

Studying complex ions of copper (ii)



**ASSIGN
BUSTER**

Aim

In part A of the practical, the empirical formula of hydrated copper (II) sulphate was determined, is the waters of hydration of water of crystallisation. Making complex ions of copper (II) sulphate with Chloride and Ammonia ligands is done in part B.

Introduction

In this case, copper (II) exists as a hydrated molecule, also, x is often equal to 5 in the formula $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$. Firstly, these experiments mostly involve copper (II) sulphate. Hydrated Copper (II) sulphate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, is a blue and crystalline material which can be used to make pigments, germicides and batteries (Your Dictionary 2009). The structure can be seen below in Figure 1.

Copper (II) sulphate reacts with hydrochloric acid and ammonia solution. Secondly, Hydrochloric acid is a colourless, toxic, fuming, highly acidic watery solution of hydrogen chloride, which can be written as HCl, used as a chemical semi - manufacturer and in fossil oil production, etc. It is discovered in the stomach in thinning form (Answers Corporation 2009). According to The Free Dictionary (2009a), ammonia solution, NH_3 are colourless and irritant, widely used in the manufacture of chemical fertilizers and nitric acid. Also, it is used in making other nitrogenous compounds.

Hydrate, which means solids complexed with waters of crystallisation.

Copper (II) is a transition metal. It is claimed (Clark 2003a) that transition metals are in the middle of the Periodic Table, the place where the d orbitals are being filled, and d block elements are called widely. The general

definition of a transition metal is one which forms one or more stable ions which have partially filled d orbitals (Clark 2003a), see figure 2.

The definition of complex formation is given. It is reported that when a transition metal ion is besetted by other molecules or ions which use lone pairs to make up dative covalent bonds with the d – block metals, a complex is formed (Lister and Renshaw, 2000).

The theory of the hydrated copper (II) sulphate coloured can be given, and it can be regarded as the cause of why the copper solution is blue. If white light passes through copper (II) sulphate solution, absorption of some wavelengths in the light is done by the solution (Clark 2003b). A copper (II) ion in solution absorbs light in the red region, and hence reflects blue and has all (Clark 2003b). Except for the red colour, the light passes through the solution and the colours in it, this mixture of wavelengths can be seen as pale blue or cyan. (Clark 2003b).

Method

In this experiment, hydrous copper (II) sulphate (s), hydrochloric acid and ammonia solution were used as samples. A dessicator, a crucible, a paper clip, a burner, a stand, a spatula, tongs and an electronic balance were used as simple items. Laboratory coats and safety glasses were used to ensure safety.

According to the handout (Lane 2009), these steps were done during the hydrates copper (II) sulphate experiment:

Firstly, a cloth was used to clean the inside of the crucible. Secondly, after doing this, a paper clip was placed in the crucible and it was weighed on the electronic balance. 0.01g was written down. Thirdly, the crucible was put on the small electronic balance and the spatula was used to place about 2 to 3 g of copper sulphate in the crucible. After that, it was weighed. Fourthly, the burner was lit and placed under the stand; the crucible was placed on the stand and it was heated for about 5 minutes. Fifthly, the crystals were stirred with the paper clip to break up. The change in colour was noted. Sixthly, the tongs were used to place the crucible inside the dessicator for about 5 minutes to cool down (the paper clip was left in the dish). When it was cool enough to touch, the crucible was weighed. Step 4 to 6 can be repeated to check the weight stays the same after heating. Finally, some water was added to the crucible.

During the experiments in part B, these steps were done (Lane 2009):

Firstly, some copper sulphate and water were added into 3 conical flasks, they were shaken to dissolve. After doing this, a pipette was used to drop concentrated hydrochloric acid into one flask until the colour changed. Next, another pipette was used to drop some ammonia solution into a second flask until the colour changed. Then, more ammonia solution was added.

Discussion

To ensure the experiments were performed accurately, the procedures were read carefully before the practical, such as writing down the weight to 0.01g, waiting about 5 minutes for the crucible to heat, placing about 2 to 3g of copper sulphate and adding hydrochloric acid into the flask until the

colour changes. These are all about accuracy. Also, the simple items had to be used correctly, for example, the paper clip could not be put outside the crucible, or a loss of mass could happen.

Maybe some possible errors have been made during the experiment, such as the crucible was not heated enough or cooled enough. To avoid this possible error, observing the changes of the copper sulphate in the crucible carefully are essential.

In part A, The value of x of empirical formula of hydrated copper (II) sulphate was calculated:



$$1.23(160+18x) = 160 \times 1.93$$

$$196.8 + 22.14x = 308.8$$

$$22.14x = 112$$

$$x = 5.06$$

The definition of molecular mass is given. According to About.com (2010), it gives the mass of a molecule links to that of the C atom, 'which is taken to have a mass of 12', the number equals to the sum of the atomic mass of an atom in a molecule. In this case, 160 mean the sum of atomic mass of copper, sulphur and oxygen, $160 = 64 + 32 + 16 \times 4$, and also, $18 = 1 \times 2 + 16$.

The reason for the equation is, 1.23g is the mass of anhydrous copper sulphate, and 1.93g is mass of hydrated copper sulphate, using the ratio

and then calculates the x. Therefore, according to the empirical formula, x of $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$ is 5, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is obtained.

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O} (\text{s}) \rightarrow \text{CuSO}_4 (\text{s}) + 5\text{H}_2\text{O} (\text{g})$ is also obtained.

The reason for repeating heating the copper sulphate is to ensure the all hydrate water was evaporated. If the copper sulphate was overheated, the chemical reaction below can occur.

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O} (\text{s}) \rightarrow \text{CuO} (\text{s}) + \text{SO}_3 (\text{g})$

The solid would turn black of colour because the colour of CuO, copper (II) oxide is black. However, this reaction will not happen in the laboratory because of the equipment, for example, the burner, the maximum temperature of its flame can be 400 – 500? (Hudong. com 2009), nevertheless, CuO can not be formed until the temperature has reached 650? (Hudong. com 2009). As a result, in this case, this reaction will not happen.

The theory of part B experiment is given here. According to Clark (2003c), the theory is about copper (II) ion and conc hydrochloric acid. The colour of the tetrachlorocuprate (II) ion, $[\text{CuCl}_4]^{2-}$, is practically always seen mixture of the original hexaaque ion, $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (Clark, 2003c).

The equation of the reversible reaction can be given (Clark 2003c):

$[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightleftharpoons [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$

The colour of $[\text{CuCl}_4]^{2-}$ is described as olive-green or yellow (Clark 2003c)

It is claimed (Clark 2003d) that, hexaaqua reacts with ammonia solution metal ions in two clear ways, ' because it can act as a base as well as a ligand'.

If a small amount of ammonia solution is added, precipitates of the metal hydroxide – will be obtained, in this case, the ammonia is acting as a base (Clark 2003d). In some cases, these precipitates redissolve when more ammonia is added, ' to give solutions in which a ligand exchange reaction has occurred' (Clark 2003d).

Conclusion

The value of the x of the empirical formula was calculated; therefore, copper (II) sulphate can dissolve in water and then form hydrate copper sulphate. In part B, the observation is as good as what expected, from studying the theory, Chlorine and ammonia; these two ligand can replace the water in the chemical reaction.

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