**Title: Must include the dependent and independent variable, must be specific.**

**Introduction**

Start with a few sentences on your personal interest in this investigation. Give the necessary background including information such as chemical equations with state symbols to understand the investigation. Communicate very clearly to your peers. Include any research to show what value is expected or what your slight change will be to previous research. Reference all you information. Include research into alternative methods and why you chose the method you did.

**Research questions**

1. State the questions you hope this study will answer

2. Can be more than one, number them.

**Variables**

|  |  |  |
| --- | --- | --- |
| Independent Variable: | Write the variable you will change here | Minimum range of 5. Each increment value must be listed. What was the instrument used to measure these increments. What was the range and uncertainty of this instrument. Units. |

|  |  |  |
| --- | --- | --- |
| Dependent Variable: | Write the variable you will measure here | How was it measured. What was the instrument used to measure this. What was the range, uncertainty, and units of the instrument. |

|  |  |  |
| --- | --- | --- |
| Controlled Variables: | Write all the variables that are important to control. | Give exact values to show you know they are controlled. Give the instrument used to measure this control. Include range, uncertainty, and units of this instrument. |
|  |  |  |
|  |  |  |
|  | State the room temperature, pressure and humidity. |  |

**Materials**

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **Quantity**  **measured** | **Absolute**  **uncertainty** | **Percentage**  **uncertainty** |
| Graduated pipette 10.0cm3 | 5.00cm3 | ±0.05cm3 | 0.01% |
| Copper sulphate crystals (99.9% CuSO4.5H2O) | 5.00g | ±0.01g | 0.002% |
| Stirring rod | 1 | - | - |
|  |  |  |  |

Use the smallest quantity measured, and so always use the largest uncertainties for your uncertainty propagation calculations.

**Safety**

Preferably use CLEAPPS, otherwise search for MSDS. List the chemicals you find dangerous with the intended concentration, their dangers, disposal and specific safety precautions. Include any relevant ethical or environmental considerations.

**Method**

Number the steps with explanations as necessary. Include a labelled photo.

**Results**

Minimum range of 5 and repetition of 3. Aim for just one table.

|  |  |  |
| --- | --- | --- |
| **Independent variable**  **(± 0.5⁰C)** | **Dependent variable (± 0.5⁰C)→** | |
| ↓ | 0.051 | Wrong, as doesn’t match increments of 0.5  Should be 0.0 |
|  | 5 | Wrong as it should be to one decimal place as in the uncertainty of 0.5, should be 5.0 |
|  | 1.0 |  |
|  | 2.0 | Wrong – if all the values are in increments of 1. Why are there not any 1.5, or 2.5? Is the real uncertainty 1 and not 0.5? |

Qualitative Observations:

You must give qualitative observations to supplement the quantitative data.

**Data analysis:**

Example calculation must have uncertainty propagation (or the halfway method if this is bigger) and comparison to literature value (percentage error calculation).

Calculations must be clear (formula, substitution, units) with relevant assumptions and explanations given, and have full uncertainty propagation (random error). Calculations are complete once percentage error is complete (systematic error). Reference the published value.

Graph must have labelling, units, uncertainties, error bars, line of best fit, clear grid lines, axis with the correct significant figures, and relevant annotations.

**Discussion**

Paragraph 1: State the actual value or result. Explain the relationship of the graph using scientific theory where appropriate. Discuss the closeness of the result to the expected result. Discuss if the error was more due to random error (uncertainty propagation) or systematic error (percentage uncertainty).

Paragraph 2: **Anomalous results** – discuss the data itself, focussing on the points that don’t fit on the line of best fit. Discuss the degree to which the **random error** contributed to the uncertainty. Discuss the degree to which the **systematic error** contributed to the percentage error. You must have the words in bold actually in the paragraph.

**Evaluation**

Have minimum of four of the most significant errors.

|  |  |  |  |
| --- | --- | --- | --- |
| **Error and explanation** | **Type of error** | **Effect on the calculated final result** | **Solution** |
|  | Random  or  Systematic | What will this do to the calculations? High, low or just increased uncertainty. |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Conclusion**

Answer the research questions

**Further investigations**

Suggest other experiments that could be done to enhance or further extend what you have done.

**References**

A proper reference has the authors, dates, title, journal name, volume and pages. Use a proper referencing system.

**Appendix**

Report should not go over 12 pages. If it does make sure it is just the reference and appendix section.