



Ordinance, Munitions and Explosives

HNC

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Flame Test Lab Report

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(NB. Remove if the degree award is based solely on examination of the thesis)

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Abstract

This report is an evaluation of the results obtained during undergoing a flame experiment. The results are then interpreted and their significance explained. The experiments link to Ordinance, Munitions and Explosives. As well as the limitations experienced during the practical.

1 Introduction

1.1 Objectives of the Experiment

The purpose of this experiment is to determine the presence of certain metals within different metal salt solutions. This will be done by dipping a nichrome wire inside each solution and holding the wire above a Bunsen burner to produce a coloured flame. The presence of certain metals inside these solutions can be determined by the colour of the flame.

1.2 Hypothesis

The hypothesis that was brought forward before the experiment was that each solution would produce a flame with a different colour that would be different from the rest.

1.3 Variables

The variables in this experiment are the colour of the flame (dependent), the salt solution (independent) and the nichrome wire (control).

1.3.1 Dependent

The colour of the flame is our dependent variable as this is what is being measured. The colour is dependent on the metal ion present in the solution being tested.

1.3.2 Independent

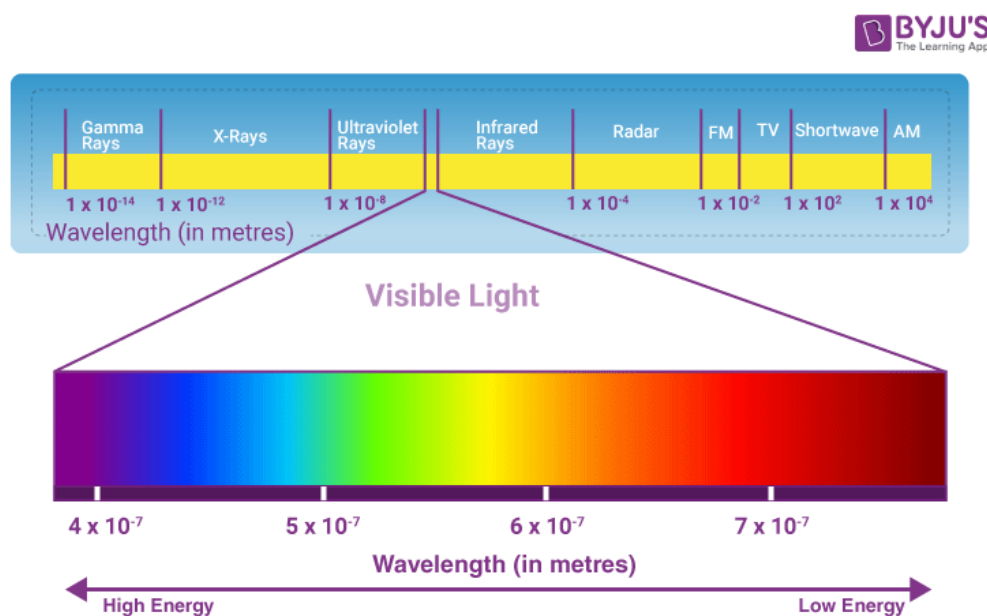
The solutions are our independent variable due to each of the solutions being different. It is also not affected by other variables.

1.3.3 Control

The Nichrome wire is our control variable. This is because we are not changing the Nichrome wire at all during the experiment, it is only being cleaned after each solution test.

2 Results

After testing each solution, we also determined what wavelength the colours correlate to on the electromagnetic spectrum (as seen below).



[1]

2.1 Experimental Data

The data that was collected has been arranged in the table below.

Metal salt	Colour of flame	Metal detected	Wavelength
A	Yellow/orange	Sodium	600nm
B	Lavender	Potassium	400nm
C	Red/orange	Calcium	620nm
D	Red	Strontium	700nm
E	Blue/green	Copper	490nm
F	Red/pink	Lithium	780nm
G	Yellow/green	Barium	560nm
H	Orange(purple through cobalt)	Sodium, Potassium	620nm, 390nm

2.1.1 Key Findings

As showcased by the table above, the colour orange was viewed when testing multiple solutions. At first, this result could suggest that Sodium was in each of the solutions; however, this is false and a more probable explanation could be Sodium contamination. Despite the Nichrome wire being cleaned between each test, it is likely that Sodium was still present on the wire giving rise to an “unexpected” orange flame. The fact that this unforeseen colour was observed in numerous tests suggests that contamination affected the reliability of our results.

3 Discussion

3.1 How Significant are the Results?

Throughout our experiment, the testing of each solution was only done once which increases the probability of random error skewing the results. This could be reduced by doing the full experiment several times and comparing the results with online data books. Repeating the experiment also allows for easier identification of anomalies resulting in our findings being more reliable. Furthermore, our dependent variable could relay a difference due to chance and so statistical analysis would be required. The issue with this is that qualitative data is hard to process and so a more quantitative approach would be more suitable for metal analysis. If quantitative data were to be collected, this would involve using "Colour specification" via spectrophotometry to determine the metals in each solution. "Color specification is a means of expressing color quantitatively" [2]. After calculating the absorbance, the metal within each solution would become certain after cross-examination with data books and peers. The results from this method would also be easier to statistically analyse as the data would be quantified making it easy to determine whether chance affected the conclusion. Peer reviewing our results would also make it simple to check the repeatability of our experiment and identify any bias in our procedure. Overall, it is evident that our results are insignificant as they are subject to random error and no statistical analysis gives a lack of insight into the effects of chance.

Calculations were done on two metals: Potassium and Lithium. These can be seen below.

Equations used:

$$\lambda = \frac{c}{f}$$

$$E = hf$$

f = frequency
 c = Speed of light
(3×10^8)

v = frequency
 h = Planck's constant
 E = energy

λ = wavelength

Potassium

$$f = \frac{3 \times 10^8}{400 \times 10^{-9}}$$

$$\text{Frequency} = 7.88 \times 10^{14} \text{ Hz}$$

$$E = 6.626 \times 10^{-34} \times 7.88 \times 10^{14}$$

$$\text{Energy} = 5.22 \times 10^{-19} \text{ J (3 s.f.)}$$

Lithium

$$f = \frac{3 \times 10^8}{780 \times 10^{-9}}$$

$$\text{Frequency} = 3.85 \times 10^{14} \text{ Hz}$$

$$E = 6.626 \times 10^{-34} \times 3.85 \times 10^{14}$$

$$\text{Energy} = 2.55 \times 10^{-19} \text{ J (3 s.f.)}$$

During these calculations, the speed of the wave was assumed to be the speed of light as a flame is a form of light. Comparing the energies, the slight increase from 400nm with the Potassium to 780nm with the Lithium causes the energy to drop dramatically. This is because the wavelength and the frequency are inversely proportional as the speed of light is a constant.

3.1.1 Relevance to Ordinance, Munitions and Explosives

The experiment is relevant to Ordinance, Munitions and Explosives (OME) as coloured flames can be utilized in many ways. Flares, smoke grenades and tracers can all come in different colours. These are all used in a passive manner within the Defence industry however they could be utilized offensively as well. Flare guns, for example, are used in various ways but are mainly used for signalling. Flare guns could also be used to inflict pain. There have been many cases of flare guns causing burn injuries (an example [3]). The phenomenon seen during this practical can also be seen frequently within OME. The 120mm High Explosive Squash Head (HESH) round uses red tracers to easily trace the path of the shot. This can then be used in calculations if need be.

3.2 Limitations

The limitations that were encountered during the practical was that one member of the team was colourblind. This caused a minor problem as this member could not observe the flame colour or give a second opinion on the colour being tested. This was quickly resolved by switching the roles of the team members but this could've affected the accuracy of the results. This is because the results were determined by one person's observation. This increases the chance of human error affecting the results and hence their credibility.

4 Conclusions

4.1 Practical Conclusion

The results obtained during this experiment provide evidence for a review of the method undertaken. If the experiment was to be done again, there would be an unused Nichrome wire for each solution being tested. This would be done to prevent Sodium contamination on the wire. The hypothesis made before the experiment was that each of the solutions would produce a different coloured flame that was easily distinguishable from the others. This was proven to be false due to the sodium contamination of the Nichrome wire which resulted in some solutions showing a very similar coloured flame.

4.1.1 Future Research

Based on the observations made during this experiment, future tests should be centred on a method that wouldn't be subjected to sodium contamination. If the experiment were to be done again, the quantitative approach would result in more credible observations. Statistical analysis could be introduced to increase the accuracy of the result and make a causal relationship easier to establish.

References

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- [3] J.H.Stevenson. H.G. Thomson. (1984), *Burn injury to the face with associated fracture caused by a flare gun: a case report* [online]. Available: [PII: 0007-1226\(84\)90044-4 \(jprasurg.com\)](https://pubmed.ncbi.nlm.nih.gov/1226(84)90044-4/). (accessed on 25/06/2024)

Appendices

The materials used in this experiment were:

- Hydrochloric acid solution (HCL)
- Barium chloride
- Calcium chloride
- Lithium chloride
- Strontium chloride
- Strontium nitrate
- Potassium chloride
- Potassium nitrate
- Sodium chloride
- Copper chloride

The equipment that was used was:

- Bunsen burner
- Heat-resistant mat
- Matches
- Nichrome wire
- 1 M solutions of unknown metal salts labelled A-H
- Beaker with 1 M HCL
- Beaker with deionised water
- Blue cobalt glass

The procedure undertaken was:

1. The Bunsen burner was placed on a heat-resistant mat. It was then lit and the air vent was opened to attain a non-luminous flame.
2. The wire was then dipped into the HCL and heated by the flame. This was done to clean the wire. This step is repeated until no colour was shown.
3. The wire was then dipped into the deionised water. This was done to cleanse the wire of any HCL.
4. Steps 2 and 3 were repeated between testing each solution.

5. The wire was then dipped into an unknown solution. It was then heated and the colour of the flame produced was observed. The cobalt glass was used to identify a sodium and potassium mixture.
6. The observations were then recorded.