Determining the Formula of a Hydrate

What is a Hydrate?

A **hydrate** is a compound that contains water molecules bound to each formula unit. Hydrates have a chemical formula in the form of **AxBy⋅ zH2O**.

An example of a hydrate is cobalt chloride hexahydrate, which has an empirical formula of CoCl2⋅6H2O. This empirical formula tells us that each formula unit contains 1 Co atom, 2 Cl atoms, and 6 water molecules.

An **anhydrate** is the remaining substance once the water is removed. In our CoCl2⋅6H2O, the anhydrous form is CoCl2.



Steps to Determine the Formula of a Hydrate

Step 1: Find the mass of the water that has been removed (or the mass of the anhydrate).

Ie: mass of hydrated compound- mass of anhydrate

Step 2: Calculate the moles of the anhydrous compound

Step 3: Calculate the moles of water

Step 4: Compare the moles of the anhydrous compound to the moles of water.

Ie: find the mole ratio (divide by the smallest number of moles)

**Example:**

A chemical, lithium sulfate (Li2SO4) is hydrated. A sample of the hydrated ionic salt is weighed at 3.25 g. The chemical is then heated, and the water removed. The resulting new mass is 2.80 g. Calculate the empirical formula of this hydrated compound.

**Step 1:** Find the mass of the water that has been removed.

3.25 g – 2.80 g = 0.45g

**0.45g of water has been removed.**

**Step 2:** Calculate the moles of the anhydrous compound.

Li2SO4 molar mass:

Molar mass Li= 6.9 g/mol

Molar mass S=32.1 g/mol

Molar mass O= 16.00

Mass Li2SO4= (2x6.9) +32.1 + (4x 16) = 109.9 g/mol

Mol Li2SO4, n= mass Li2SO4

 molar mass Li2SO4

Mol Li2SO4, n= 2.80 g

 109.9 g/mol

**Mol Li2SO4, n= 0.025 mol**

**Step 3:** Calculate moles of water.

H2O molar mass:

Molar mass H= 1.008 g/mol

Molar mass O= 16.00 g/mol

Molar mass H2O = (2x1.008) +16= 18.016 g/mol

Mol H2O, n= mol H2O

 molar mass H2O

Mol H2O, n= 0.45 g

 18.016 g/mol

**Mol H2O, n= 0.025 mol**

**Step 4:** Compare moles of each

Li2SO4: H2O

0.025: 0.025

0.025 0.025

1:1

Therefore, the formula for this hydrate is Li2SO4⋅6H2O