

Flame Tests - Lab 1

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Introduction

Flames tests are a form of basic spectroscopy using the naked eye to undergo a preliminary assessment of what compounds are present in a mixture. It is done by using heat to excite the electrons in the substances and when they ascend energy levels and then fall back down they release the excess energy in the form of a photon. The photon's wavelength is determined by what element is being excited.

In this test we will be testing 8 unknown aqueous metal salts using a bunsen burner to attempt to figure out which solution contains which salt. We will compare the colours seen when heating each solution to known colours produced by each salt.

The variables will be:

- The 8 Different solutions (independent)
- The colour of the flame (dependant)

Equations i will use are:

- $\Delta E = hf$
- $c = f\lambda$

Method and Equipment

Equipment:

- Bunsen Burner
- Heatproof mat
- 8 1 M Unknown metal salt solutions labelled A-H
- Matches
- Metal rod
- Beaker of 1 M HCL
- Beaker with deionised water
- Blue cobalt glass

PPE:

- Nitrile gloves
- Protective eyewear
- Lab Coat
- Any loose items/hair removed or tied back

Method:

1. Place the Bunsen Burner onto the heatproof mat, light the burner and set it to the safety (orange) flame
2. Clean the metal rod using HCL and heat it in the roaring (blue) flame of the bunsen burner, repeat until no colour is shown when heated
3. Wash the rod with DI water and then heat again to remove any HCL (repeat steps 2&3 after each metal ion sample)
4. Dip the cleaned rod into the unknown solution and then heat the rod in the roaring flame, record the colour (see Table 1), use cobalt glass to identify the mix of sodium and potassium
5. Collect results for each sample

Results

Unknown metal salt	Colour of flame	Identity of Metal	Wavelength (nm)
A	Green	Barium	490
B	Red	Strontium	700
C	Orange	Calcium	600
D	Lilac	Potassium	400
E	Yellow	Sodium	590
F	Pink/Red	Lithium	650
G	Blue/Green	Copper	480
H	Orange/Yellow	Sodium + Potassium	610

Wavelengths are estimated based on the colour of the flame and the wavelength chart given
Images of results the figure letter corresponds to the unknown salt:



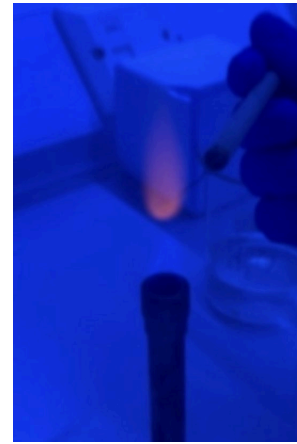
Appendix A



Appendix B



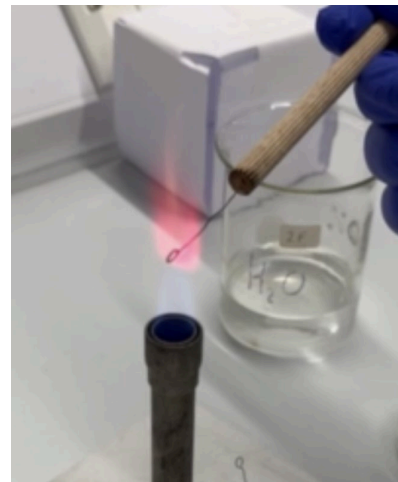
Appendix C



Appendix D



Appendix E



Appendix F



Appendix G



Appendix H

While completing the experiment we found that there was some slight disagreement over specific colours of the salts and this led to us repeating the experiment for a number of the samples. We were able to confidently identify each sample after this repetition with all 3 group members agreeing.

Discussion

The experiment showed how you can easily identify metal salts present in a compound when heating it. In the case of copper it produced a blue/green flame, seen in appendix G. I estimated the wavelength was about 480nm, using the equation $c = f\lambda$ where c is the speed of light and λ is the wavelength we can estimate the frequency to be approximately $\frac{3 \times 10^8}{4.8 \times 10^{-7}} = 6.5 \times 10^{14} \text{ Hz}$ this can then

be put into formula $\Delta E = hf$ where h is planck's constant,

$(6.5 \times 10^{14}) \times (6.63 \times 10^{-34}) = 4.31 \times 10^{-19} \text{ J}$ or 2.69 eV. Looking at sources online the values I got are quite similar to real measured values[1]. And in terms of strontium which burned a red colour with an approximate wavelength of 700nm again using the same equations we can find strontium to have a wavelength of

$\frac{3 \times 10^8}{7 \times 10^{-7}} = 4.3 \times 10^{14} \text{ Hz}$ and an energy of

$(4.3 \times 10^{14}) \times (6.63 \times 10^{-34}) = 2.85 \times 10^{-19} \text{ J}$ or 2.78 eV. This again is almost identical to the values I found[1]. The relationship of these equations are both linked to different constants being the speed of light in a vacuum and planck's constant.

The relevance of this specific experiment to OME is applications in different parts of the industry for example different compounds in flares to be used for signalling and in tracer compounds so you can follow where rounds are going no matter what the conditions are and in certain cases only with (infrared) IR vision devices [2]. It could also be used in rapid onsite/in-theatre analysis of an unknown compound to provide a rough idea of its chemical makeup and then its potential properties and how to best deal with it. It relates back to our basic scientific understanding of how waves transfer energy and how their properties impact how much energy they can transfer

The main limitation/potential source of error comes from the fact this test is subjective and does not provide any quantitative results this limits its accuracy especially when certain metal ions produce wavelengths of light that may be difficult to distinguish with the human eye or if there are multiple compounds in one mixture as seen with the sodium and potassium mix. [1]

Conclusions

The main finding of this experiment in my opinion was that flame photometry has a number of advantages and disadvantages.

Advantages:

- Cheap
- Easy
- Quick

Disadvantages:

- Not precise
- Subjective
- No quantitative data
- Being colour blind makes method unusable

So while being a good choice for some scenarios in either more complex machinery is preferred. The finding support the hypothesis of each metal ion producing a different colour flame.

Future research could potential look into the affects of the concentration of the metal salt solution and the effect on the colour of the flame and then compare the approximate wavelengths to known values discovered using more precise equipment.

References

[1] Nassau, K. (February 13 2024), "colour." Encyclopedia Britannica [online], Available: <https://www.britannica.com/science/color>.

[2] R Sadek, M Kassem, M Abdo, S Elbasuney, (March 2018), Novel blue flare tracer with enhanced color quality and luminous intensity, *journal of luminescence (online)*, vol 195 pg 8-13, Available: <https://www.sciencedirect.com/science/article/pii/S002223131730114X>

[3]