ATOMS AND LIGHT

The visible light that we can see, along with ultraviolet light and x-rays, all originate in atoms, specifically from the movement of electrons between energy levels in the atom. When an electron in an atom absorbs a sufficient amount of energy, whether it comes from heat or electricity or light, the electron will jump to a higher energy level. The difference between higher and lower energy levels is called the *energy gap*. If an electron absorbs a certain amount of energy to jump to the higher energy level, it will release the same amount of energy when it falls back to the lower level. The energy released by the electron is always in the form of a photon of electromagnetic radiation, commonly visible light, ultraviolet light, infrared radiation, or an x-ray. X-rays are the most energetic, followed by ultraviolet, visible, and infrared. X-rays and ultraviolet radiation are dangerous because they contain enough energy to damage cells.

The energy levels in an atom are arranged like to a staircase, with each step representing an energy level. If you throw a ball to the top of the stairs, it can roll back down in a number of different ways. It might bounce down one step at a time, or two or three, or any combination of these. Each jump between two different steps results in the emission of a photon. The type of energy emitted depends on how far the electron has fallen. A jump of one step or level might result in a photon of low energy infrared radiation, while a jump of several levels would produce a high energy photon of ultraviolet radiation.

The hypothetical staircases in atoms differ from normal staircases in two important ways. First, the steps in our atomic staircases are not equally spaced. While there is a large gap between the first and second steps, this gap becomes smaller and smaller as we move up the stairs. Thus, an electron falling from the second to the first step would fall much farther than an electron falling from the third step to the second step. Second, the distances between these atomic steps are different for each element. The energy gap between the first and second steps in hydrogen is not the same as the energy gap between the same two steps in helium.

Just as the various forms of electromagnetic radiation vary in the amount of energy they contain, so do the different colors of visible light. The colors of the rainbow: red, orange, yellow, green, blue, and violet all have different energies. Red light has the lowest energy while violet has the highest. When an atom emits red light, that indicates that an electron has fallen a short distance down the staircase, green would correspond to a greater distance, and violet to an even greater distance.

An atom can emit many different colors of light simultaneously, and the blend of colors is like a fingerprint of that particular atom. Many metal atoms emit bright light when heated in a flame. The color of the light can be used to identify the metal in a chemical compound. In this experiment you will first see various known metal compounds heated in the Bunsen burner, and will record the color of light produced by each. You will then see the same procedure for two unknown samples that contains one of the known metals. By matching the color of your unknown with one of the known samples, you will be able to identify the metal in the unknown sample.

EXPERIMENTAL PROCEDURE

1. If you haven't already done so, read sections 4.2 and 4.3 in the text, watch and listen to the audio version of these sections, or watch the online lectures for them.

   https://preparatorychemistry.com/Bishop_Book_atoms_4.pdf

   or

   https://preparatorychemistry.com/Bishop_audiobook_atoms_Section_4_2.html

   and
   https://preparatorychemistry.com/Bishop_audiobook_atoms_Section_4_3.html

   or

   https://preparatorychemistry.com/Bishop_lecture_Mysterious_Electron.html

   and
   https://preparatorychemistry.com/Bishop_lecture_Multi_Electron_Atoms.html

2. Watch my video of the explanation of the theory behind this experiment at

   https://preparatorychemistry.com/Atoms_and_Light_online.html

3. When you start the video linked below, you will hear and eventually see Dr. Phil Reedy at Delta College. The experiment itself begins at about 7:40. You should read steps 4 and 5 below before you start the video.

4. When Dr. Reedy shows you the flame tests for the known samples (sodium, Na, potassium, K, calcium, Ca, strontium, Sr, barium, Ba, and copper, Cu), on the data sheet on page 3, write a description of the colors you see around the outside of the flame. This is difficult to do on the computer screen, but do the best you can. You might need to run the video back and forth a couple of times before you make your decision.

5. You are shown seven unknowns that are each the same as one of the six knowns. Try to identify them from their colors. It's a challenge for some of them, but do the best you can. I will not penalize you for incorrect answers.

6. Open the YouTube video at the following web address and complete steps 4 and 5.

   https://youtu.be/RVDBLevsfFE

7. Answer the questions on the last page.

8. Just scan pages 3 and 4 with Adobe Scan and share them with me at mbishop@mpc.edu in one PDF. Follow steps 8 and 9 in the following instructions to name your file with (last name)(Chem class)Light.pdf, and follow step 12 to use the "Share a Copy" option to upload your file to Canvas.

   https://preparatorychemistry.com/How_to_use_Adobe_Scan_Canvas.pdf

9. As always, ask questions if you have them.

Name _____

Atoms and Light Results

METAL TESTED	COLOR OBSERVED
sodium, Na	
calcium, Ca	
potassium, K	
barium, Ba	
strontium, Sr	
copper, Cu	

Unknown #18 metal _____

Unknown #10 metal _____

Unknown #14 metal _____

Unknown #16 metal _____

Unknown #15 metal _____

Unknown #5 metal _____

Unknown #21 metal _____

Answer the following questions. My video of the explanation of the theory behind this experiment should help.

https://preparatorychemistry.com/Atoms_and_Light_online.html

1. Why does heating hydrogen gas to very high temperature release light photons of different energies and therefore different colors?

2. Is the color you see for the heated hydrogen gas just one color or a blend of colors? Please explain your answer.

3. Why do the different elements that you saw in the video give off different colors?