Hydrates

Hydrated Compounds

Some compounds exist in a “hydrated” state. Hydration, you know, has to do with WATER!

Some specific number of water molecules are present for each molecule of the compound.

Anhydrides Without Water

Prefix “an-” means “without”
anarchy, anaerobic

A compound that is normally a hydrate and has lost its hydration water is said to be anhydrous and is called an anhydride.

$BaCl_2 \bullet 2H_2O$ → Barium Chloride Dihydrate

$BaCl_2$ → Barium Chloride Anhydride

-or-

Anhydrous Barium Chloride

Hydration Number

Some compounds attach themselves to water molecules. This is done in set numbers, depending on the compound. For example, magnesium sulfate attaches to 7 water molecules. We say its hydration number is 7.

$MgSO_4 \bullet 7H_2O$

(Magnesium Sulfate Heptahydrate)

Dessicants

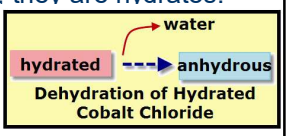
- You've probably noticed that some consumer goods contain a small packet labeled "Silica gel: Do not eat". What's that packet for, anyway?

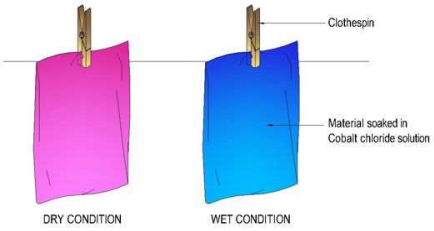
Dessicants absorb moisture

- As you know, many goods can be easily damaged by moisture. The silica gel in each packet is used to soak up water from the atmosphere. This minimizes moisture that causes damage during shipping.

Hydrate vs. Anhydrate

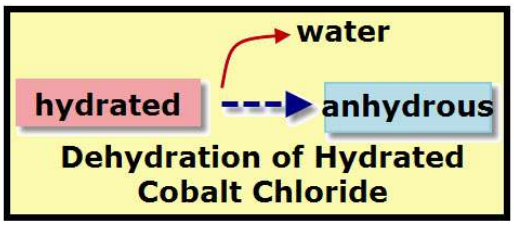
- Many ionic compounds can be used to soak up water. Before they absorb water, they're referred to as "anhydrous", which means "without water". After absorbing water, they are hydrates.
- Cobalt chloride hexahydrate is an example.





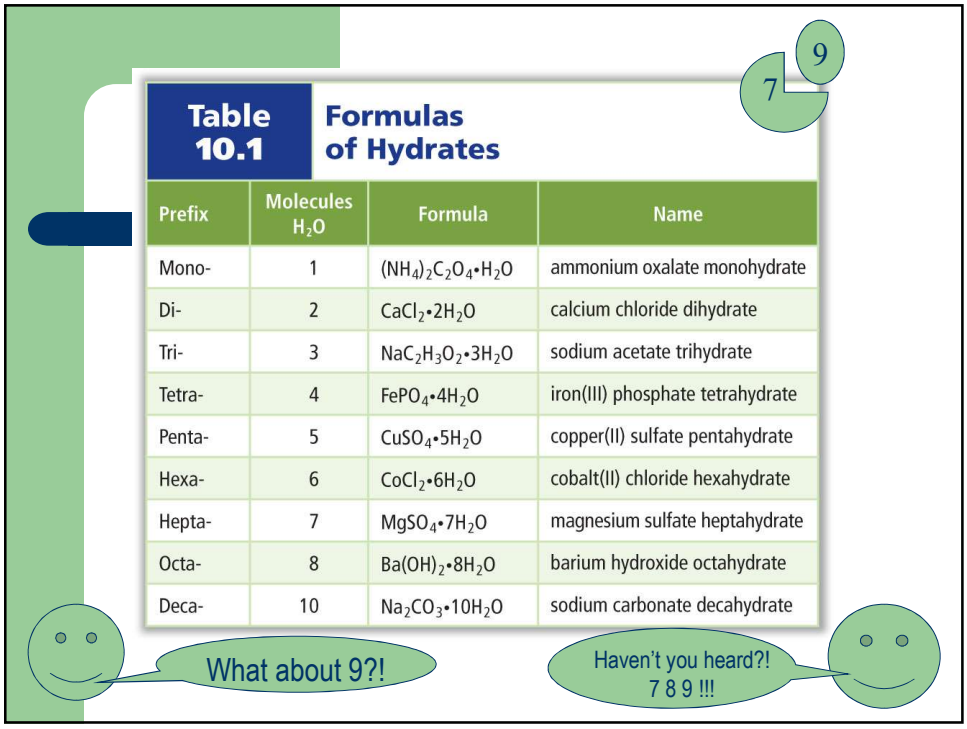
Used to gauge effectiveness of dessicants… or to make Weather Dolls ☺

- After they've soaked up the maximum amount of water, they're called "hydrates", making that water molecules are stuck to them



Other examples

- Epsom salts…magnesium sulfate 7
- Water softener…sodium carbonate 10
- Fireproofing…magnesium chloride 6
- Dyes…barium chloride 2
- Photo film…cadmium nitrate 4
- Embalmer…zinc chloride 6
- Fireworks, soldering…lithium chloride 4
- Dessicant & weather predictor…cobalt (II) chloride 6
- Plaster of Paris…calcium sulfate 2



Prefix	Molecules H_2O	Formula	Name
Mono-	1	$(NH_4)_2C_2O_4 \cdot H_2O$	ammonium oxalate monohydrate
Di-	2	$CaCl_2 \cdot 2H_2O$	calcium chloride dihydrate
Tri-	3	$NaC_2H_3O_2 \cdot 3H_2O$	sodium acetate trihydrate
Tetra-	4	$FePO_4 \cdot 4H_2O$	iron(III) phosphate tetrahydrate
Penta-	5	$CuSO_4 \cdot 5H_2O$	copper(II) sulfate pentahydrate
Hexa-	6	$CoCl_2 \cdot 6H_2O$	cobalt(II) chloride hexahydrate
Hepta-	7	$MgSO_4 \cdot 7H_2O$	magnesium sulfate heptahydrate
Octa-	8	$Ba(OH)_2 \cdot 8H_2O$	barium hydroxide octahydrate
Deca-	10	$Na_2CO_3 \cdot 10H_2O$	sodium carbonate decahydrate

How do you figure out the hydration number?

- If you heat hydrates to very high temperatures, they “dehydrate”, meaning that the water is lost.
- Once all of the water is lost, these compounds are again referred to as “anhydrous”.

Finding the Hydration Number

The hydration number can be conveniently found by heating the compound and measuring its mass loss. This mass loss is usually due to the hydration water molecules being driven off.

For example…

A 15.35 g sample of Strontium nitrate, $Sr(NO_3)_2 \bullet nH_2O$, is heated to a constant mass of 11.45 g. Calculate the hydration number.

Sample Data:

Mass Hydrate	15.35g
Mass Anhydride	— 11.45g
Mass of Water (mass loss)	3.90g

Calculations

Moles Anhydride

$$\frac{11.45\text{g Sr(NO}_3)_2}{} \times \frac{1\text{ mol Sr(NO}_3)_2}{211.64\text{ g Sr(NO}_3)_2} = 0.05410\text{ mol Sr(NO}_3)_2$$

Moles Water

$$\frac{3.90\text{g H}_2\text{O}}{} \times \frac{1\text{ mol H}_2\text{O}}{18.02\text{ g H}_2\text{O}} = 0.216\text{ mol H}_2\text{O}$$

Molar ratio…

$$\frac{\text{mol H}_2\text{O}}{\text{mol Sr(NO}_3)_2} = \frac{0.216\text{ H}_2\text{O}}{0.05410\text{ mol Sr(NO}_3)_2} = 3.99 \approx 4$$

Hydration Number is 4, $Sr(NO_3)_2 \bullet 4H_2O$

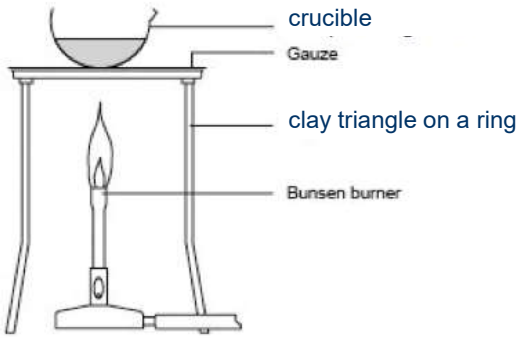
(Strontium Nitrate Tetrahydrate)

(or, think of it like the other problems, and divide both values by smallest to get a whole number ratio)

Simulated lab data to demonstrate method and calculations

- In this sample lab, we will be dehydrating the hydrate of calcium nitrate.
- Using the data from this lab, you will determine the formula of the hydrate

The setup



EXAMPLE

- Find amount of water in calcium nitrate *n* hydrate and the formula for the hydrate.
- A 7.0 g sample of hydrated calcium nitrate is heated in a ceramic dish to constant mass
- 4.9 grams remains after heating. This is the anhydrous salt.
- How much water was driven off from the hydrate?
- 7.0 g sample of hydrated calcium nitrate

- 4.9 g anhydrous salt

2.1 grams of water

- Here is a table with the experimental data

Data for Determining Hydrate Formula	
Substance	**Mass in g**
Crucible	50.00
Crucible and hydrate	57.00
Mass of hydrate (no dish)	7.00
Crucible and anhydrate	54.90
Mass of anhydrate (no dish)	4.90
Mass of water lost	2.10

Determine moles of anhydrate and water

Convert the mass of anhydrous salt to moles.

4.9 ~~g Ca(NO3)2~~ | 1 mole Ca(NO3)2 = .0299 mol Ca(NO3)2
| 164.10 ~~g Ca(NO3)2~~

Convert the mass of water to moles.

2.1 ~~g H2O~~ | 1 mole H2O = .117 mol H2O
| 18.02 ~~g H2O~~

Determine the ratio of water to anhydrate

- Determine the ratio of moles of water to moles of anhydrate: (or divide both values by the smallest to get whole number ratio)

$$\frac{\text{MOLES WATER}}{\text{MOLES ANHYDRATE}} = \frac{.117 \text{ mol } H_2O}{.0299 \text{ mol } Ca(NO_3)_2}$$

= 3.91 ~4 moles of water
for every mole of calcium nitrate

Write the formula

- Write the formula:

(formula of the anhydrate • hydration # H_2O)

$Ca(NO_3)_2 \cdot 4H_2O$

- Name it:

(name of anhydrate #prefix-hydrate)

Calcium nitrate tetrahydrate

x