

Flame Test Lab Report

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Lab Report 1 – Flame Photometry Experiment

Chemistry ACDB4011

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excellent ToC; all relevant sections/subsections are included detailed, with page numbers

Section 1: Introduction

1.1 The Purpose

The purpose of this experiment was to identify different metal ions by putting them in a flame and observing a colour change. This is not a very accurate way of identifying different metal ions as it is qualitative data instead of quantitative data, meaning it is partly left to interpretation. However, this is a very quick and easy way to have a rough idea of what metal ions you are dealing with.

the purpose of qualitative analysis is very different than quantitative and by principle, flame test is perfect for identification of metal ions (not their amount)

1.2 The Hypothesis

The aim of this experiment is to see if the flame colour would change when the metal salts being placed in the flame changed.

1.3 Variables

In this experiment some of the control variables were the position the metal rod was placed in the Bunsen burner to try and achieve the same temperature for each compound and the flame intensity. The independent variable was the compound being tested. The dependant variable was the colour of the flame produced from the compound.

Section 2: Results

Unknown metal Salt	Colour of the flame – first time	Colour of the flame – second time	Identity of the metal	Wavelength	Other notes
DI water	Clear	Clear	--	--	--
1 M HCl	Clear	Clear	--	--	--
A	Very orange	Orange	Sodium	585 nm	
B	Purple / pink	Pink / orange	Potassium	390 nm	
C	Orange / red	Orange / red	Calcium	620 nm	
D	Red	Red	Strontium	730 nm	
E	Green	Green	Copper	490 nm	The solution itself was blue
F	Red / pink	Red / pink	Lithium	660 nm	
G	Green	Green	Barium	530 nm	
H	Orange	Yellow / orange	Sodium potassium	600 nm	Could see through the cobalt glass

Table 1

Unknown metal salt H was decided to be Sodium Potassium as although the flame colour was very similar to metal salt A it could also be seen through the cobalt glass meaning it was not just Sodium in the mixture as you cannot see Sodium's flame through cobalt glass, so you were witnessing Potassium's flame through the cobalt glass. Similarly, metal salts E and G

both had very similar flame colours however metal salt E's solution was blue indicating it was copper.

Section 3: Discussion

3.1 General overview

Due to the nature of this experiment, there was a lot of cross contamination, possibly hindering a few of the results. With the combination of the low molarity of HCl and time constraints cleaning the metal rod in between different compounds proved to be very difficult, so the cross contamination was very high. However, some of the results are still accurate and show how different metal compounds when heated emit distinctive colours by their electrons being excited from their ground state and this energy being turned into light as they return to their ground state.

3.2 Relationship Between Wavelength Frequency and Energy

Unknown metal Salt G was identified as Barium due to the green flame that occurred when it was placed in the Bunsen burner. The colour green has a range of wavelengths from 495 nm to 570 nm [1]. For the green that Barium emitted the wavelength was approximated to be around 530 nm.

Wavelength (λ) is inversely proportional to frequency (f) [2], shown by the equation: $c = f \times \lambda$, where c is $3.0 \times 10^8 \text{ ms}^{-1}$, the constant speed of light. A second equation, $\Delta E = h \times f$, shows the relation between frequency and energy [2]. The second equation uses the change of energy of an electron as it falls back to its ground state after being heated to establish the frequency.

what?

As the wavelength for Barium was the frequency was, $3.0 \times 10^8 \text{ ms}^{-1} / 530 \times 10^{-9} \text{ m} = 5.7 \times 10^{14} \text{ Hz}$. Then using the second equation, the change in energy can be found, $6.63 \times 10^{-34} \text{ Js} \times 5.7 \times 10^{14} \text{ Hz} = 3.8 \times 10^{-19} \text{ J}$. Similarly, this can be done for any other metal salt, for example Strontium with the wavelength of 730 nm has a frequency of $4.1 \times 10^{14} \text{ Hz}$ leading to a change of energy experienced by its electrons when they drop to their ground state of $2.7 \times 10^{-19} \text{ J}$.

3.3 Relevance to OME

The colour of any flame is related to the wavelength, as discussed above, and wavelength is related to energy with is paramount in OME. Without different material having different amounts of energy needed to initiate the start of their deflagration to detonation transition larger explosions would often not be possible [3]. They are made possible using primary explosives and secondary explosives. Primary explosives have a relatively small initiation energy compared to secondary explosives; it is the detonation of primary explosives that initiate the secondary explosive [3].

An example of coloured flame being used would be flares, they are integral to the safety of those at sea and other dangerous situations. They do not detonate only deflagrate [4] showing off a colourful flame to alert others to people's location.

Section 4: Conclusions

4.1 Summary

The experiment showed that the flame did in fact change colour with different metal salts provided the metal rod used to hold the metal salts had been thoroughly cleaned between the use of each metal salt.

4.2 Directions for Further Use

The best idea would be to repeat the experiment with more care taken to clean the metal rod to help reduce cross contamination. For future research seeing what colour would show for combinations of different metal salts in one solution would be interesting to see how the combination of the metal salts would affect the wavelength of the flame produced.

what about more advanced analytical methods such as spectrometry?

Section 5: References

- [1] A. M. Helmenstine. (2024, June. 07.) *The Visible Spectrum: Wavelengths and Colours* [Online]. Available: <https://www.thoughtco.com/understand-the-visible-spectrum-608329>
- [2] L. Sutter, M. Teel, *Wave Physics and Engineering (Concepts and Applications)*. Library Press, 2014.
- [3] Q. Tariq, "Recent advances in the synthesis and energetic properties of potassium-based potential green primary explosives" *Defence Technology*, Vol;18, Issue: 11, pages 1945 – 1959, 2022
- [4] C. Mocella, J. A. Conkling, *Chemistry of Pyrotechnics*, 3rd Edition. Boca Raton: CRC Press, 2019.

Section 6: Appendix

6.1 Materials and Methods

The materials required are:

- 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

Procedure:

1. Set up the Bunsen burner on the heat-resistant mat. Light the Bunsen burner and turn to the blue non – luminous flame. When not in use ensure the flame is turned to the yellow safety flame.
2. Clean the wire by dipping into the HCl and heating in the hottest part of the flame, repeat until no colour is shown in the flame
3. Dip the wire into the DI water and heat again to remove the residue of HCl.
4. Wait for the metal rod to cool down and place into one of the unknown salts. Place into the hottest part of the flame and record the colour. Use cobalt glass to identify sodium potassium. Clean the rod and repeat with the same salt.
5. Repeat steps 2-4.
6. Record colour of the flame for the DI water and 1 M of HCl.

6.2 Scan of the original data sheet

University of Wales Trinity Saint David – OME Programme

DATA SHEET to RECORD OBSERVATIONS, CALCULATIONS and RESULTS

STUDENT'S NAME: Pippa Shaw
PARTNERS' NAMES: Charlotte McCarrie

REPORT IS DUE MARCH 14th (21st with DO), 2025

submitted via Moodle

Observations and Identification:

Complete the table below. Based on the observed colour of the flame and Table 1, identify the metal ion in each unknown salt. Using the electromagnetic spectrum in Fig 2, estimate and report with the appropriate unit the wavelength for each observed colour. Identify the solution containing mixture of sodium and potassium:

Unknown metal salt	Colour of the flame		Identity of metal	Wavelength
DI water	clear	clear	-----	-----
1 M HCl	clear	clear	-----	-----
A	very orange	orange/carmine blue/black	~~Sodium~~ Sodium	585nm
B	Purple to pink deep orange	pink/orange	potassium	390nm
C	orange/red	orange/red	calcium	620nm
D	red	red	Strontium	730nm
Blue solution E	green	green	Copper	490nm
F	red/pink	red/pink	Lithium	660nm
G	green	green	Barium	530nm
H	orange	orange can see in glass	Sodium potassium	600nm

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Flame Test Lab Report

GRADEMARK REPORT

FINAL GRADE

58/100

GENERAL COMMENTS

Engagement with Literature Skills 10/15

The report uses a good mix of literature, including a peer-reviewed article on explosives, a textbook, and credible online sources. All references are formatted using correct IEEE style. The number of sources is limited, and the OME section would benefit from deeper literature integration, especially regarding flame emission applications.

Feedback: Expand literature to include more peer-reviewed sources and support more sections with citations, particularly in the discussion.

Knowledge and Understanding Skills 11/20

The aim, hypothesis, and variables are correctly stated and relevant. The report recognises the qualitative nature of flame tests, highlighting their role in metal ion identification. However, the absorption-emission process is not explained at the atomic level (i.e., no mention of electron orbitals or quantum transitions), and Table 1 lacks a title, reducing clarity.

Feedback: Explain electron transitions in atomic terms and ensure all tables are titled for clarity and completeness.

Cognitive and Intellectual Skills 13/25

The report includes accurate calculations relating wavelength, frequency, and energy for two metals (Barium and Strontium), demonstrating strong understanding. However, the discussion on deflagration to detonation, while interesting, is not directly connected to the flame test, and more advanced analytical methods like spectrometry are not considered.

Feedback: Better tie OME discussion to the experiment and mention advanced techniques (e.g., spectroscopy) for enhanced analysis and comparison.

Practical Application Skills 15/25

Metal salts are mostly identified correctly, and Barium and Copper are well distinguished using solution colour and cobalt glass. The procedure is clear, and the original data sheet is attached, enhancing transparency.

Minor issue: Some cross-contamination is noted, and wavelength estimations are approximate, though reasonably accurate.

Feedback: Ensure cleaner technique to reduce contamination, and where possible, reference known spectral values for greater precision.

Transferable Skills 9/15

The report is well-structured, with a detailed Table of Contents including page numbers and all relevant sections. Language is generally formal.

However, occasional first-person writing is used, which is unsuitable for formal lab reports, and some phrasing could be more concise.
Feedback: Use passive voice throughout for professional tone, and refine phrasing for clarity.

PAGE 1

PAGE 2

Text Comment. excellent ToC; all relevant sections/subsections are included detailed, with page numbers

PAGE 3

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PAGE 4

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PAGE 5

Text Comment. what about more advanced analytical methods such as spectrometry?

PAGE 6
