ChemQuest 15

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Bohr's Atomic Model

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_\_

**Information**: Bohr’s Solar System Model of the Atom

All the planets are attracted to the sun by gravity. The reason that the Earth doesn’t just float out into space is because it is constantly attracted to the sun. Similarly, the moon is attracted to the Earth by Earth’s gravitational pull. So all of the planets are attracted to the sun but they never collide with the sun.

Negative charges are attracted to positive ones. Therefore the negative electrons in an atom are attracted to the positive protons in the nucleus. In the early 1900’s scientists were looking for an explanation to a curious problem with their model of the atom. Why don’t atoms collapse? The negative electrons should collapse into the nucleus due to the attraction between protons and electrons. Why doesn’t this happen? Scientists were at a loss to explain this until Neils Bohr proposed his “solar system” model of the atom.

**Critical Thinking Questions**: Bohr’s reasoning

1. Consider swinging a rock on the end of a string in large circles. Even though you are constantly pulling on the string, the rock never collides with your hand. Why is this?
2. Even though the Earth is attracted to the sun by a very strong gravitational pull, what keeps the Earth from striking the sun?
3. There is a gravitational attraction between the Earth and the moon. Why doesn’t the moon ever strike the Earth?
4. Keeping in mind the planetary motion and attractions between planets and the sun, explain how it could be possible for electrons to not “collapse” into the nucleus?

**Information**: Energy levels

After Bohr proposed the Solar System Model (that electrons orbit a nucleus just like planets orbit the sun), he called the orbits “energy levels”.

1st energy level

2nd energy level

Consider the following Bohr model of a certain atom:

= proton (positive charge)

= electron (negative charge)

= neutron (no charge)

There are limits on the number of electrons that are allowed to occupy each energy level. In the 1st energy level, there can only be 2 electrons. The 2nd energy level is larger—it can hold 8 electrons. The 3rd and 4th can hold more than 8, but we won’t think about those limits yet.

**Critical Thinking Questions**

1. In the preceding information section there is a “Bohr diagram” of an atom. Which atom is it?
2. Draw a Bohr diagram for the following atoms. Note: Before you can draw an electron on the 2nd energy level, you must first have 2 electrons in the 1st energy level. Before you can draw an electron on the 3rd energy level, you must first have 2 electrons on the 1st energy level and 8 on the 2nd. The first one is done for you.

a) Sulfur b) Carbon b) Sodium c) Phosphorus

**Information**: Light

You may be surprised to learn that the behavior of light gives us some clues about the electrons in an atom. Before we can dive too deeply into it, let’s recall a few things about light. First, it is a wave. White light is composed of all the colors of light in the rainbow. All light travels at the same speed (c), which is 3.00 x 108 m/s. (The speed of all light in a vacuum is always equal to 3.0 x 108 m/s.) Different colors of light have different frequencies (f) and wavelengths (). The speed (c), frequency (f) and wavelength () of light can be related by the following equation:

It is important that the wavelength is always in meters (m), the speed is in m/s and the frequency is in hertz (Hz). Note: 1 Hz is the inverse of a second so that 1 Hz = 1/s.

**Critical Thinking Questions**

1. As the frequency of light increases, what happens to the wavelength of the light?
2. What is the frequency of light that has a wavelength of 4.25 x 10-8 m?
3. What is the wavelength of light that has a frequency of 3.85 x 1014 Hz?

**Information**: Light Energy and Energy Levels

Higher energy levels are further from the nucleus. For an electron to go into a higher energy level it must gain more energy. Sometimes the electrons can absorb light energy. (Recall that different colors of light have different frequencies and wavelengths.) If the right color (and therefore, frequency) of light is absorbed, then the electron gets enough energy to go to a higher energy level. The amount of energy (E) and the frequency (f) of light required are related by the following equation:

E is the energy measured in Joules (J), f is the frequency measured in Hz, and h is Planck’s constant in units of J/Hz which is the same as J-second. Planck’s constant, h, always has a value of

6.63 x 10-34J-s.

An electron that absorbs light energy and goes to a higher energy level is said to be “excited.” If an excited electron loses energy, it will give off light energy. The frequency and color of light depends on how much energy is released. Again, the frequency and energy are related by the above equation. When an excited electron loses energy, we say that it returns to its “ground state”. Since not all electrons start out in the first energy level, the first energy level isn’t always an electron’s ground state.

The same atom is now in an “excited state”

The “ground state” of an atom

**Critical Thinking Questions**

1. If you are given a Bohr diagram of an atom, how can you tell if it is in the ground state or in an excited state?
2. Label each of the following atoms as ground state or excited state.
3. Does an electron need to absorb energy or give off energy to go from the 2nd to the 1st energy level?
4. How is it possible for an electron go from the 3rd to the 4th energy level?
5. Red light of frequency 4.37 x 1014 Hz is required to excite a certain electron. What energy did the electron gain from the light?
6. The energy difference between the 1st and 2nd energy levels in a certain atom is 5.01 x 10-19 J. What frequency of light is necessary to excite an electron in the 1st energy level?
7. a) What is the frequency of light given off by an electron that loses 4.05 x 10-19 J of energy as it moves from the 2nd to the 1st energy level?

b) What wavelength of light does this correspond to (hint: use c = f)?

1. If all of the electrons in atom “A” get excited and then lose their energy and return to the ground state the electrons will let off a combination of frequencies and colors of light. Each frequency and color corresponds to a specific electron making a transition from an excited state to the ground state. Consider an atom from element “B”. Would you expect the excited electrons to let off the exact same color of light as atom “A”? Why or why not?