Data Collection

Quantitative Data

Table 1: *data collected during the experiment*

Mass of Basin ± 0.01g	Mass of basin + unknown A, before heating ±0.02g	Mass after 1st heating of basin + unknown A ± 0.02g	Mass after 2nd heating of basin + unknown A ± 0.02g	Mass after 3rd heating of basin + unknown A ± 0.02g
46.76g	49.77g	48.77g	48.74g	~

Qualitative Data

On heat for 1-5 mins

there were smoke coming from the crystal sample in the basin, this may suggest that evaporation may be taken place. When the beaker was placed on top of the basin water droplets were formed on the beaker, showing condensation. Both these observations show that the hot plate has been effectively used that is to remove water from the substance Unknown **A**.

Without beaker covering

Unknown crystal substance turns colour from blue to lighter blue, this change shows that the process of removing water is active and that it can be physically observed.

Few mins later

Unknown substance **A** has turned colour again but this time from pale blue to grey. **A**fter 10 mins without beaker covering on the hot plate the mass was then measured it was observed that the mass of basin + unknown **A** has decreased.

After heating

After the 1st heating the substance was observed again, most of the crystals have changed into the colour grey/white. The assumption of these transformations in colour is that the dry substance of unknown **A** is grey/white and that the blue colour shows that water may be present. **A**fter the second heating the mass was weighed, once again the mass had decrease. Therefore it can be concluded that after the 1st heating not all of the water were removed from the substance.

Data Processing

Table 2: ***Processed data, gathered from the raw data in Table 1.***

	Before Heating	**After 1st heating**	**After 2nd Heating**
Mass of basin + Unknown A ± 0.02g	49.77	48.77	48.74
Mass of Basin ± 0.01g	46.76	46.76	46.76
Mass of Unknown A	3.01 ± 0.030g	2.01 ± 0.030g	1.98 ± 0.070g
Mass of water in Unknown A ± 0.04g	~	1.00	1.03
Final Mass of Water in Unknown A ± 0.04g	~	~	1.03
Final Mass of Unknown A ± 0.07g	~	~	1.98

Note: [illegible]

Calculation, to find the mass of unknown A

$$(Mass\ of\ Basin\ and\ Unknown\ A) - Mass\ of\ Basin = Unknown\ A$$

$$(49.77 \pm 0.020g) - (46.76 \pm 0.010g) = Unknown\ A$$

$$(49.77 - 46.76) \pm (0.020g + 0.010g) = Unknown\ A$$

$$3.010 \pm 0.030g = Unknown\ A$$

*Note: after 1st heating , Calculations procedures are exactly the same as for <**Calculation, to find the mass of unknown A**>.*

Calculation, to find the final mass of unknown A

$$(Mass\ of\ Basin\ and\ Unknown\ A) - (mass\ after\ 2nd\ heating\ of\ Basin\ and\ Unknown\ A) = final\ mass\ of\ Unknown\ A$$

$$[[49.77 - (49.77 - 46.76)] - 46.76] \pm (0.02g + 0.04g + 0.01g) = Unknown\ A$$

$$1.98 \pm 0.07g = final\ mass\ of\ Unknown\ A$$

Calculation, to find the mass of water in unknown A

$$(Mass\ of\ Basin\ and\ Unknown\ A) - (Mass\ after\ 1st\ heating\ of\ Basin) = mass\ of\ water\ in\ Unknown\ A$$

$$(49.77 \pm 0.02g) - (48.77 \pm 0.02g) = mass\ of\ water\ in\ Unknown\ A$$

$$(49.77 - 48.77) \pm (0.02g + 0.02g) = massof\ water\ in\ Unknown\ A$$

$$1.00 \pm 0.04g = mass\ of\ water\ in\ Unknown\ A$$

*Note: after 2nd heating, calculations procedures are exactly the same as for <**Calculation, to find the mass of water in unknown A**>. This is also the answer (49.77-48.74 =1.03) to (a) on the practical sheet <calculate the mass of water in the hydrate>see table 2 for the answer and the uncertainty.*

Finding the ratio of the anhydrous compound and the hydrate

$$xCuSO_4.yH_2O \rightarrow xCuSO_4 + yH_2O$$

Mass from the experiment ⇒ $3.01 \pm 0.030g$ $1.98 \pm 0.070g$ $1.03 \pm 0.040g$

to find x and y convert the products into moles…

	$CuSO_4$	H_2O
Molar mass $(g\ mol^{-1})$ ⇒	$(63.55 + 32.06 + 64)$	$(2.01 + 16)$
$< \frac{mass\ (g)}{Molar\ Mass\ (g\ mol^{-1})} >$		
moles (n) ⇒	$\frac{1.98 \pm 0.070g}{(63.55+32.06+64)}$	$\frac{1.03 \pm 0.040g}{(2.01+16)}$
	$= \frac{1.98}{159.61} \pm \left(\frac{0.070}{1.98} \times 100\right)\%$	$\frac{1.03}{18.02} \pm \left(\frac{0.040}{1.03} \times 100\right)\%$
	$= 0.0124 \pm 3.54\%$	$= 0.0572 \pm 3.88\%$
	$x \approx 0.0124 \pm 0.000448$ mols	$y \approx 0.0572 \pm 0.00222$ mols

$\therefore$ *the ratio is* ⇒ $0.0124 \pm 0.000448 : 0.0572 \pm 0.00222$

simplified to integers ⇒ $\frac{0.0124 \pm 0.000448}{0.0124 \pm 0.000448} : \frac{0.0572 \pm 0.00222}{0.0124 \pm 0.000448}$

- $\langle \frac{0.0124}{0.0124} \pm 2\left(\frac{0.000448}{0.0124} \times 100\right)\% \rangle : \langle \frac{0.0572}{0.0124} \pm \left[\left(\frac{0.000448}{0.0124} \times 100\right) + \left(\frac{0.00222}{0.0572} \times 100\right)\right]\% \rangle$
- $1 \pm 7.23\% : 4.62 \pm 7.49\%$

= $1 \pm 0.0723 : 4.62 \pm 0.346$

Simplest *ratio* $\approx 1 : 4.62$

This means that for every 1 mole of copper sulphate there will be 4.62 moles of water molecule. As it impossible to have fraction of a molecule it is therefore rounded up to 5. Hence the empirical formula for copper sulphate hydrate from the experiment is $(1)CuSO_4.5H_2O$.

Finding the percentage of water in the sample

$$\%water\ in\ sample = \frac{mass\ of\ water(g)}{total\ mass\ of\ the\ sample(g)} \times 100$$

$$= \frac{1.03 \pm 0.04}{3.01 \pm 0.03} \times 100$$

$$= \left(\frac{1.03}{3.01} \times 100\right) \pm \left[\left(\frac{0.04}{1.03} \times 100\right) + \left(\frac{0.03}{3.01} \times 100\right)\right]\%$$

$$= 34.22\% \pm 4.88\%$$

Finding the percentage of water from the theoretical formula

$$\%water\ in\ sample = \frac{Molar\ mass\ of\ water(g\ mol^{-1})}{Molar\ mass\ of\ CuSO_4.\ 5H_2O(g\ mol^{-1})} \times 100$$

$$= \frac{90.1}{249.71} \times 100$$

$$= 36.08\%$$

Discrepancy of the, experimental and theoretical value…

$$= (36.08\%) - (34.22\% \pm 4.88\%)$$

$$= 1.86\% \% \pm 4.88\%$$

From the calculations of the percentages of water contained in either the sample or the theoretical formula both percentage are of similar value, that is only $1.86\% \% \pm 4.88\%$ difference, this can also justify that the experimental value are fairly accurate.

CONCLUSION

It is evident in table 1 that the *mass of basin + unknown* is constantly declining, suggesting that evaporation of water is occurring. Hence through calculations the loss of water can be obtained, this then allows the value of x and y in the compound i.e. x $CuSO_4$.y H_2O to be found. The aim of this was achieved as shown in the data processing aspect (see *finding the ratio of the anhydrous compound and the hydrate*, *finding the percentage of water in the sample*, *finding the percentage of water from the theoretical formula*) the conclusion is that the experimental value of the number of moles obtained was in fact similar to that of the theoretical ratio. This is evident in the calculations above "Finding the ratio of

the anhydrous compound and the hydrate". When comparing the experimental value ($1:4.62 \pm 0.346$) the ratio and the uncertainty range of it, did not lie within the [1]literature value (1:5). However as is it impossible to have a fraction of a molecule it is therefore rounded up to 5, where the ratio of the experimental value is now 1:5. Under these experimental conditions there is no significance difference in relation to the number of moles of water per 1 mole of copper sulphate. The error between the % water in the sample and the %water obtained from the formula is about$0\%\sim6.74\%$, this allows the experimental value to be justified as fairly accurate. Overall the experiment conducted helped support the literature value of having a ratio of 1:5 that is 1 molecule of $CuSO_4$ can hold 5 moles of water molecules that are withheld inside the crystal structure, in which removal of them are allowed(via energy e.g. heat). In addition the purpose for obtaining the molar ratio and the percentage composition of any hydrate allows scientists to determine the number of moles of water molecules that the hydrate compound holds, per 1 anhydrous molecule.

Percentage yield/error

$$percentage\ error = \frac{theoretical\ value - experimental\ value}{theoretical\ value} \times 100$$

$$= \frac{5-(4.62\pm0.346)}{5} \times 100$$

$$= \frac{5-4.62}{5} \times 100 \pm 7.49\%$$

$$= 7.6\% \pm 7.49\%$$

$$\therefore the\ percentage\ error\ is\ between\ 0.11\% - 15.09\%$$

As it is shown in the percentage yield/error calculated is between 0.11% ~ 15.09%. Although the percentage error is minor, errors during the experiment could have altered this. (More details in Evaluation) In addition, the theoretical value did not fit within the calculated uncertainty range. As a result major faults during the experiment may have occurred.

Reference:

The literature value of $CuSO_4 . 5H_2O$ is given by the teacher, the website below also has the same literature value:

C[illegible]S [illegible] (C[illegible]SO4.5H2O) [illegible] 98.3%(C[illegible]25%), [illegible]999-2009 [illegible].com, [illegible]://www.[illegible].com/[illegible] [illegible]/2037[illegible]82[illegible]/C[illegible]S[illegible]_C[illegible]SO4_5H2O_[illegible] viewed 2[illegible]02-09

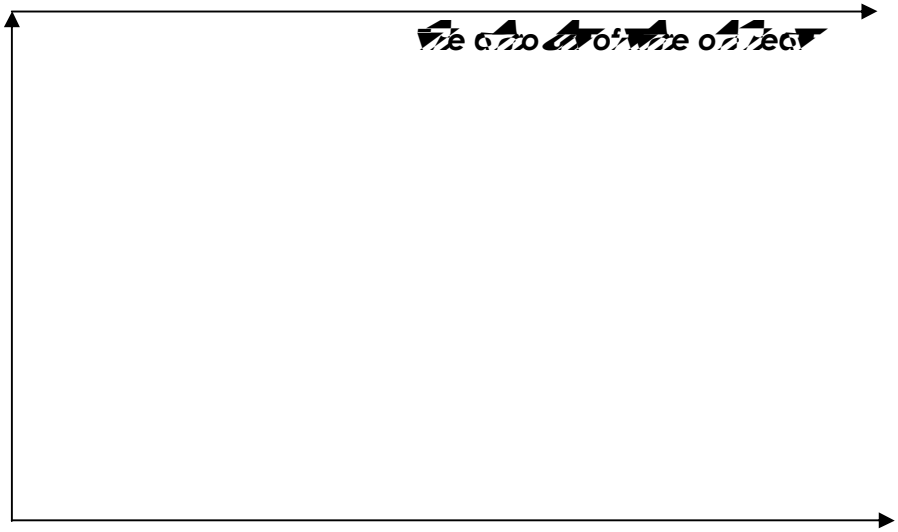
EVALUATION

Although the percentage difference in the final result was not very large. There is however still errors that could have caused a percentage difference between the literature value and the experimental value to occur, during the experiment. Thus in order to gain a better result the table below must be taken into account when doing the experiment next time.

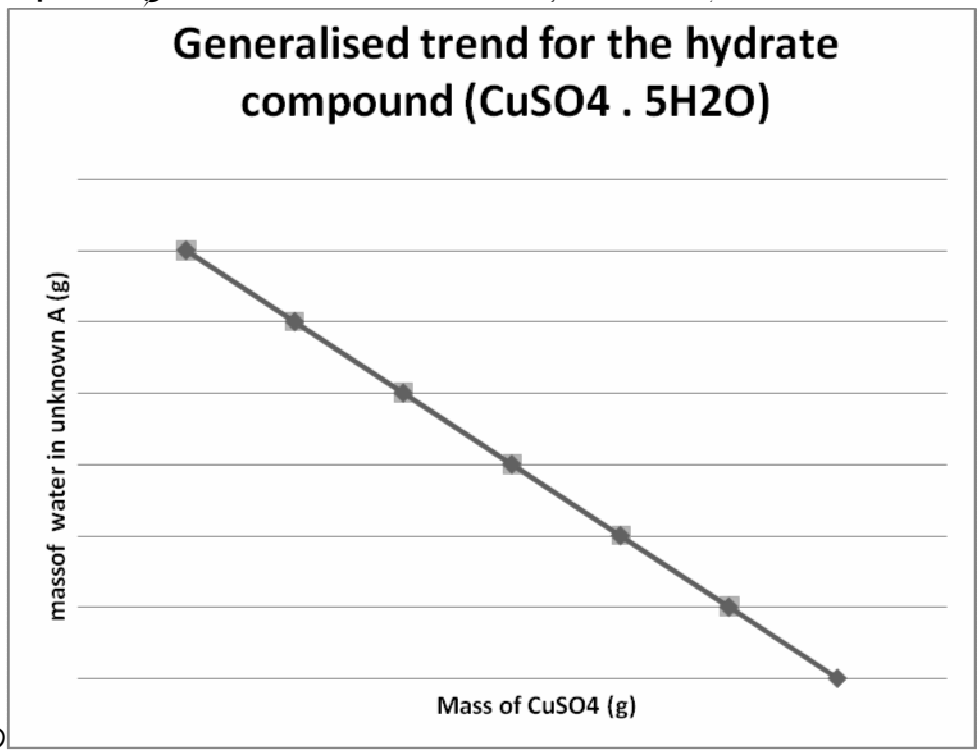
List of errors	Impact on experimental results and the implications	Improvement
The crystals were not completely dehydrated	The mass of the anhydrous may be altered. As a result the calculations to find the molar ratio of the experimental value may slightly differ.	Make sure sufficient time is available. Or that the heating surface area of the Copper sulphate hydrate could be increased. Or continue to heat the basin and weigh it regularly until the mass value on the electronic balance agrees within 0.02g with the previous mass reading.
The tongs that may have influenced the mass of the overall mass of basin + unknown A	When the experiment was carried out, due to the hot plate it had melted part of the tongs plastic rubber. This melting substance was left on the basin as a residue while weighing it on the electronic substance. Therefore there may be a possibility that the mass of the overall apparatus was affected.	Use a tong that is resistance to heat.
The amount of time available for this prac.	When this prac was conducted in sufficient time caused the experiment to be unable to complete the experiment. This may have influence the data collected as there may be still some water remaining in the anhydrous. .	Allow plenty of time to finish the prac; if it impacts on the calculations later, it is possible for the groups to continue through lunch time until the practical is complete.
Mis-calibrated balances or other electronics. (systematic error)	During the experiment the electronic balance was used to measure the mass of the evaporating basin and the compound. If the electronics were not properly calibrated it will cause all the measurement to be incorrect. For example it may be consistently reading too low or too	Weigh the evaporation basin and the compound with other electronic balances to double check if the balance have problems and obtain an average from the different weight measurements from the balances used. OR just make sure that everything is calibrated properly

	high. Thus the calculations later may be affected	before beginning to use.
The experiment was only done once	The accuracy of the practical may be an issue. Hence unable to process values for the mean, standard deviation and statistical analysis	Perform more trials and obtain a closer value to theoretical. Repeating measurements until consistent results are obtained (within 1%)
The amount of desiccants in the desiccators	If insufficient desiccants are available in the desiccator, or that the amount of time the anhydrous compound was left inside can alter the final weighing of the basin + unknown **A**. **A**s a result not all water molecules are completely removed.	Make sure that procedures are followed properly. **A**llow adequate time to complete the experimental procedures. **A**dd more desiccants to the desiccators if not enough is available.
The temperature the hot plate was set to.	Over heating of the $CuSO_4.5H_2O$ may cause contamination with oxygen hence altering the mass present in the basin. Similarly under heating to isolate the $CuSO_4$ may be difficult to achieve, as evaporation ongoing may be ineffective/slow.	Set the heating to an appropriate temperature where the hydrate will not be burnt or still have water remains.
Environment the experiment was conducted	**A**s copper sulphate is hydrophilic, absorption of moisture from the atmosphere will occur, which also may change the mass of the hydrate.	Ensure that the atmosphere/ environment where the experiment is taken place is a dry, well-aired laboratory etc. E.g., don't do the experiment on a rainy day/ cloudy day etc.

Appendix



Graph 1: *Generalised trends for the hydrate compound $CuSO_4 \cdot 5H_2O$.*



- As the amount of time increases the mass of water in unknown A decreases.
- As mass of copper sulphate increase the mass of water in unknown is decreased