SCH3U3 Period # 2 / Room 311

“Copper(II) Sulphate”

Given: Oct. 30, 2019
Due: Nov. 1, 2019

Lab Partners:
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Purpose:

To find the empirical formula of copper(II) sulphate hydrate, its mass can be compared with its mass after evaporating the water within the copper(II) sulphate hydrate.

Materials:

Please refer to the lab sheet "Copper(II) Sulphate Lab"

Procedure:

Please refer to the lab sheet "Copper(II) Sulphate Lab"

Observations:

For Calculations, refer to "Calculations" underneath the observation time

Crucible Mass	27.479grams
Initial Mass of copper(II) sulphate hydrate	1.002grams
Final Mass of copper(II) sulphate	0.620 grams
Mass of Water (Difference)	0.382 grams
Moles of Water	2.1204×10^{-2}mol
Moles of copper(II) sulphate	3.88×10^{-3}mol
Empirical Formula	$CuSO_4 \bullet 5H_2O$
Colour of crystal	Light blue

Table 1.1

Calculations:

Crucible mass and the initial mass of copper(II) sulphate were measured at the beginning of the experiment and can be thought of as given.

$$Final\ Mass\ of\ copper(II)\ sulphate\ = Mass\ of\ crucible\ with\ copper(II)\ sulphate\ hydrate\ - \ Crucible\ Mass$$
$$Final\ Mass\ of\ copper(II)\ sulphate\ = 28.099\ grams\ - \ 27.479\ grams$$
$$Final\ Mass\ of\ copper(II)\ sulphate\ = 0.620\ grams$$

$$Mass\ of\ Water\ = Initial\ Mass\ of\ copper(II)\ sulphate\ hydrate\ - \ Final\ Mass\ of\ copper(II)\ sulphate$$
$$Mass\ of\ Water\ = 1.002\ grams\ - \ 0.620\ grams$$
$$Mass\ of\ Water\ = 0.382\ grams$$

$$Moles\ of\ Water\ = \frac{Mass\ of\ Water}{Atomic\ Mass\ of\ Water}$$
$$Moles\ of\ Water\ = \frac{0.382}{2*1.008 + 15.999}$$
$$Moles\ of\ Water\ = 2.1204 \times 10^{-2}\ mol$$

$$Moles\ of\ copper(II)\ sulphate\ = \frac{Mass\ of\ copper(II)\ sulphate}{Atomic\ Mass\ of\ copper(II)\ sulphate}$$
$$Moles\ of\ copper(II)\ sulphate\ = \frac{0.620}{63.546 + 32.06 + 4\times15.999}$$
$$Moles\ of\ copper(II)\ sulphate\ = 0.00388$$
$$Moles\ of\ copper(II)\ sulphate\ = 3.88\ \times 10^{-3}\ mol$$

$$Empirical\ Formula\ = Moles\ of\ copper(II)\ sulphate : Moles\ of\ water$$
$$Empirical\ Formula\ = 3.88\ \times 10^{-3} : 2.1204\ \times 10^{-2}$$
$$Empirical\ Formula\ = 1 :\ 5.465$$
$$Empirical\ Formula\ \simeq 1 : 5$$
$$Empirical\ Formula\ =\ CuSO_4 \bullet 5H_2O$$

Analysis:

1. In this lab experiment, how did you know when to stop the reaction?

Once the difference between the previous mass recorded and the current mass recorded of the copper(II) sulphate became very small, the amount of water that remained in the copper(II) sulphate also decreased, yielding the highest possible amount of copper(II) sulphate that can be obtained. Moreover, the very small differences between the previous and current masses recorded of copper(II) sulphate imply that repeating the process will not yield a substantially higher amount of copper(II) sulphate.

2. Was your value for the number of waters for each copper (II) sulphate a whole number? Talk about why or why not. Show your work

The value for the number of water molecules for each copper(II) sulphate was found by reducing the original ratio between the moles of copper(II) sulphate and moles of water:

$$Empirical\ Formula\ = Moles\ of\ copper(II)\ sulphate : Moles\ of\ water$$
$$Empirical\ Formula\ = 3.88\ \times 10^{-3} : 2.1204\ \times 10^{-2}$$
$$Empirical\ Formula\ = 1 :\ 5.465$$
$$Empirical\ Formula\ \simeq 1 : 5$$
$$Empirical\ Formula\ =\ CuSO_4 \bullet 5H_2O$$

The value of water molecules for each copper(II) sulphate molecule was calculated to be 5.465, which was rounded to yield the empirical formula. The difference between the experimentally found value of water molecules per copper(II) sulphate molecule, 5.465, and the true value of water molecules per copper(II) sulphate molecule, 5, can be explained through the inaccuracies of this experiment and the precision to which masses measured. Since the molar mass, is given by $n\ =\ \frac{m}{M}$, and M is constant at 18.015 g/mol, the mass of the experimentally found mass of water must have been too high. This error could be caused by excess moisture or impurities in the crucible that may have influenced the mass recorded as the crucible was heated. Moreover, since the masses for the copper(II) sulphate and

water in this lab were known to at least 3 significant digits, the ratio calculated between the molecules of copper(II) sulphate and water is known to limited precision.

3. How do you know that it was water that evaporated?

The colour change between copper(II) sulphate hydrate and anhydrous copper(II) sulphate indicates that water evaporated from heating the copper(II) sulphate. The water molecules that bond with copper(II) sulphate are known as the water of crystallization, which is also responsible for the geometry of the crystal and the crystal’s colour. Since the crystal’s colour comes from the water, once the water evaporates, the crystal turns into anhydrous copper(II) sulphate, which is white.

Conclusion

This lab explored finding the empirical formula of copper(II) sulphate hydrate by comparing the molar masses of copper(II) sulphate hydrate and anhydrous copper(II) sulphate. Sources of error that could have influenced the results of this experiment include: The repeated process of heating and cooling in the experiment served to evaporate the water in copper(II) sulphate hydrate, and each iteration reduced the amount of water in the copper(II) sulphate. However, there can only be a finite number of iterations, which leaves some water still in the copper(II) sulphate, yielding a higher mass recorded for the final mass of copper(II) sulphate. Moreover, the materials used, like the crucible, may have contained moisture that affected the measured mass which would have evaporated as the experiment continued, yielding inaccurate values for the mass measured. Finally, the method in which the crucible containing the copper(II) sulphate was transported is susceptible to yielding inaccurate results as some of the copper(II) sulphate could have stuck to the tongs or spilled out.