Experiment 15 - Line Emission Spectra and Flame Tests

Line emission spectra are markedly different for the various elements. In fact, each element has its own particular set of colored lined (different wavelengths of emitted light) that are due to the unique spacing of electronic energy levels in that one kind of atom. In this experiment the spectra of a number of elements will be generated in two ways: by heating in a burner flame, and by electric discharge in a sealed glass tube. The objects of this lab are:

1. To observe the color of light (seen by the eye) when a sample of a chemical is heated, and to use this color as a means of identifying a few positive ions that give recognizable colors to the unaided eye;
2. To observe the individual wavelengths of the emitted light from a gaseous sample in a discharge tube, after each wavelength has been separated from the mixture of wavelengths that make up the total emission. This separation of light is done by an instrument called a spectroscope.

Part 1 - Flame Tests

In this part of the experiment, different solutions containing metal ions are heated in a burner flame. The flame excites the electrons in these metal ions to higher energy levels. As the excited electrons fall back down to lower energy levels, they give off light of specific wavelengths. A number of different wavelengths (each with a different color) are emitted in each case, but without a spectroscope the eye merely sees them as a single color. Sometimes this color is distinctive enough that it can be used to identify the element.

Part 2 - Spectroscopic Examination

Most natural light is a mixture of different wavelengths, each a different color. The spectroscope is an instrument that separates any beam of light into its constituent wavelengths, and spreads these separated beams out, so they can be seen. (The action of a spectroscope is similar to the action of a prism.)

If the light that is shone into a spectroscope consists of a very large number of wavelengths, each only very slightly different from the ones next to it, the separated light makes what is called a continuous spectrum. It looks like a rainbow of colors, each one merging into the next. An actual rainbow is a continuous spectrum that you see when the atmosphere acts like a giant spectroscope.

Discrete spectra or line spectra are those that consist of just a very few wavelengths of light, all of which are sufficiently different so that when separated, they fall at widely-spaced intervals, with large dark gaps in between them. This type of spectrum looks like separate lines of colored light that have spaces between them. Such spectra occur when elements in the form of very thin gases are heated. It was the study of these line emission spectra that led to the modern theory of electronic energy levels in the atom.

Safety Precautions:
- Wear your safety goggles.
- Use caution when handling the HCl.

Waste disposal:
- Used solutions of metal ions should go in the INORGANIC WASTE bottles (which have a blue label) in one of the fume hoods after the experiment.

Procedure

Part 1 - Flame Tests

1. Obtain a piece of nickel/chrome wire about 15 cm long. Collect a few milliliters of 6 M HCl in a test tube for use as a cleaning solution.
2. Bend one end of the wire into the smallest possible loop, about 1 mm in diameter. This loop will hold a drop of solution when you are doing the flame tests.
3. Clean the wire by first dipping it into 6 M HCl, then holding it in the hottest part of the flame. Repeat until you no longer see any significant color to the flame that comes off of the wire. (Repeat this cleaning process between each sample tested.)
4. To test a solution, let a drop of the solution fall onto the loop of the wire. (Do not let the dropper itself touch the wire; this could cause contamination of the solution in the dropper bottle.)
5. Hold the drop of solution in the burner flame, recording the color you see. **Note:** Na^+ ion gives an especially strong and persistent color. This ion is present as an impurity in most solutions, since glass (bottles) contain Na^+ which contaminates the solution. The strong color of Na^+ in the flame can obscure other colors such as the pale lavender of K^+. To avoid this difficulty, try looking at a K^+ flame test through a piece of blue glass, which should remove the sodium flame color. Colors that are not orange should come through. It is also a good idea to test the sodium solutions last.
6. Test the known solutions containing K^+, Ba^{2+}, Ca^{2+}, Cu^{2+}, Sr^{2+}, and Na^+. In each case, record the color of the flame produced. Then do flame tests on various miscellaneous items, as follows:
   1. purified water, from a squeeze bottle
   2. tap water
   3. a drop of your saliva
   4. urine from a dropper bottle provided (optional!!)
   5. a raisin (it will be necessary to heat it for several minutes to drive off moisture before the ion's flame color is visible)
   6. pink liquid soap

   In each case, record the color of the flame and decide which positive ion(s) are present.
7. Test an unknown liquid to find out which positive ion is present. (It will be one of the six ions you already tested.) Report the flame color observed and your

conclusion as to the identity of the ion. **IMPORTANT:** each person should test his or her own unknown. You and your lab partner must use different unknowns.

Part 2 - Spectroscopic Examination

8. Look through a spectroscope at daylight or a regular tungsten light bulb and at the overhead fluorescent light bulb. All of these sources give "continuous" rather than "discrete line" spectra; that is they give the whole rainbow of colors, each merging into the next.
9. Without moving any of the spectroscopes, look at the displayed elements in gas discharge tubes, and record the spectrum produced by each. Use crayons to record the colors seen by making vertical lines on your lab report to represent the spectra obtained.

Questions

(Note: to answer these questions, refer to your textbook and your lecture notes.)

1. What causes light to be emitted from an atom?
2. Why are only certain wavelengths emitted from an atom? (In other words, why do the spectra show lines of light instead of a continuous rainbow of light?)
3. Why does hydrogen emit different wavelengths of light than mercury?