

Percentage Composition

- But first, a word or two about hydrates

Hydrates

- **Hydrates** are ionic compounds (salts) that have water molecules bound to their ions.
 - Examples:
 - $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
 - $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$
 - $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$
 - $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$
- Water can sometimes be removed by heating.
 - A hydrate that loses all of its water becomes **anhydrous** (“without water”)

Hydrates



Anhydrous cobalt(II) chloride, CoCl_2



Cobalt(II) chloride hexahydrate,
 $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$

Naming Hydrates

- Name ionic compound.
- Add prefix + “hydrate”.
 - $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ = cobalt(II) chloride hexahydrate
 - $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ = copper(II) sulfate pentahydrate
 - $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ = iron(III) nitrate nonahydrate
 - $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ = tin(II) chloride dihydrate

Molar Mass of Hydrates

■ Add appropriate number of moles of water:

– Molar mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$:

- $1 \times \text{Cu} = 1 \times 63.55 \text{ g/mol} = 63.55 \text{ g/mol}$
- $1 \times \text{S} = 1 \times 32.06 \text{ g/mol} = 32.06 \text{ g/mol}$
- $4 \times \text{O} = 4 \times 16.00 \text{ g/mol} = 64.00 \text{ g/mol}$
- $5 \times \text{H}_2\text{O} = 5 \times 18.02 \text{ g/mol} = 90.10 \text{ g/mol}$
- Total = 249.71 g/mol

– Molar mass of anhydrous CuSO_4 :

- $1 \times \text{Cu} = 1 \times 63.55 \text{ g/mol} = 63.55 \text{ g/mol}$
- $1 \times \text{S} = 1 \times 32.06 \text{ g/mol} = 32.06 \text{ g/mol}$
- $4 \times \text{O} = 4 \times 16.00 \text{ g/mol} = 64.00 \text{ g/mol}$
- Total = 159.61 g/mol

Percentage Composition

- **Percentage Composition** – percent of a compd's mass that is made of each element.

Percentage Composition

■ What is the % Comp. of H₂O?

– First, find the molar mass.

▪ $2 \times \text{H} = 2 \times 1.01 \text{ g/mol} = 2.02 \text{ g/mol}$

▪ $1 \times \text{O} = 1 \times 16.00 \text{ g/mol} = 16.00 \text{ g/mol}$

▪ Total = 18.02 g/mol

– $\% \text{ H} = (2.02 / 18.02) \times 100\% = 11.2\%$

– $\% \text{ O} = (16.00 / 18.02) \times 100\% = 88.79\%$

■ What does that mean?

– In 100 grams of water, there are 11.2 grams of hydrogen and 88.79 grams of oxygen.

Percentage Composition

■ What is the % Comp. of FeCl_3 ?

– Find the molar mass:

- $1 \times \text{Fe} = 1 \times 55.85 \text{ g/mol} = 55.85 \text{ g/mol}$
- $3 \times \text{Cl} = 3 \times 35.45 \text{ g/mol} = 106.35 \text{ g/mol}$
- Total = 162.20 g/mol

– % Fe = $(55.85 / 162.20) \times 100\% = 34.43\%$

– % Cl = $(106.35 / 162.20) \times 100\% = 65.567\%$

■ How many grams of Fe can be obtained from 250. grams of FeCl_3 ?

– What is 34.43% of 250. grams?

– $0.3443 \times 250. \text{ g} = 86.1 \text{ grams of Fe}$

Percentage Composition

■ What is the % Comp. of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$?

- Treat water as a unit.
 - Do not break it into elements.
- Find molar mass:
 - $1 \times \text{Ca} = 1 \times 40.08 \text{ g/mol} = 40.08 \text{ g/mol}$
 - $2 \times \text{Cl} = 2 \times 35.45 \text{ g/mol} = 70.90 \text{ g/mol}$
 - $2 \times \text{H}_2\text{O} = 2 \times 18.02 \text{ g/mol} = 36.04 \text{ g/mol}$
 - Total = 147.02 g/mol
- % Ca = $(40.08 / 147.02) \times 100\% = 27.26\%$
- % Cl = $(70.90 / 147.02) \times 100\% = 48.22\%$
- % H_2O = $(36.04 / 147.02) \times 100\% = 24.51\%$

■ What is the mass of water contained in 45.00 grams of calcium chloride dihydrate?

- What is 24.51% of 45.00 grams?
- $0.2451 \times 45.00 \text{ grams} = 11.03 \text{ grams of H}_2\text{O}$