutherford diagrams of a neutral sulfur atom and a sulfur ion.

Sulfur Atom | Sulfur Ion



S | S^{2-}

Notice that the charged sulfur ion [represented as S^{2-}] has a ***full outer orbit***. The 2- indicates a charge due to the addition of the 2 electrons. Notice that the nucleus remains the same.
Ions will be discussed in more detail in section 6.1.

ISOTOPES **see page 191**

Isotopes are atoms of the same element with different atomic masses due to the number of neutrons in the nucleus. For example, most normal carbon atoms found in the universe are **C-12** which contains **6 protons** and **6 neutrons**. However, some carbon atoms contain **8 neutrons instead of 6**, and these **carbon-14** atoms are isotopes. Note that the number of neutrons has changed, but the atom is still carbon, because the number of protons has remained constant.

Draw Bohr-Rutherford diagrams for the following isotopes.

a) **carbon – 12**
(6P + 6N)
Atomic mass = 13

b) **carbon – 14**
(6P + 8N)
Atomic mass = 14

c) **oxygen – 16**

d) **oxygen – 17**

Did you know?

Carbon – 14 is important in determining the ages of artifacts and fossils up to 70 000 years old. Carbon – 14 is unstable and through a radioactive decay process **one of the neutrons will be broken down into a proton and an electron**. The electron is emitted leaving the remaining atom with 7 protons and 7 neutrons. **Is this still a Carbon atom? No, the 7 protons indicate the Carbon – 14 atom has changed into a stable N – 14 atom**. Since a living organism exchanges carbon with its environment and a dead organism does not, if we look at the amount of Carbon – 14 left in the organism, we can get an idea of how old it is.

<u>CHECK YOUR UNDERSTANDING</u>

1. An atom has an atomic number of 8 and a mass number of 16. How many protons and neutrons does the atom have? Explain.

2. Draw a Bohr-Rutherford model to show how the electrons in an atom of argon (atomic number 18, with 22 neutrons) are arranged.

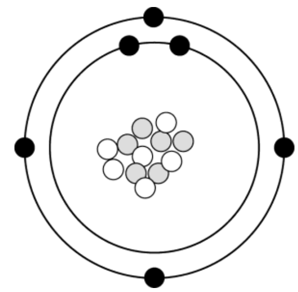
3. a. What is the difference between an atom and an ion?

   b. Draw Bohr-Rutherford models of a phosphorus atom and its ion.

3. Use the internet to determine all of the isotopes of magnesium. Draw Bohr-Rutherford diagrams of two different isotopes of magnesium.

4. What does taking a neutral position about an issue mean? Relate this to the term neutron.

This diagram represents an atom of the element carbon. Use this diagram to answers questions 1 & 2.



1. Complete the table.

Subatomic Particles				
Name	**Colour**	**Relative Mass**	**Electric Charge [+ / 0 / –]**	**Location in the Atom (inside or outside nucleus)**
	grey	1836		
	white	1837		
	black	1		

2. The _______________ and the __________________ are attracted to each other with a strong force.

3. Fluorine – 19 is an isotope of fluorine. The notation for this isotope is ${}^{19}_{9}F$.
Complete the sentences.
The isotope flourine – 19 has a mass number of ______, so it has __________ neutrons.
It has an atomic number of __________, so it has __________ protons.

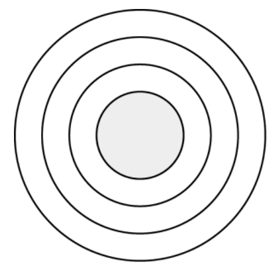
4. You know this about an isotope:
- The atom is oxygen.
- Its atomic number is 8.
- Its mass number is 20.

Write the standard atomic notation for this isotope: ______________

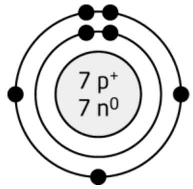
5. **a.** Draw 12 electrons on the Bohr-Rutherford diagram of an atom.

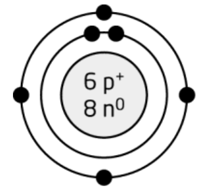
b. How many energy levels contain electrons? ______________

c. Name the element. ______________



6. **a.** Name each atom.





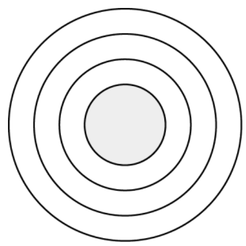
__________________________ __________________________

b. What is the same about each atom?

____

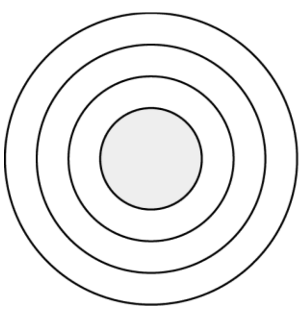
c. What is different? ____

7. Draw a Bohr-Rutherford model of an atom that has 8 protons, 9 neutrons, and 8 electrons.

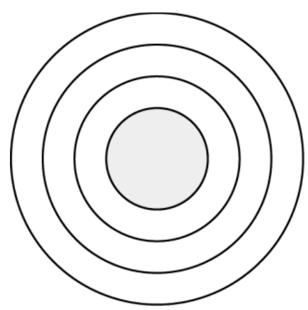


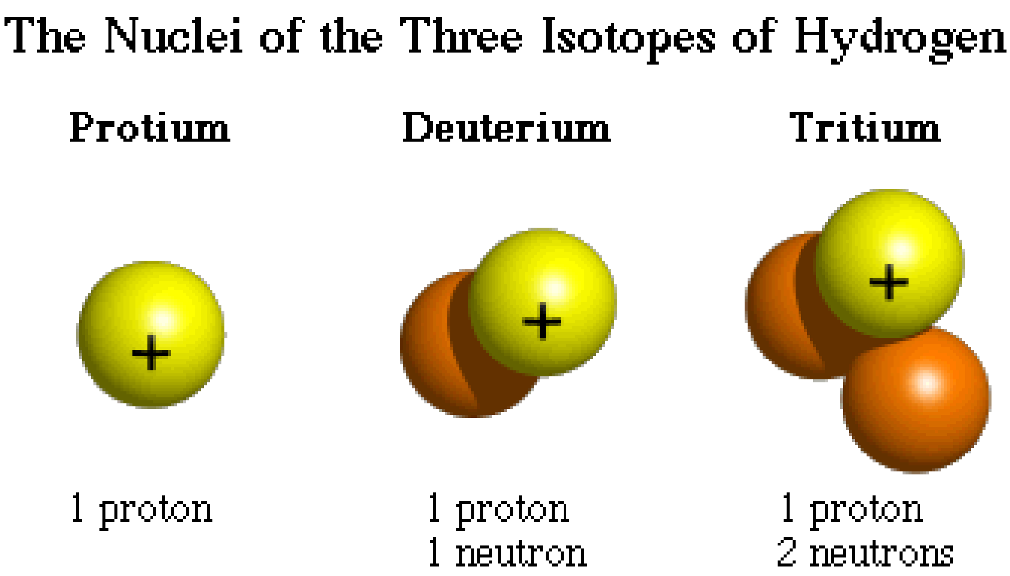
8. Draw a Bohr Rutherford diagram of each atom.

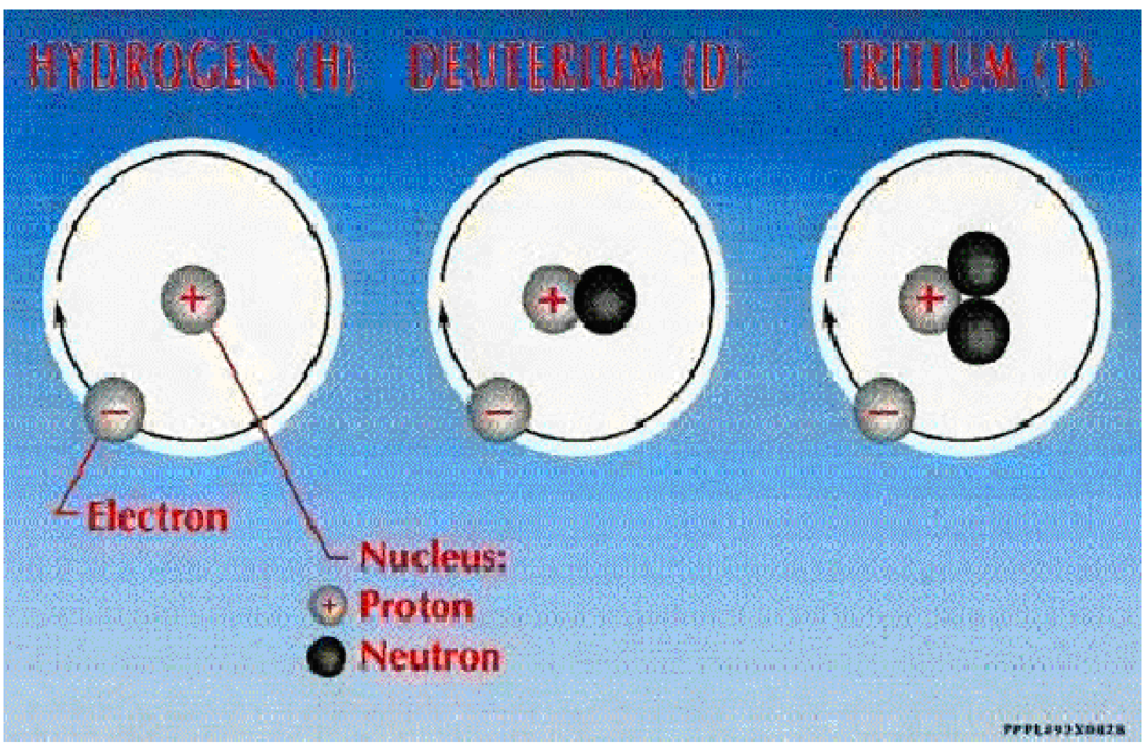
a. hydrogen-1 atom



b. hydrogen-2 atom




The Nuclei of the Three Isotopes of Hydrogen
Protium
Deuterium
Tritium
+
+
+
1 proton
1 proton
1 neutron
1 proton
2 neutrons


HYDROGEN (H)
DEUTERIUM (D)
TRITIUM (T)
Electron
Nucleus:
Proton
Neutron

Isotopes of Carbon

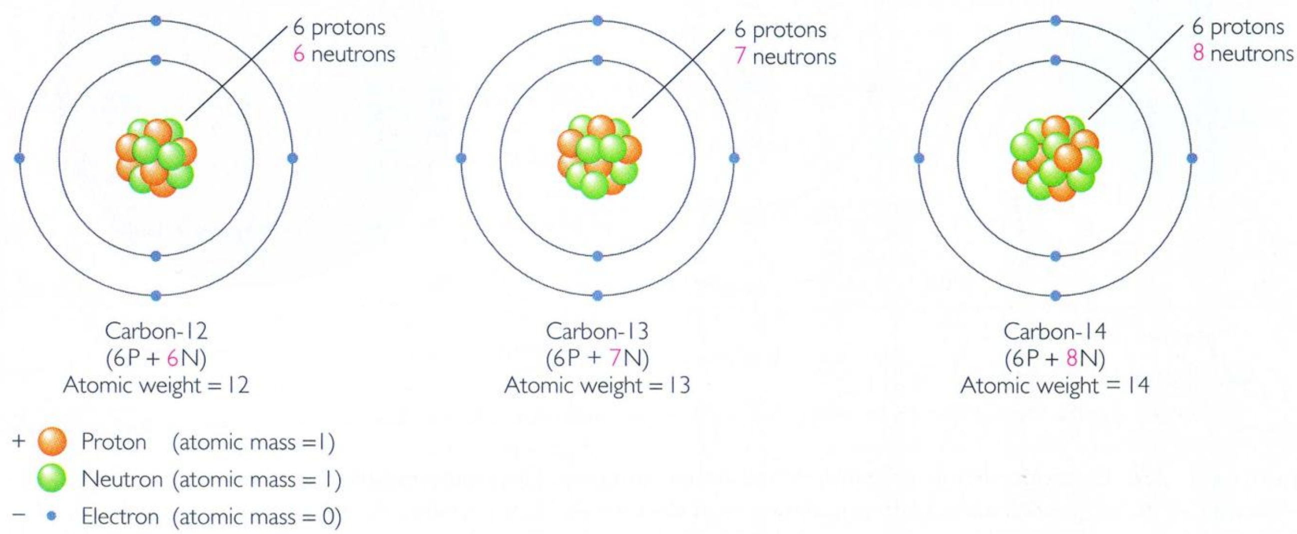


FIGURE 2.3 These three carbon isotopes all have the same number of protons and thus the same atomic number, 6. Their atomic masses differ, however, because they have slightly different numbers of neutrons. The atomic mass of any element is the average of the weighted sum of the atomic masses of its various isotopes. One isotope of an element—for example, carbon-12—is far more abundant than the others because natural processes favor that particular isotope.

Isotopes of Oxygen