Experiment 12 Name: ____________________________

^{9}F LAME TE ^{16}S T

When an atom absorbs heat (a type of energy), the energy could be absorbed by the electrons. If energy is absorbed by the electrons, the electrons of that atom can jump up to higher energy levels or states. After a brief period of time, the electron often returns to lower energy levels or the ground state. In doing so, the electrons release energy in the form of light. Since each element has different distances between these energy levels, the lights emitted when the electrons return to lower energy levels can have different wavelengths for different elements (Figure 1). The wavelength determines the colour of light, as a result, different elements emit different coloured light.

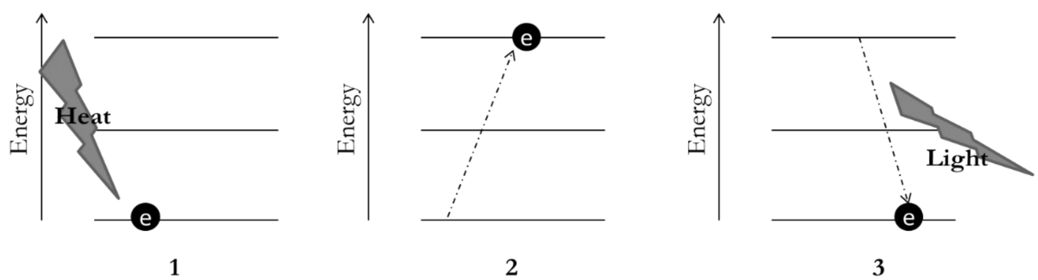

Figure 1: Heat (energy) is transferred to an electron in the ground state (1), this excites the electron and the electron jumps up to a higher energy level (2), after a very short time, the electron returns to a lower energy level and emits light at a specific energy and wavelength (3).

The wavelength of the emitted light can be measured and used to determine the difference in energy between the higher energy level the exited electron jumped up to and the lower energy level that the electron returned to. This difference in energy is known as an energy gap.

The energy (E) and wavelength (λ) are related through the frequency (ν) of light where:

$$E = h\nu \qquad \text{(Equation 1)}$$

$$\lambda = \frac{c}{\nu} \qquad \text{(Equation 2)}$$

If you rearrange the Equation 2 to solve for frequency and substitute that into Equation 1:

$$E = \frac{hc}{\lambda} \qquad \text{(Equation 3)}$$

Planck's constant: h = 6.626 x10^{-34} J·s
Speed of light: c = 3.00 x10^{8} m/s

Therefore, if the energy, frequency, or wavelength is known, the other two values can be calculated using the above equations.

For example, if a compound is heated and the wavelength of light emitted was 618 nm, the amount of energy of a photon released can be calculated. Note that the speed of light is in m/s and the wavelength is in nm. The wavelength must first be converted to m.

This can be solved one of two ways:

$$c = \lambda \nu$$

$$618\ nm\ \frac{1\ m}{10^9 nm} = 618\ x10^{-9} m = 6.18\ x10^{-7} m$$

$$\nu = \frac{c}{\lambda} = \frac{3.00\ x10^8 m/s}{6.18\ x10^{-7} m} = 4.85\ x10^{14} \frac{1}{s}\ or\ Hz$$

$$E = h\nu = (6.626x10^{-34} J\ s)\left(4.85\ x10^{14} \frac{1}{s}\right) = 3.22x10^{-19} J$$

Alternatively,

$$E = \frac{hc}{\lambda}$$

$$618\ nm\ \frac{1\ m}{10^9 nm} = 618\ x10^{-9} m = 6.18\ x10^{-7} m$$

$$E = \frac{(6.626x10^{-34} J\ s)(\frac{3.00x10^8 m}{s})}{6.18x10^{-7} m} = 3.22x10^{-19} J$$

The energies and wavelengths of the emitted lights are related to the energy levels that the electrons sit in around an atom's nucleus. Each element has unique energy levels due to the electrostatic (positive and negative) interactions between the nucleus and the electrons. Therefore, the wavelengths, or in other words, the colours of light emitted are determined by the type of element. This is how we are able to identify different elements using flame tests and spectroscopy.

When burned, different elements emit different colours. For example, when lead is burned, it emits a blue colour, which is visible to the naked eye (since it is in the visible range of the electromagnetic spectrum). (Note that not all wavelengths of energy emitted are in the visible part of the electromagnetic spectrum (see Figure 2). So, not all elements produce a visible colour when burned.) Therefore, if an unknown sample is burned to identify its composition and the sample burns blue, it may contain lead.

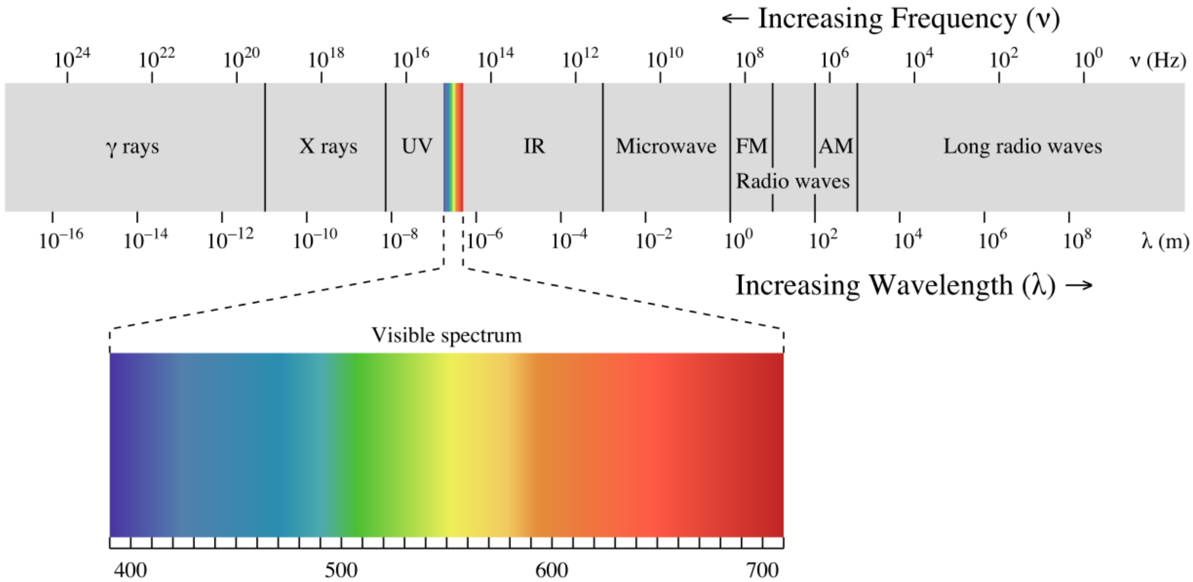

Figure 2: The electromagnetic spectrum.

PROCEDURE

1. Place one wooden splint into one of the solutions and leave it in there for three minutes.

2. Light the Bunsen burner and adjust the flame so that you have a blue flame.

3. Put the wet end of the wood splint into the flame and record the colour it burns.
4. Remove the wood splint from the flame and blow out the flame. Use an empty beaker to store the extinguished wood splints.

Extinguish the flames by blowing them out and placing into an empty beaker.

5. Repeat steps 1 – 4 for all the solutions labelled with compound names, working with a **<u>new</u> wood splint** each time.

Do NOT stick wood splints into multiple solutions.

6. Repeat steps 1 – 4 with two of the four unknowns (your choice), working with one at a time. The unknowns are chloride compounds. Identify them based on the colour of their flame.

Note: $LiCl$ and $SrCl_2$ are similar in colour, but distinguishable. Light these one after the other to see the difference.

CLEAN-UP

- Place the discarded wood splints into the provided waste container in the fume hood.

Name: ___________________________________ **Date:** ________________

Partner's Name: ___________________________

FLAME TEST

OBSERVATIONS

Group 1 Alkali Metals

Solution	Colour
LiCl	
NaCl	
KCl	

Group 2 Alkaline Earth Metals

Solution	Colour
$CaCl_2$	
$SrCl_2$	
$BaCl_2$	

Group 17 Halides

Solution	Colour
NaCl	
NaBr	
NaI	

Transition Metals

Solution	Colour
$CuCl_2$	
$MnCl_2$	

Unknowns

Solution	Colour	Formula of Chloride Compound
Unknown ______		
Unknown ______		

POST-LAB QUESTIONS

1. What happens to the flame colour as you go down Group 1 (alkali metals)?

2. What happens to the flame colour as you go down Group 2 (alkaline earth metals)?

3. What happens to the flame colour as you go down Group 17 (halides)?

4. Based on your observations, what elements cause the colour of the flame?

5. If a company wanted to make fireworks that were purple and green, what elements' compounds should they use for each colour?

6. If the wavelength of the light emitted from a flame test was measured to be 536 nm, how much energy did the electron release when it returned to its ground state?

7. If a photon absorbed 2.043×10^{-17} J of energy, what is the wavelength of this photon?

8. What part on the electromagnetic spectrum does the wavelength calculated in question 7 fall in (Refer to Figure 2)?

9. What is the wavelength of light with a frequency of 2.59×10^{15} Hz?

10. What is the frequency of a photon with 1.594×10^{-24} J of energy?