CLASSIFICATION OF SOLIDS: By structure

- Solids may also be classified by structure. A more in-depth look at solids is something you would find in a materials science class, but we'll discuss two broad categories of solid materials.

(1) AMORPHOUS SOLIDS

- have a disordered structure at the microscopic level.

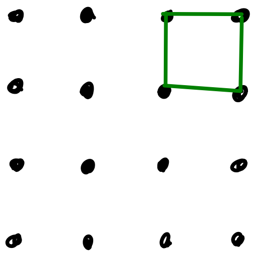
- a very small amount of solids are completely amorphous, but quite a few plastics are at least partially amorphous.

(2) CRYSTALLINE SOLIDS

- have a well-defined three dimensional structure at the microscopic level.

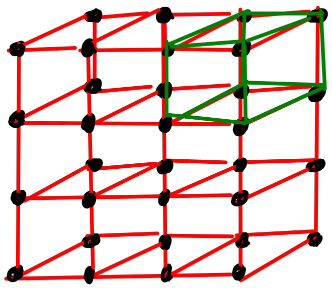
- structure is made up of a regular, repeating arrangement of points in space - a CRYSTAL LATTICE

MORE ON CRYSTALS



Here's a simple CRYSTAL LATTICE in 2D. The points represent atoms occupying LATTICE POINTS

The simplest repeating pattern that describes the entire crystal is called the UNIT CELL. It's outlined in GREEN here.



Here's a crystal lattice in three dimensions. This one is called a SIMPLE CUBIC lattice. This simple structure can be found in some solid metals like polonium. A polonium atom occupies each lattice point.

The unit cell, again, is highlighted in GREEN.

See pages 449-450 (9th) for more types of crystal systems and more unit cells.

(p458 - 459 in 10th edition)

CRYSTAL DEFECTS

- Natural crystals almost always have some DEFECTS in their structure.

  - Holes in the crystal lattice, where an atom should be but isn't
  - Misaligned planes in the crystal
  - Substitutions of one atom for another in the crystal lattice

- Often defects are undesirable, but not always:

Alumina: Al_2O_3

- clear / white in color
- usually used as the "grit" in cleaners like Comet and Soft Scrub!

ruby: Al_2O_3 with some Al replaced with Cr

- red in color
- valuable gemstone!

SOLUTIONS

- a SOLUTION is a HOMOGENEOUS MIXTURE.

Uniform properties throughout!

- parts of a solution:

(1) SOLUTE(S)

- component(s) of a solution present in small amounts.

(2) SOLVENT

- the component of a solution present in the GREATEST amount

- in solutions involving a solid or gas mixed with a LIQUID, the liquid is typically considered the solvent.

- solutions are usually the same phase as the pure solvent. For example, at room temperature salt water is a liquid similar to pure water.

SOLVENTS

- We traditionally think of solutions as involving gases or solids dissolved in liquid solvents. But ANY of the three phases may act as a solvent!

(1) GAS SOLVENTS

- Gases are MISCIBLE, meaning that they will mix together in any proportion.
- This makes sense, since under moderate conditions the molecules of a gas don't interact wth each other.
- Gas solvents will only dissolve other gases.

(2) LIQUID SOLVENTS

- Can dissolve solutes that are in any phase: gas, liquid, or solid.
- Whether a potential solute will dissolve in a liquid depends on how compatible the forces are between the liquid solvent and the solute.

(3) SOLID SOLVENTS

- Solids can dissolve other solids, and occasionally - liquids.
- Solid-solid solutions are called ALLOYS. Brass (15% zinc dissolved in copper) is a good example.
- AMALGAM is a solution resulting from dissolving mercury into another metal.

CONCENTRATION

- When you discuss a solution, you need to be aware of:
  - what materials are in the solution
  - how much of each material is in the solution

- CONCENTRATION is the amount of one substance compared to the others in a solution. This sounds vague, but that's because there are many different ways to specify concentration!

- We will discuss four different concentration units in CHM 111:

1. MASS PERCENTAGE

$$= \frac{\text{mass solute}}{\text{mass solution}} \times 100\% \qquad \%,\ \%\ w/w$$

2. MOLARITY

$$= \frac{\text{moles solute}}{\text{L solution}} \qquad M \text{ or } \underline{M}$$

3. MOLALITY

$$= \frac{\text{moles solute}}{\text{kg solvent}} \qquad m$$

4. MOLE FRACTION

$$= \frac{\text{moles component A}}{\text{moles solution}} \qquad X_A$$

57 How would you prepare 455 grams of an aqueous solution that is 6.50% sodium sulfate by mass?

$$\text{mass }\% = \frac{\text{mass solute}}{\text{mass solution}} \times 100\%$$

6.50% (mass %) — 455 g (mass solution)

Since we know all the terms in this definition except MASS SOLUTE, we will need to solve for that term to figure out how to make the solution.

$$6.50 = \frac{\text{mass solute}}{455\text{ g}} \times 100$$

① × 455 g
② ÷ 100

$$\frac{6.50 \times 455\text{ g}}{100} = \text{mass solute} = 29.6\text{ g } Na_2SO_4$$

How much water? Find by subtraction.

$$455\text{ g solution} - 29.6\text{ g } Na_2SO_4 = 425\text{ g water}$$

SO, mix 29.6 g sodium sulfate with 425 g water to prepare this solution!

What's the MOLALITY and MOLE FRACTION OF SOLUTE of the previous solution?

29.6 g Na_2SO_4, 425 g water ← previous solution

$$m = \frac{\text{moles solute } (Na_2SO_4)}{\text{Kg solvent (water)}} \begin{matrix} ① \\ ② \end{matrix}$$

① Convert mass sodium sulfate to moles using formula weight.

② Convert mass water from grams to kilograms.

Na_2SO_4 Na: 2 × 22.99
S: 1 × 32.07
O: 4 × 16.00

142.05 g Na_2SO_4 = mol Na_2SO_4

①

$$29.6\text{ g } Na_2SO_4 \times \frac{\text{mol } Na_2SO_4}{142.05\text{ g } Na_2SO_4} = 0.2083773319 \text{ mol } Na_2SO_4$$

$\text{kg} = 10^3\text{ g}$

②

$$425\text{ g } H_2O \times \frac{\text{kg}}{10^3\text{ g}} = 0.425\text{ kg}$$

$$m = \frac{0.2083773319 \text{ mol } Na_2SO_4}{0.425\text{ kg}}$$

$= 0.490\text{ m } Na_2SO_4$

29.6 g Na_2SO_4, 425 g water ← previous solution

$$X_{Na_2SO_4} = \frac{\text{mol } Na_2SO_4}{\text{mol solution } (Na_2SO_4 + H_2O)}$$ (1) (2)

(1) Calculate moles sodium sulfate from mass - but we did that already for finding molality.

(2) Filnd moles water from mass water, then add to moles sodium sulfate.

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(1) 0,2083773319 mol Na_2SO_4 Soo previous page for calculation.

H_2O: H : 2 x 1.008
O 1 x 16.00
18.016 g H_2O = mol H_2O

$$425 \text{ g } H_2O \times \frac{\text{mol } H_2O}{18.016 \text{ g } H_2O} = 23.5901421 \text{ mol } H_2O$$

mol solution = 0,2083773319 mol Na_2SO_4 + 23.5901421 mol H_2O
= 23.7985194 3 mol solution

$$X_{Na_2SO_4} = \frac{0,2083773319 \text{ mol } Na_2SO_4}{23.79851943 \text{ mol solution}} = \boxed{0.00876}$$