

Flame Test - Lab Report

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Introduction

This report is about a flame test carried out in class. The flame test is used to identify different metal ions by looking at the colours they produce in a flame. When different metals ions are heated, their atoms absorb energy, causing their electrons to go from a ground state to an excited state. As the electrons return to ground state, they release the previously gained energy in the form of photons of light. Each metal produces a unique colour/ wavelength, which helps us figure out which metal is present in a solution. For this flame test we were given 8 unidentified salt solutions labelled A to H. For the experiment we had to place each solution under the flame and identify the colour it produced, therefore identifying the metal ion and the wavelength. The procedure for the experiment can be seen in Appendix 2.

Hypothesis

When different metal ions are heated in a flame, they will produce a specific colour due to the way its electrons absorb and release energy in the form of photons.

Variables

- **Independent Variable:** The metal salt used.
- **Dependent Variable:** The colour of the flame produced.
- **Controlled Variables:** The flame from the Bunsen burner and the amount of metal salt used.

Equations

The energy difference of the high energy level and the low energy level is related to the frequency of emitted light.

Equation 1: $\Delta E = h \times f$

Where ΔE is the energy difference between the energy levels, h is a Planck constant ($h = 6.63 \times 10^{-34} \text{ Js}$), and f is a frequency of light in $\text{Hz (s}^{-1}\text{)}$. Frequency, f , and the wavelength, λ , are inversely proportional.

Equation 2: $c = f \times \lambda$

Where $c = 3.0 \times 10^8 \text{ ms}^{-1}$ is the constant speed of light. [Reference 1]^[1]

Results the table with the observed colours, wavelengths and metal ion IDs MUST be shown here! the key elements of the report cannot be shown in appendix.

The flame test experiment produced clear results, proving that each metal ion when heated emits a unique wavelength of light. The results from ^{this}our experiment can be seen in Appendix 3. As Shown in Appendix 3 the results show clearly different colours in the flame when heated. This was then compared to the metal ions and there corresponding colours table provided, seen in Table 1 below. From here we then compared the colours shown to the colours and wavelengths of visible electromagnetic spectrum, seen in Figure 1 below, to predict the wavelength of the colour shown in the flame.

metal ion	Flame colour	Metal ion	Flame colour
barium, Ba ²⁺	GREEN	potassium, K ⁺	LAVENDER
calcium, Ca ²⁺	ORANGE	sodium, Na ⁺	YELLOW
lithium, Li ⁺	RED/PINK	copper, Cu ²⁺	BLUE/GREEN
strontium, Sr ²⁺	RED		

Table 1 – Metal Ions and corresponding flame colours.

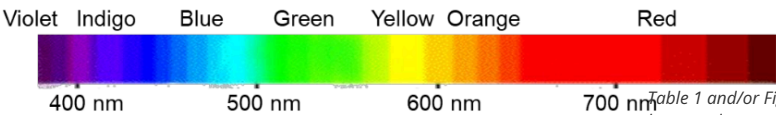


Figure 1 - Colours and wavelengths of visible electromagnetic spectrum

Table 1 and/or Fig 1 could be moved to appendix as a supporting information

By completing this experiment, and identifying the colours and wavelengths shown in Appendix 3 it confirms the idea that when the electrons from different metal ions release their energy and go from excited to ground state, they emit different wavelengths of light. The findings of the experiment enabled ^{us}to identify the metals with high accuracy and proves the hypothesis.
was it really that high :-)

Discussion

The flame test results can be used to confirm metal ions due to them producing different colours in the flame, this is significant because we can identify unknown metals with a simple flame test. From this we can also identify the wavelength of light emitted, which can be used to work out the difference between the high energy level and the low energy level.

The relationship between wavelength, frequency and energy is crucial in understanding the emitted light. Regarding strontium the frequency is calculated using Equation 2, seen below:

$f(Sr) = 3.0 \times 10^8 \text{ ms}^{-1} \text{ (Speed of light)} / 650 \times 10^{-9} = 4.62 \times 10^{14} \text{ Hz}$ sig figs!

Using the frequency above this can be used to identify the energy difference between the high energy level and the low energy level of strontium, by using Equation 1.

ΔE
Change in energy = 6.63×10^{-34} Js (Planck Constant) $\times 4.62 \times 10^{14}$ Hz = 3.06×10^{-19} J.

This shows that the energy of light with a wavelength of 650nm is 3.06×10^{-19} Joules per photon emitted.

Comparing this to Potassium:

Frequency of Potassium = 3.0×10^8 ms⁻¹ (Speed of light) / 390×10^{-9} = 7.69×10^{14} Hz.

ΔE
Change in energy = 6.63×10^{-34} Js (Planck Constant) $\times 7.69 \times 10^{14}$ Hz = 5.10×10^{-19} J.

From these results it shows that potassium has a higher frequency than strontium, it also shows that it takes 2.04×10^{-19} more Joules of energy per photon emitted from potassium than strontium. So, energy and frequency are directly proportional and inversely proportional to the wavelength.

The use for this in an OME environment is within pyrotechnics. Different metal ions produce very specific colours when burned, this is what is used in fireworks. Fireworks work by lighting the fuse, this then burns to the propellant (providing upward thrust), it then ignites the timer fuse, which sets off the burst charge, scattering the stars. These stars are made up of different metal ions that when ignited create the colours seen in fireworks [Reference 2][2]
what about flares? sodium lamp?

Another use for the flame test could be environmental science. Scientist can use the flame test to identify the presence of metal ions in soil, stone, water and even the air. This is a quick and easy way to identify metal ions present in an environment [Reference 3][3]

The main limitation for the flame test is that it is based on opinion. One person might believe the colour produced in the flame to be different from someone else. It relies on the interpretation of the person carrying out the experiment, this opens the experiment up to human error. Another limitation is contamination, between each test we had to clean off the metal wire to get rid of the last metal salt. ^(it was) We found that some metal salts were harder to clean than others, so the risk of contamination could also alter the colour produced in the flame.

Conclusions

In conclusion, the flame test confirmed that different metal ions emit different colours due to the way their electrons absorb and release energy in the form of photons. The results matched the expected colours and wavelengths. This demonstrates the relationship between change in energy, frequency and the wavelength of light seen. This results therefore support the hypothesis. For future investigations, equipment like a spectroscope could be used. This will increase the reliability of the test and provide us with the exact wavelengths emitted from the flame. Making the results more accurate, as well as providing more data [Reference 4].

References

- [1] U. Moodle, "Log in to the site | Home," *Uwtsd.ac.uk*, 2025.
<https://moodle.uwtsd.ac.uk/mod/resource/view.php?id=651174> (accessed Mar. 10, 2025).
- [2] U. Moodle, "Log in to the site | Home," *Uwtsd.ac.uk*, Feb. 14, 2024.
<https://moodle.uwtsd.ac.uk/mod/resource/view.php?id=590558> (accessed Feb. 20, 2025).
- [3] "What are some applications of flame tests in industry? Describe at least three, one of them MUST include - brainly.com," *Brainly.com*, 2020.
<https://brainly.com/question/18562328> (accessed Feb. 27, 2025).
- [4] Royal Society of Chemistry, "Flame tests using metal salts," *RSC Education*, 2015.
<https://edu.rsc.org/resources/flame-tests-using-metal-salts/1875.article>

Appendices

Appendix 1 – Materials and Equipment.

- Bunsen burner
- Heat-resistant mat
- Matches
- Metal rod
- 1 M solutions of unknown metal salts labelled A-H
- Beaker with 1 M HCL
- Beaker with deionised water (DI water)
- Blue cobalt glass

Appendix 2 – Experimental procedure.

1. Set up a Bunsen burner on the surface of the heat-resistant mat. Light it and open the air vent to obtain a non-luminous flame with two blue cones. Ensure that the safety yellow flame is on when the Bunsen burner is not in use.
2. To clean the wire, dip it into the 1M HCl and heat it in the hottest part of the flame. This step is usually repeated several times until no colour is shown. If the flame's colour changes, there is still an impurity on the wire. Dip it again in the acid and return it to the flame until the wire is clean.
3. Record the colour of the flame for DI water and 1 M HCl.
4. Dip the wire in DI water and heat as before to remove any residue of HCl from the cleaning step.
5. Cool down the wire and dip it in the solution of an unknown metal salt mixture. Heat the wire in the hot part of the flame. Record your observation of the coloured flame in the table (Appendix 3). Use the cobalt glass to identify the mixture of sodium and potassium.
6. Repeat steps 2-4 for all other unknown samples.

Appendix 3 – Observation sheet.

Unknown metal salt	Colour of the flame	Identity of metal	Wavelength
DI water	Orange	-----	-----
1 M HCl	Orange	-----	-----
A	Yellow/light Orange	Sodium	590nm
B	Lavender	Potassium	390nm
C	Orange	Calcium	620nm
D	Red	Strontium	650nm
E	Light Blue/ Green	Copper	490nm
F	Dark Pink/ Red	Lithium	640nm
G	Green	Barium	550nm
H	Starts Orange, Lavender through cobalt.	Sodium and Potassium	620nm and 400nm

all metal ions are properly identified and the wavelengths are correctly estimated

Flame Test - Lab Report

GRADEMARK REPORT

FINAL GRADE

51 /100

GENERAL COMMENTS

Engagement with Literature Skills 7/15

The report includes four sources, and IEEE formatting is mostly correct. The in-text citations are properly shown as [#], though the report unnecessarily writes "[Reference #]", which is not needed in IEEE format. References [1] and [2] are not viable (Moodle resources, lacking credibility), Reference [3] is from Brainly.com, a non-academic site, and Reference [4] is missing an access date. **Feedback:** Replace non-viable sources with peer-reviewed literature, correct referencing style, and include missing access dates for accuracy and credibility.

Knowledge and Understanding Skills 10/20

The report presents an excellent hypothesis, clear and concise, and correctly identifies variables. Emission/absorption process is clearly explained at the atomic level

Cognitive and Intellectual Skills 12/25

The fireworks application explanation is excellent but flares are not discussed as an OME application. The report includes energy and frequency calculations for two metal ions and a sound discussion of human error, including contamination and subjectivity in flame colour perception. Spectroscopy is proposed as a solution, demonstrating critical thinking. The relationship between E , f , and λ is accurately analysed. Unit of energy is missing in the equation description,.

Practical Application Skills 14/25

All metal ions are correctly identified, and wavelengths are properly estimated. Results table is clear and well-labelled, but placing it only in the appendix reduces its impact. Including it in the results section would better highlight data quality and accuracy. Some equations have unnecessary terms and missing units. Errors in sig. figs.

Feedback: Place results directly in the main body to better showcase the experiment's success and reinforce findings. Define all equation terms with units.

Transferable Skills 8/15

The report is clearly structured with relevant sections, and Comment: Additionally, references appear in the conclusion, which is not appropriate for formal reports. There are some grammar and spelling errors, and writing uses first-person language, which reduces professionalism. **Feedback:** Remove references from the conclusion, avoid first-person writing, use passive voice instead and correct language errors.

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PAGE 2

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