Name: ____________

Mystical Fire Investigation

Background

*The Visible Portion of the Electromagnetic Spectrum*

Visible light is a form of electromagnetic radiation (EMR). The visible portion of the electromagnetic spectrum is the only portion that can be detected by the human eye—all other forms of electromagnetic radiation are invisible. The visible spectrum spans the wavelength region from about 400 to 700 nm. Light of 400 nm is seen as violet and light of 700 nm is seen as red. Wavelength ($\lambda$) is inversely proportional to frequency ($\nu$), related by the speed of light ($c$).

$$c = \lambda \nu$$

Frequency is directly proportional to energy.

$$E_{\text{photon}} = h \nu$$

Where $h = 6.626 \times 10^{-34}$ J*sec (Planck’s constant)

The table below lists the wavelengths associated with each of the colors in the visible spectrum. The representative wavelengths may be used as a benchmark for each color. For example, instead of referring to green as light in the wavelength range of 500-560 nm, we may approximate the wavelength of a green light as 520 nm. An infinite number of shades of each color may be observed.

<table>
<thead>
<tr>
<th>Representative wavelength, nm</th>
<th>Wavelength region, nm</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>650</td>
<td>650-700</td>
<td>Red</td>
</tr>
<tr>
<td>600</td>
<td>580-650</td>
<td>Orange</td>
</tr>
<tr>
<td>580</td>
<td>580-585</td>
<td>Yellow</td>
</tr>
<tr>
<td>565</td>
<td>560-580</td>
<td>Yellow-green</td>
</tr>
<tr>
<td>520</td>
<td>500-560</td>
<td>Green</td>
</tr>
<tr>
<td>490</td>
<td>480-500</td>
<td>Blue-green</td>
</tr>
<tr>
<td>470</td>
<td>425-480</td>
<td>Blue</td>
</tr>
<tr>
<td>410</td>
<td>400-425</td>
<td>Violet</td>
</tr>
</tbody>
</table>

**Salts:**

A salt is a solid ionic compound consisting of metal *cations* (positive ions) and non-metal *anions* (negative ions) bonded in a crystal structure. For example, in calcium chloride, the calcium ion is the cation, and the chloride ion is the anion. A variety of salts will be available for testing. In addition, the covalent compounds urea and sugar are available for your investigation.

**Objectives**

- Use the Bunsen burner properly.
- Understand how wavelength, frequency and energy of light are related and be able to convert between them.
- Memorize and properly use the equations $c = \lambda \nu$ and $E_{\text{photon}} = h \nu$
- Develop a testable question about a natural phenomenon.
- Design a procedure to investigate a testable question.
- Collect qualitative data in order to answer a scientific question.
- Differentiate between “data” and “results”.
Pre-Lab Questions

1. Fill in the blanks: When an atom absorbs energy, the electrons move from their _________ state to a(n) _________ state. When an atom emits energy, the electrons move from a(n) _________ state to a _________ state or the _________ state and give off _________.

2. Draw a diagram depicting the energy transitions described in #1. Be sure to label ground state, excited state, absorbing energy, giving off light (photons), and the electron. (Do not use a “Bohr model” = no rings!)

3. According to the background information, which is higher energy, violet light or red light? Support your answer with logic or calculations.

4. Circle the correct choices: In the compound sodium iodide, the sodium ion is the (cation, anion) and the iodide ion is the (cation, anion).

Investigation
Your task as a group is to come up with two testable questions about the Mystical Fire shown in the video. For example, consider things such as:

- the elements’ placements on the periodic table
- atomic masses
- cations vs. anions
- single substances vs. mixtures
- other

The question should not be too specific (What color does potassium iodide make?”) nor too broad (“What effects do all salts have on the flame?”) Write your questions below.

Testable Questions:

Once they have been approved by your teacher, choose one or two of these questions to test in the lab, keeping in mind your time constraints. About 7-8 flame tests can easily be conducted within a class period, including time for set up and clean up. Circle the question(s) you decide to test.
Note: As you experiment, you may *modify* or completely *change* your question as you make observations!

**Investigation**
- Once your instructor has approved your questions, prepare to conduct your experiments.
- Be sure to record all data in a data table. You may use data table provided *or create your own* on a separate sheet of paper. If you create your own data table note that recording, *the flame color for each of your tests is required.*
- Each group member should fill in or create their own data table. Edit the title of the data table to fully describe the data you are entering.

**Materials**
- Beakers, 250-mL
- Bunsen burner
- Lighter
- Scoopula or spatula
- Weighing boats
- Wooden splints soaked in water
- Water, distilled or deionized
- Labeling tape
- Cobalt glass (for looking at flames)
- Hand lens
- **Available Salts for testing:**
  - Calcium chloride, CaCl₂
  - Calcium sulfate, CaSO₄
  - Copper (II) chloride dihydrate, CuCl₂·2H₂O
  - Copper (II) sulfate pentahydrate, CuSO₄·5H₂O
  - Lithium chloride, LiCl
  - Magnesium chloride, MgCl₂
  - Magnesium sulfate heptahydrate, MgSO₄·7H₂O
  - Sodium bromide, NaBr
  - Sodium chloride, NaCl
  - Sodium iodide, NaI
  - Sodium sulfate, Na₂SO₄
  - Strontium chloride, SrCl₂
- **Covalent compounds**
  - Urea
  - Sugar

- Note: The “·H₂O” on the ends of some them mean that water molecules have become trapped within their crystal structures

**Safety**
- **Copper (II) chloride** is highly toxic by ingestion; avoid contact with eyes, skin, and mucous membranes.
- **Lithium chloride** is moderately toxic by ingestion and is a body tissue irritant.
- Read all labels to be familiar with the hazards involved with each chemical. Only use the amounts determined by your teacher.
- Fully extinguish the wooden splints by immersing them in a beaker of water before discarding.
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.
Always use caution around open flames. Keep flames away from flammable substances.
Always be aware of an open flame. Open flames can cause burns. Do not reach over it, tie back hair, and secure loose clothing.
Wash hands after handling materials used to prepare for or perform this experiment.

**Procedure**

**Set-up**
1. Fill a 250-mL beaker about half-full with tap water. Label this beaker “waste water”.
2. Fill a 250-mL beaker about half-full with deionized water. Label this beaker “D.I. water”.
3. Label weighing dishes with the formulas or names of the substances to be tested.
4. Obtain enough wooden splints that have been soaked in deionized water for the planned tests. Place them in the “D.I. water” beaker to continue soaking at your lab station.
5. Place one small scoopful (about the size of a jelly bean) of each solid to be tested into its weighing dish. Rinse the spatula in tap water and dry it in between touching each chemical.

**Experiment**
6. Light the Bunsen burner.
7. Dip the soaked end of one of the wooden splints into the small pile of one of the salts. A small amount of salt will stick to the wooden splint.
8. Tip the Bunsen burner slightly, and then place the wooden splint with the salts attached in the flame. *Do not allow any of the solid to fall into the barrel of the burner!* Observe and record the color of the flame. Allow the splint to burn until the color fades (unless the splint sets on fire, then stop.) If necessary, repeat the test with the same splint and additional solid. *Remember that wood burns orange.*
9. Optional: observe the flame through cobalt glass (masks the yellow color of the stick) - especially recommended for compounds containing potassium.
10. Immerse the wooden splint in the “waste water” to extinguish it and leave it in the beaker.
11. Record observations for the flame color as well as other observations pertinent to your research question in a Data Table.
12. Repeat steps 7-11 as needed.

**Cleanup**
13. Dispose of the used wooden splints in the trash can. Return unused splints to the soaking beaker.
14. Dispose of the extra solids in the trash (unless told otherwise). Do not put any solids in the sinks.
15. Wash and dry the weigh boats. Put the cleaned weigh boats next to their chemical.
16. Wipe down the countertops with damp paper towels or sponges.
17. Wash your hands with soap and water.

**Data**
<table>
<thead>
<tr>
<th>Substance</th>
<th>Color of Flame</th>
<th>Other/Observations</th>
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<tbody>
<tr>
<td>Mystical Fire (Video)</td>
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### Analysis/Results

*Report all calculated results in the **Results Table** provided.*

1. Choose a representational wavelength for each color observed and enter it into the Results Table. Choose only one wavelength. If the color seems to be on the edge of a color (such as red-orange), choose a wavelength on that side of the wavelength range. Faint lavender or light pink/silver is “violet”; deep red-pink is on the red end of the spectrum.

2. Convert each representative wavelength from nanometers to meters. Show *one* example calculation with a conversion factor and correct units *here below*:
   
   \[ (1 \text{ meter} = 1 \times 10^9 \text{ nanometers}) \]

3. Convert each representative wavelength meter to frequency \((\nu)\) in “per seconds” \((\text{sec}^{-1})\). Show *one* example calculation with a conversion factor and correct units *here*.
   
   \[ c = \lambda \nu \]
   
   \[ (c = 3.00 \times 10^8 \text{ m/s}) \]

4. Convert each frequency to energy in joules \((J)\). Show *one* example calculation with a conversion factor and correct units *here below*:
   
   \[ E = h \nu \]
   
   \[ h = 6.626 \times 10^{-34} \text{ J*sec (Planck’s constant)} \]

5. Fill in the appropriate headers for the above calculations (2, 3 and 4) in the blank headers of the columns in the Results Table.

### Results
Representative wavelengths, frequencies and energies of flame colors observed

<table>
<thead>
<tr>
<th>Substance</th>
<th>Color of Flame</th>
<th>Representative wavelength, $\lambda$ (nm)</th>
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**Conclusion**

Using *claim, evidence and reasoning*, thoroughly answer the testable question(s) that you chose using specific *data* and *results* from the lab. Discuss at least two sources of experimental error and how they each may have affected your results.