Hydrated and Anhydrous Compounds Revision Notes | CIE | A-Level

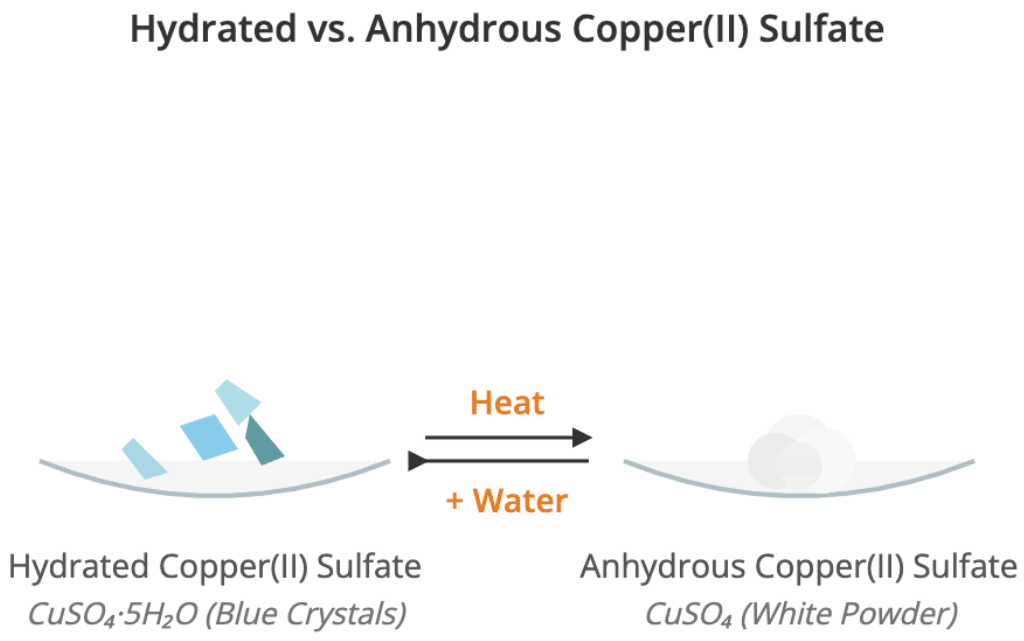
Water of Crystallisation

Some crystalline compounds incorporate a fixed number of water molecules into their structural lattice. This water is referred to as the water of crystallisation.

Key Definitions

A **hydrated compound** is a substance that contains water of crystallisation within its structure. A well-known example is hydrated copper(II) sulfate, $CuSO_4 \cdot 5H_2O$, which is blue.

An **anhydrous compound** is a substance that does not contain water of crystallisation. For example, anhydrous copper(II) sulfate, $CuSO_4$, is a white powder.



A single compound can have different degrees of hydration. For instance, cobalt(II) chloride exists as both cobalt(II) chloride-6-water ($CoCl_2 \cdot 6H_2O$) and cobalt(II) chloride-2-water ($CoCl_2 \cdot 2H_2O$).

When writing formulae for hydrated compounds, a dot is used to separate the main formula

from the water of crystallisation.

Comparison of Hydrated and Anhydrous Compounds

Feature	Hydrated Compound	Anhydrous Compound
Definition	Contains a fixed ratio of water molecules (water of crystallisation) within its crystal structure.	Does not contain water of crystallisation.
Appearance (Example)	Blue crystals ($CuSO_4 \cdot 5H_2O$)	White powder ($CuSO_4$)
Formula (Example)	$CuSO_4 \cdot 5H_2O$	$CuSO_4$
Formation	Formed when water is added to an anhydrous compound.	Formed when a hydrated compound is heated.

Reversible Reactions

The process of hydration and dehydration is reversible. A hydrated compound can be formed by adding water to an anhydrous compound, and this reaction can be reversed by heating.

- Hydration: An anhydrous compound becomes a hydrated compound upon the addition of water.
  $CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4 \cdot 5H_2O(s)$
- Dehydration: Heating a hydrated compound removes the water of crystallisation, leaving the anhydrous compound.
  $CuSO_4 \cdot 5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$

Calculating Relative Formula Mass

To calculate the relative formula mass (M_r) of a hydrated salt, the mass of the anhydrous part and the mass of the water of crystallisation are calculated separately and then added together.

For example, to find the M_r of hydrated magnesium nitrate-6-water, $Mg(NO_3)_2 \cdot 6H_2O$:

1. Calculate the M_r of $Mg(NO_3)_2$: $24.3 + 2 \times (14.0 + (3 \times 16.0)) = 148.3$
2. Calculate the mass of $6H_2O$: $6 \times ((2 \times 1.0) + 16.0) = 108.0$
3. Add the two values: $148.3 + 108.0 = 256.3$