Lecture Notes: Chemical Foundations

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1 Introduction

Definition. Chemistry: branch of science dealing with the structure, composition, and properties of matter and the nature of the transformations they undergo

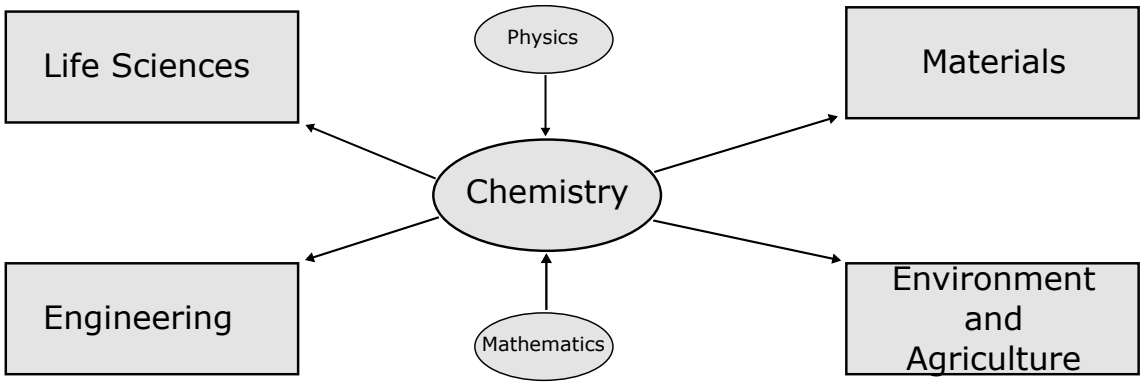

Figure 1: Chemistry as a Central Science: This diagram highlights chemistry as a central science. New developments in chemistry are driven by developments in physics and mathematics, chemistry knowledge in turn drives development in fields such as materials science, life sciences, engineering, and agriculture.

2 Accuracy, Precision, and Uncertainty

Definition. Accuracy: agreement of a particular value with the true value.

Definition. Precision: the relative degree of agreement between several measurements of the quantity using the same instrument.

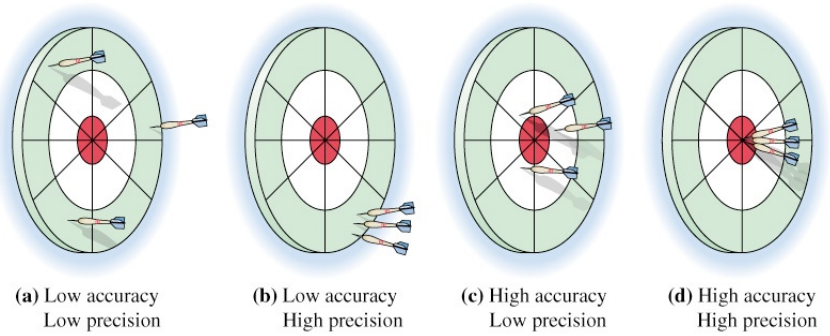

Figure 2: Classic example of darts on a dartboard to highlight the difference between accuracy and precision in measurements.

Problem 1: A true volume of a liquid is 20.5 mL. Which of the following sets of measurements represents this value with good accuracy?

A 18.9 mL, 19.0 mL, 19.0 mL, 19.0 mL

B 20.2 mL, 20.5 mL, 20.3 mL, 20.1 mL

C 18.6 mL, 17.8 mL, 19.6 mL, 17.2 mL

D 19.2 mL, 19.3 mL, 18.8 mL, 16.5 mL

Rules for Significant Figures:

1. *Nonzero Integers.* All nonzero integers count as significant figures.
2. *Rules for Zeros.* Zeros can be sigificant, or not. These three rules govern significant zeros:
   - *Leading Zeros.* ALL zeros that precede nonzero digits are NOT significant.
   - *Captive Zeros.* Zeros between two significant figures are significant.
   - *Trailing Zeros.* Zeros at the right end of a number are only significant if the number contains a decimal point.
3. *Exact Numbers.* Numbers obtained through counting or involved in a definition are assumed to have an infinite number of sig figs.

3 Dimensional Analysis, Temperature, and Density

Definition. Dimensional Analysis: a method employed by chemists and other scientists in order to convert any unit to another unit of the same dimension.

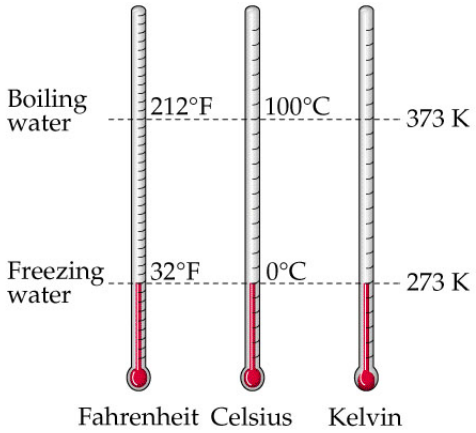

Figure 3: Three thermometers showing the same temperature reading with the respective values for the Farenheit, Celsius, and Kelvin scales shown relative to the freezing and boiling points of water.

Definition. Density: the mass of a substance per unit volume of that substance

Problem 2: A rectangular block has dimensions 2.9 cm × 3.5 cm × 10.0 cm. The mass of the block is 615.0 g. What are the volume and density of the block?

Problem 3: A copper wire (density = 8.96 g/cm^3) has a diameter of 0.25 mm. If a sample of this copper wire has a mass of 22 g, how long is the wire?

4 Classification of Matter

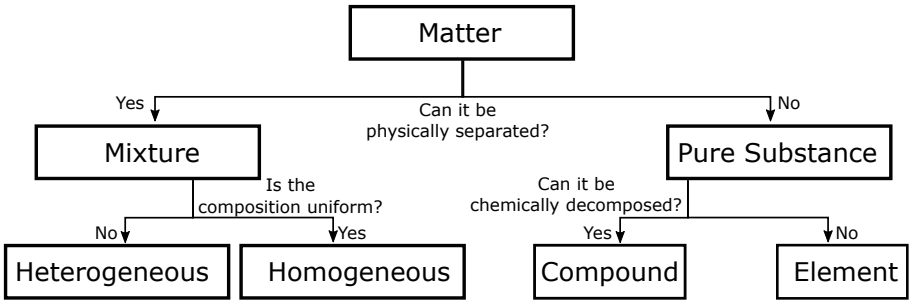

Figure 4: Useful flowchart for classifying matter based on a few simple questions regarding its composition.

Problem 4: "White Gold," used in jewelry, contains two elements, gold and palladium. Two different samples of white gold differ in the relative amounts of gold and palladium that they contain. Both are uniform in composition throughout. Without any other knowledge about this material, how would you classify it?

Problem 5: Aspirin is composed of 60.0% carbon, 4.5% hydrogen, and 35.5% oxygen by mass, regardless of its source. How would you classify aspirin?

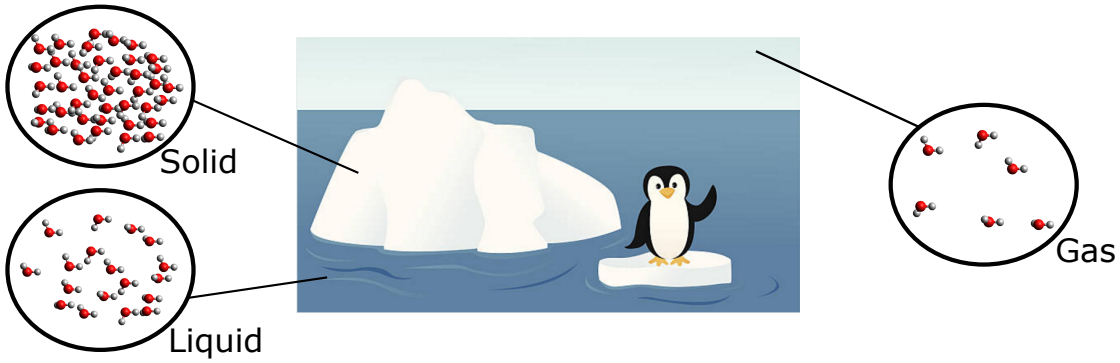

Figure 5: Cartoon drawing of an iceberg in a body of water. The insets highlight the microscopic behavior of the water molecules that give rise to the different macroscopic forms of water in its different phases.

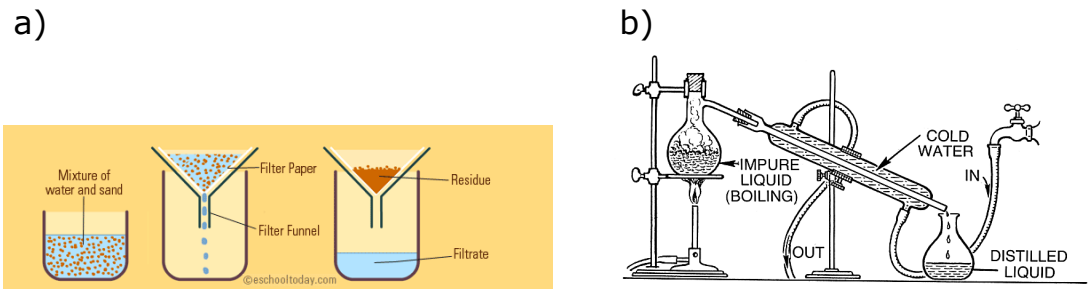

Figure 6: Examples of different separation techniques for mixtures a) Filtration, typically used when one component is a solid and the other is a liquid, and b) Distillation a technique in which the most volatile component (lowest boiling point) vaporizes, passes through a cooled tube and condenses back down to its liquid phase.