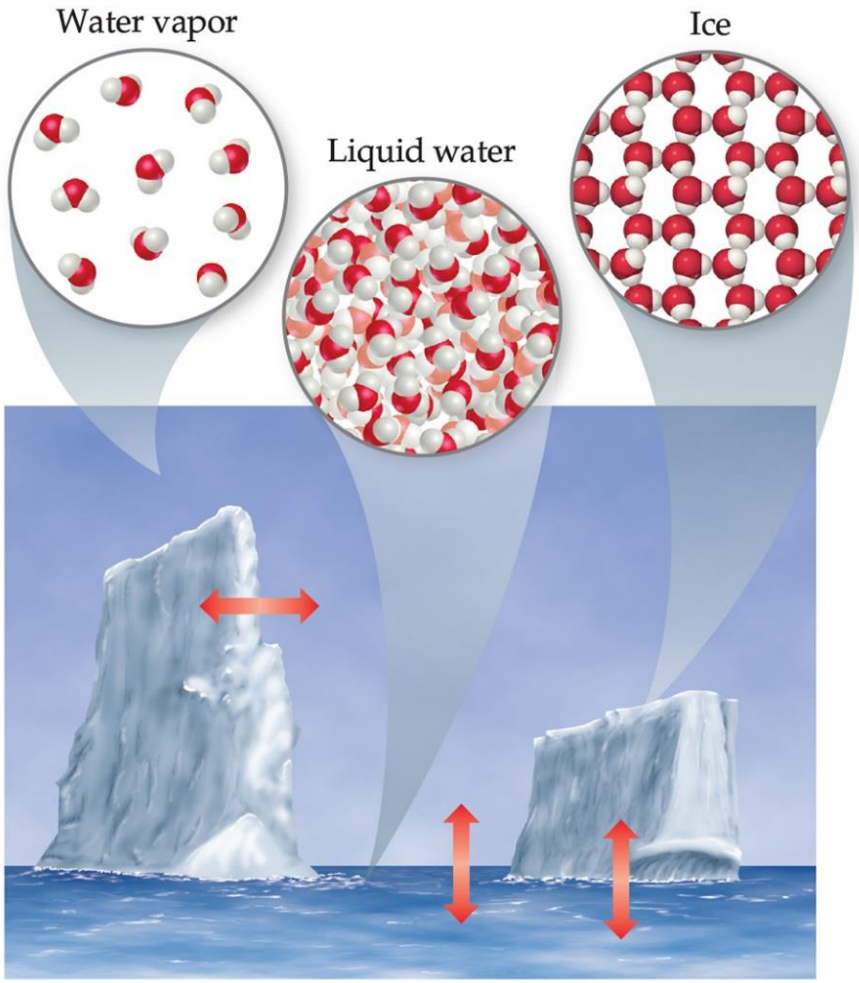
9/17 cont'd

The three States of Matter:

gas, liquid, and solid



Heat (enthalpy) of vaporization:

44.94 kJ/mol at 0 °C

44.02 kJ/mol at 25 °C

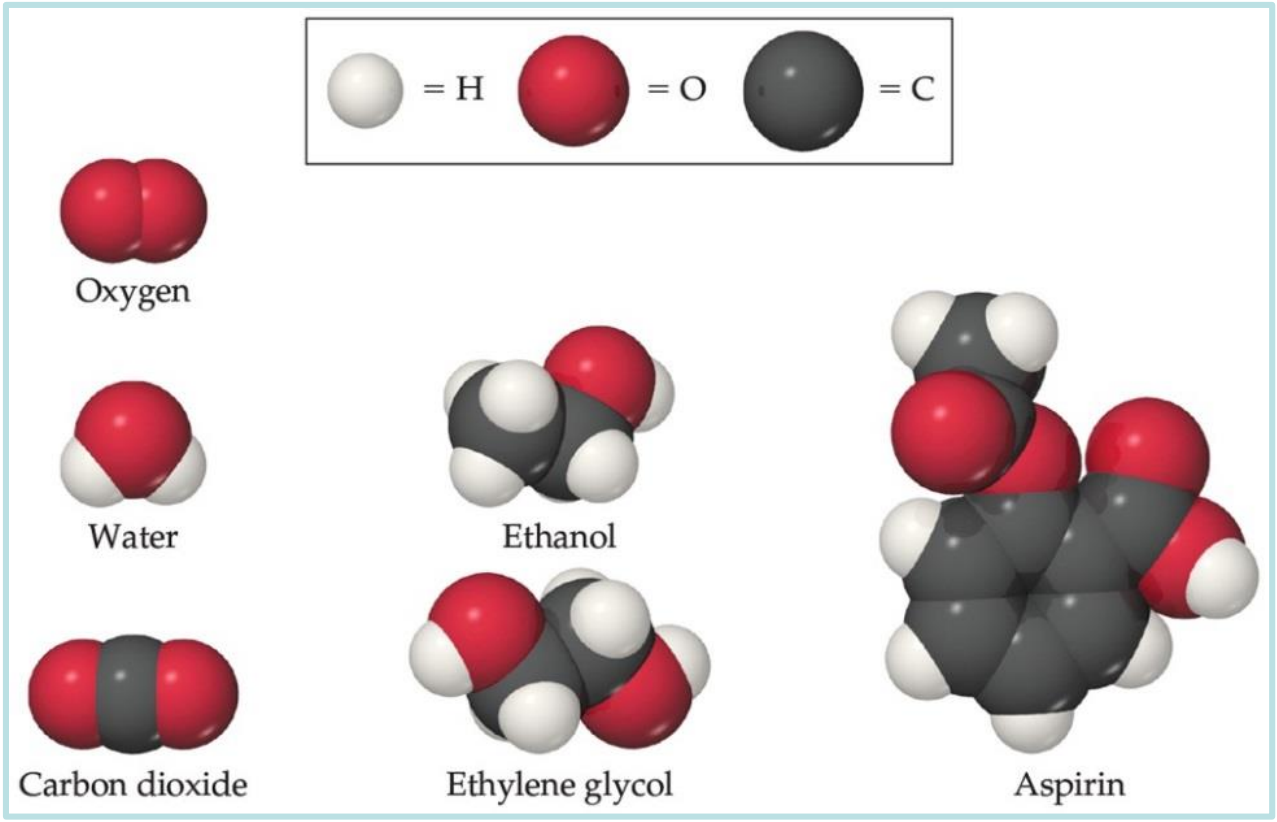
40.67 kJ/mol at 100 °C

What is the 'heat' for?

Only in molecular compounds you would see such a distinct 'state change'.

Molecular Compound

These **groups of atoms in covalent bonding** are called **molecules**.

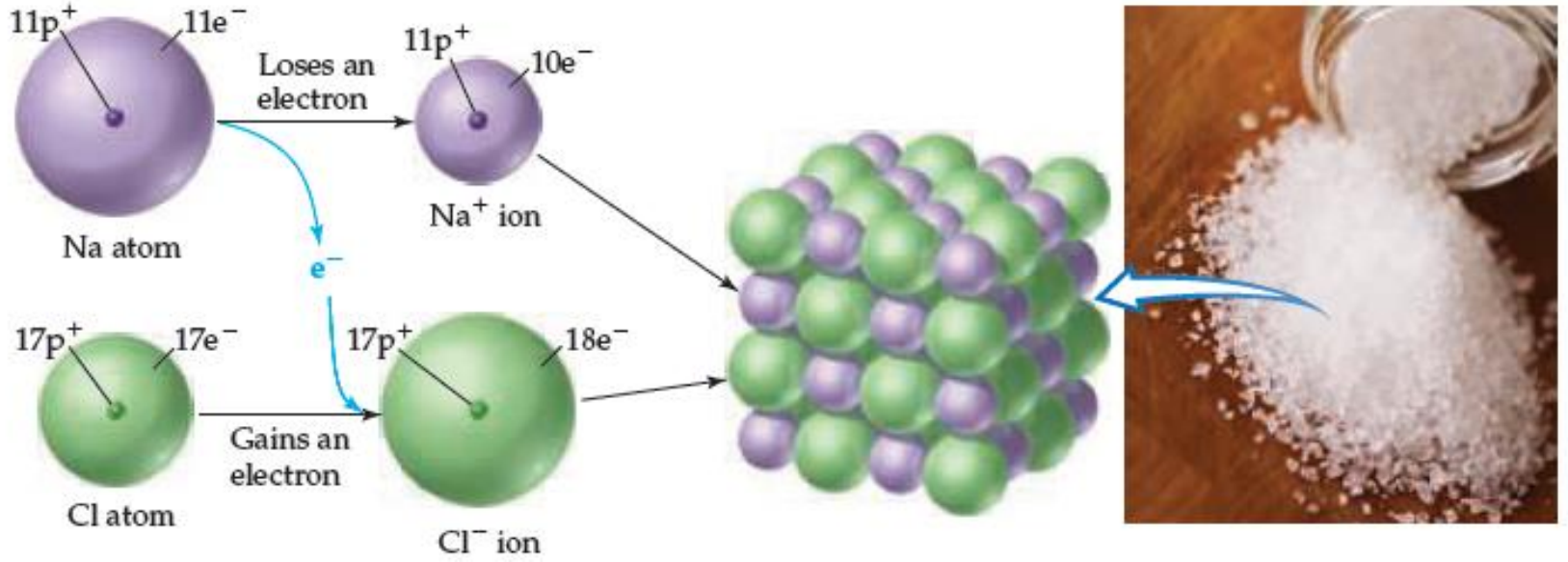


Attached balls represent connections between atoms that are seen in nature.

Write down their molecular formula.

Non-Molecular compound

Write down its chemical formula.



▲ **Figure 2.20** **Formation of an ionic compound.** The transfer of an electron from a sodium atom to a chlorine atom leads to the formation of a Na^+ ion and a Cl^- ion. These ions are arranged in a lattice in solid sodium chloride, NaCl.

The following gives 'the modern materials in the automobile'.

Are there any molecular compounds included?

Which of them are non-molecular materials?

Metals and metal alloys are incorporated into many parts of an automobile. For example, aluminum is the primary component of the radiator, intake manifold, and engine block. Steel is typically the material used for the frame and body. Stainless steel is utilized in mufflers, exhaust silencers, and catalytic converters. The inside of the catalytic converter contains small particles of platinum group metals that are deposited onto a honeycomb-shaped structural ceramic. The ceramic is composed of the ionic solids alumina (Al_2O_3) coated onto cordierite ($Mg_2Al_4Si_5O_{18}$). Semiconducting oxides are used for the oxygen sensor to monitor the air/fuel ratio in the exhaust gases, which is controlled by the engine control computer that is based on silicon, a covalent network solid. Polymers are found in a motor vehicle too, with polyesters in seat covers and carpets, polycarbonate optical reflectors, and polypropylene in bumpers and car batteries.

Pure Substances

Most forms of matter we encounter—the air we breathe (a gas), the gasoline we burn in our cars (a liquid), and the sidewalk we walk on (a solid)—are not chemically pure. *Ideally…* can, however, separate these forms of matter into pure substances. A **pure substance** (usually referred to simply as a *substance*) is matter that has distinct properties and a composition that does not vary from sample to sample. Water and table salt (sodium chloride) are examples of pure substances. *Really?*

Coagulants for tofu: epsom salts-magnesium sulfate

nigari -magnesium chloride

gypsum – calcium sulfate

$CaSO_4.2H_2O$

97% Pure Reagent Grade $6.99/4 Ounces from Amazon

≥ 99.99% trace metals basis $168/10 g from Sigma-Aldrich

Mixtures

Most of the matter we encounter consists of mixtures of different substances. Each substance in a mixture retains its chemical identity and properties. In contrast to a pure substance, which by definition has a fixed composition, the composition of a mixture can vary. A cup of sweetened coffee, for example, can contain either a little sugar or a lot. The substances making up a mixture are called *components* of the mixture.

Mixtures can vary in composition throughout a sample (heterogeneous) or can have the same composition throughout the sample (homogeneous).

A homogeneous mixture is also called a solution.

Same 'states', different substance, not a solid soln.

Different 'states' different substances.

A photograph of granite showing a **heterogeneous** mixture of silicon dioxide and other metal oxides

(b)

copper(II) sulfate pentahydrate dissolve in water to form a **homogeneous** solution

different 'states' merge into one.

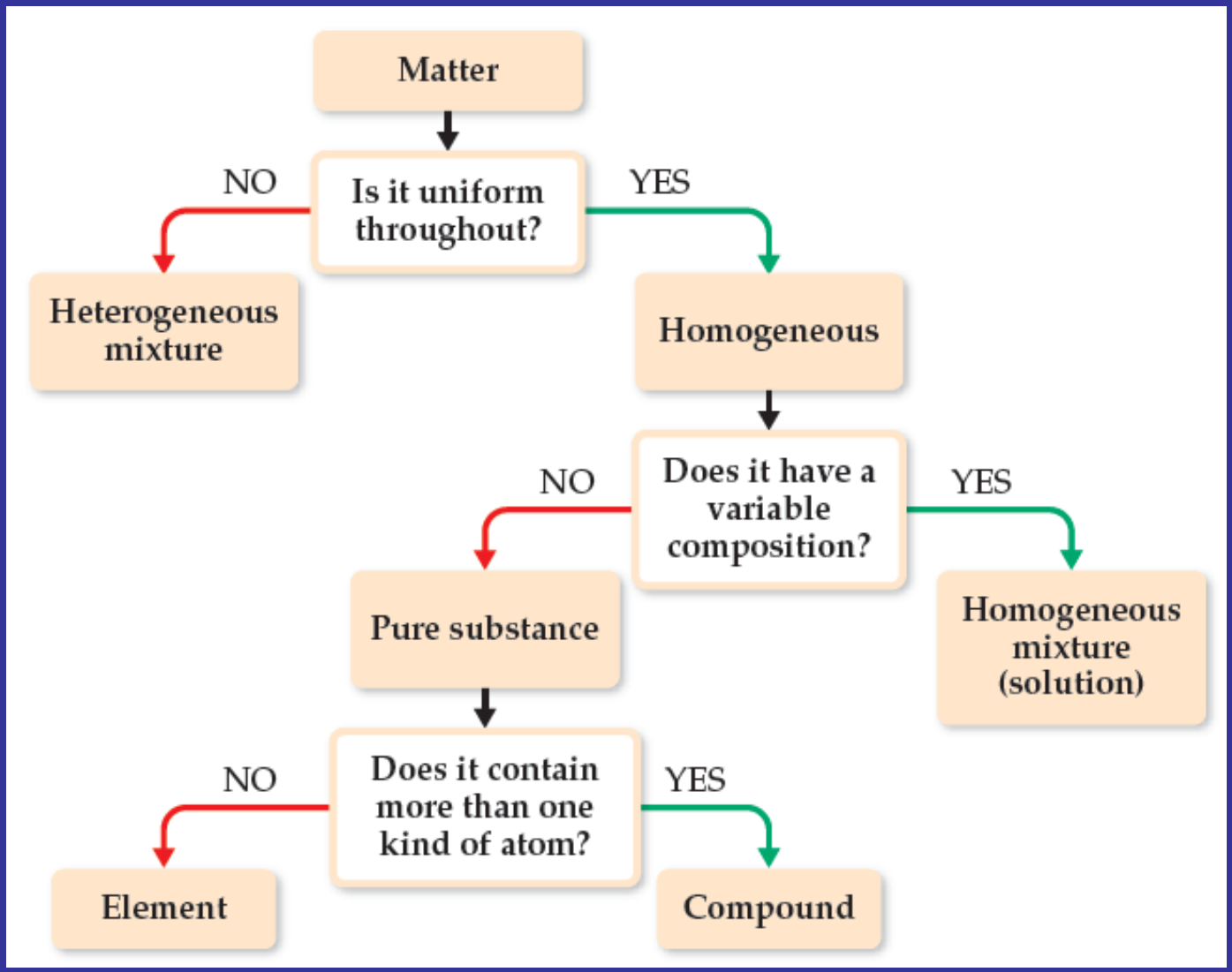
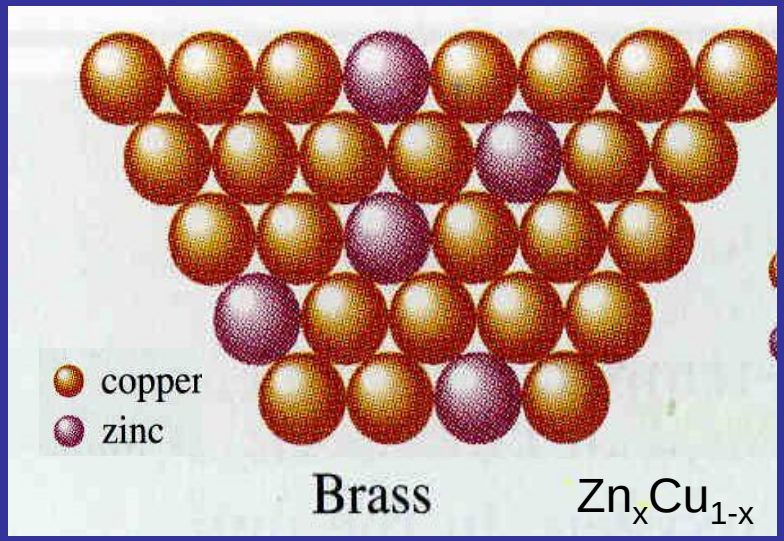


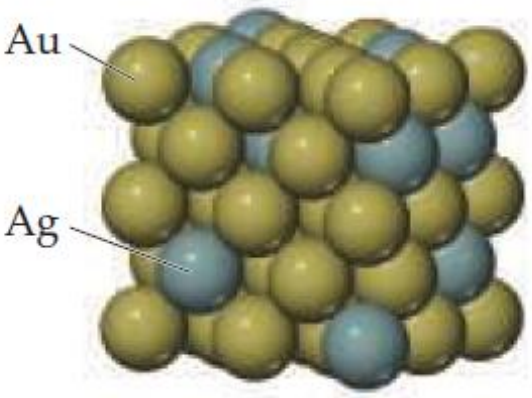
Figure 1.9 Classification of matter. All pure matter is classified ultimately as either an element or a compound.

1.3 Musical instruments like trumpets and trombones are made from an alloy called brass. Brass is composed of copper and zinc atoms and appears homogeneous under an optical microscope. The approximate composition of most brass objects is a 2:1 ratio of copper to zinc atoms, but the exact ratio varies somewhat from one piece of brass to another. (**a**) Would you classify brass as an element, a compound, a homogeneous mixture, or a heterogeneous mixture? **Why not a compound?**

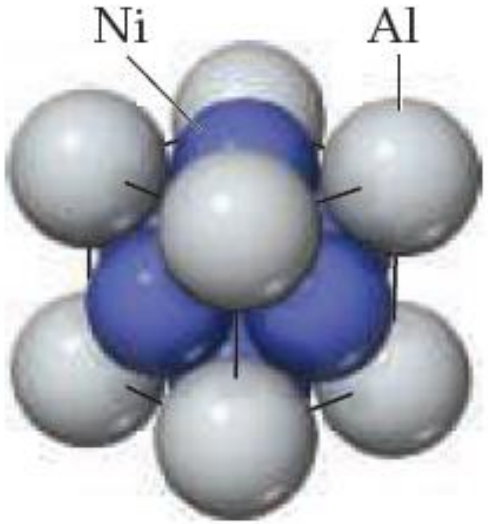


The observation that the elemental composition of a compound is always the same is known as the **law of constant composition** (or the **law of definite proportions**). French chemist Joseph Louis Proust (1754–1826) first stated the law in about 1800.

Alloys may be in the form of solid solutions or intermetallic compounds.

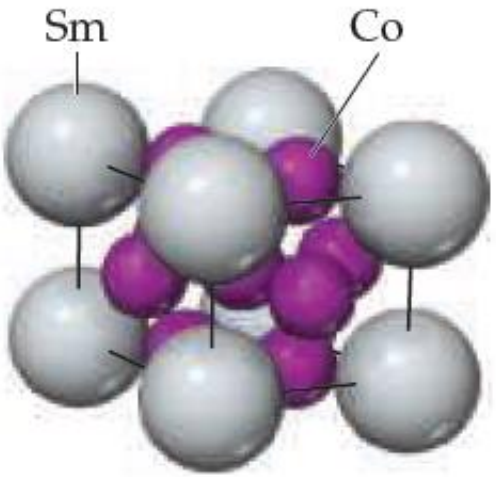


Substitutional alloy
14-karat gold



Ni_3Al

High strength at high temperature and low density



$SmCo_5$

permanent magnet

Practice

1.13 Classify each of the following as a pure substance or a mixture. If a mixture, indicate whether it is homogeneous or heterogeneous: (**a**) air, (**b**) chocolate with almond, (**c**) aluminium, (**d**) iodine tincture.

1.19 In the process of attempting to characterize a substance, a chemist makes the following observations: The substance is a silvery white, lustrous metal. It melts at 649 °C and boils at 1105 °C. Its density at 20 °C is 1.738 g/cm^3. The substance burns in air, producing an intense white light. It reacts with chlorine to give a brittle white solid. The substance can be pounded into thin sheets or drawn into wires. It is a good conductor of electricity. Which of these characteristics are physical properties, and which are chemical properties?

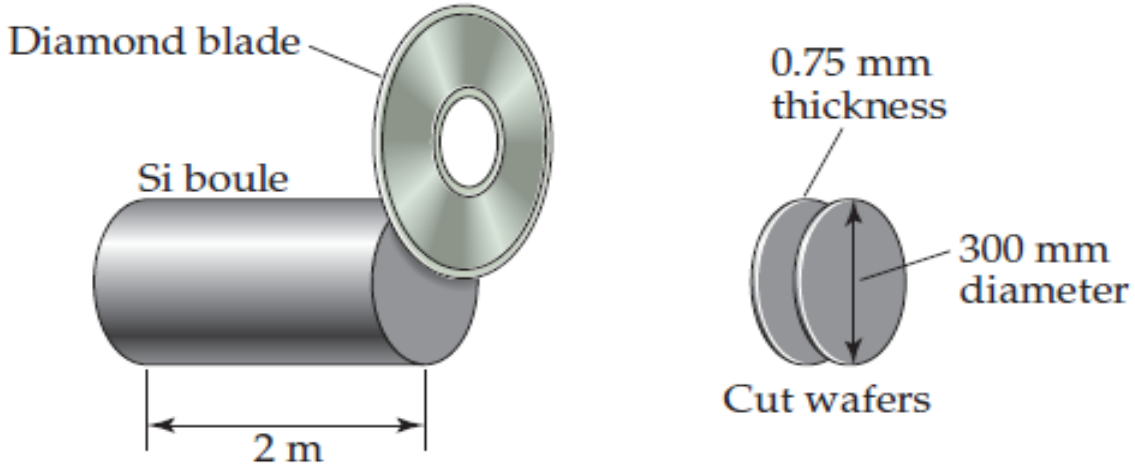
1.62 The indoor concentration of ozone above 300 μg/m^3 is considered to be unhealthy. What mass of ozone in grams is present in a room measuring 3.2 m $\times$ 2.8 m $\times$ 4.1 m?

1.74 Which of the following would you characterize as pure or nearly pure substance? (**a**) stomach acid; (**b**) dry ice; (**c**) ice-cream; (**d**) stainless steel; (**e**) petroleum; (**f**) distilled water; (**g**) carbon monoxide gas; (**h**) compressed air in balloon.

Homework (due 9/26)

1.18 Zirconia, an oxide of zirconium, is often used as an affordable diamond substitute. Just like diamond, it is a colorless crystal which sparkles under sunlight. Which of the following physical properties do you think would help in differentiating between diamond and Zirconia—melting point, density, or physical state?

1.40 Silicon for computer chips is grown in large cylinders called "boules" that are 300 mm in diameter and 2 m in length, as shown. The density of silicon is 2.33 g/cm^3. Silicon wafers for making integrated circuits are sliced from a 2.0-m boule and are typically 0.75 mm thick and 300 mm in diameter. (**a**) How many wafers can be cut from a single boule? (**b**) What is the mass of a silicon wafer? (The volume of a cylinder is given by $\pi r^2 h$, where r is the radius and h is its height.)

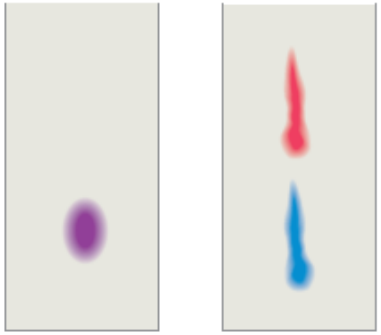


1.65 Classify each of the following as a pure substance, a solution, or a heterogeneous mixture: (**a**) a leaf, (**b**) a 999 gold bar, (**c**) stainless steel.

Homework (due 9/26)

1.68 Ethyl chloride is sold as a liquid (see photo) under pressure for use as a local skin anesthetic. Ethyl chloride boils at 12 °C at atmospheric pressure. When the liquid is sprayed onto the skin, it boils off, cooling and numbing the skin as it vaporizes. (**a**) What changes of state are involved in this use of ethyl chloride? (**b**) What is the boiling point of ethyl chloride in degrees Fahrenheit? (**c**) The bottle shown contains 103.5 mL of ethyl chloride. The density of ethyl chloride at 25 °C is 0.765 g/cm^3. What is the mass of ethyl chloride in the bottle?

1.91 Paper chromatography is a simple but reliable method for separating a mixture into its constituent substances. You have a mixture of two vegetable dyes, one red and one blue, that you are trying to separate. You try two different chromatography procedures and achieve the separations shown in the figure. Which procedure worked better? Can you suggest a method to quantify how good or poor the separation was?



Butterfly-pea flower

1.3 Properties of Matter

- Each substance has a unique set of physical and chemical properties.
  - **Physical properties** can be observed or described without changing the substance (e.g., color, density, odor, melting point, etc.).
  - **Chemical properties** describe how substances react or change to form different substances (e.g., hydrogen burns in oxygen).
  - Properties may be categorized as intensive or extensive.
    - **Intensive properties** do not depend on the amount of substance present (e.g., temperature, melting point, etc.).
    - **Extensive properties** depend on the quantity of substance present (e.g., mass, volume, etc.).
    - Intensive properties give an idea of the composition of a substance, whereas extensive properties give an indication of the *amount* of substance present.

Of the following, which is an extensive property.
A) density
B) volume
C) boiling point
D) freezing point
E) temperature

Which one of the following which is an intensive property?
A) mass
B) temperature
C) length
D) volume
E) amount

1.3 Properties of Matter

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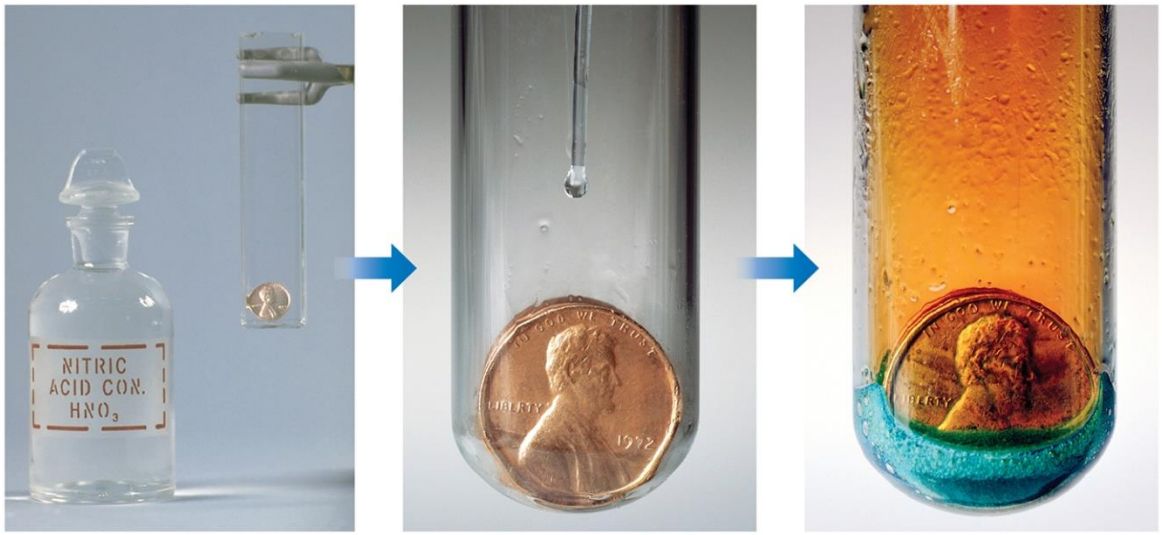
Types of Changes

- **Physical changes** are changes in matter that do *not* change the composition of a substance.
  - Examples include changes of state, temperature, and volume.
- **Chemical changes** result in new substances.
  - Examples include combustion, oxidation, and decomposition.

Chemical Reactions (Chemical Change)



In the course of a chemical reaction, the reacting substances are **converted to new substances**. Here, the copper penny reacts with nitric acid; it gives a blue solution of copper(II) nitrate and a brown gas called nitrogen dioxide.

NOTE: **Physical properties,** like **color**, often helps us SEE that chemical change has occurred.

Of the following, which is a chemical reaction?

A) melting of lead

B) dissolving sugar in water

C) tarnishing of silver

D) crushing of stone

E) dropping a penny into a glass of water

Which of the following are chemical processes?

1. rusting of a nail
2. freezing of water
3. decomposition of water into hydrogen and oxygen gases
4. compression of oxygen gas

Separating Mixtures

- **Mixtures can be separated based on physical properties of the components of the mixture. Some methods used are**
  - **filtration**
  - **distillation**
  - **chromatography**

In filtration, solid substances are separated from liquids and solutions.

Plastic fibres found in tap water around the world

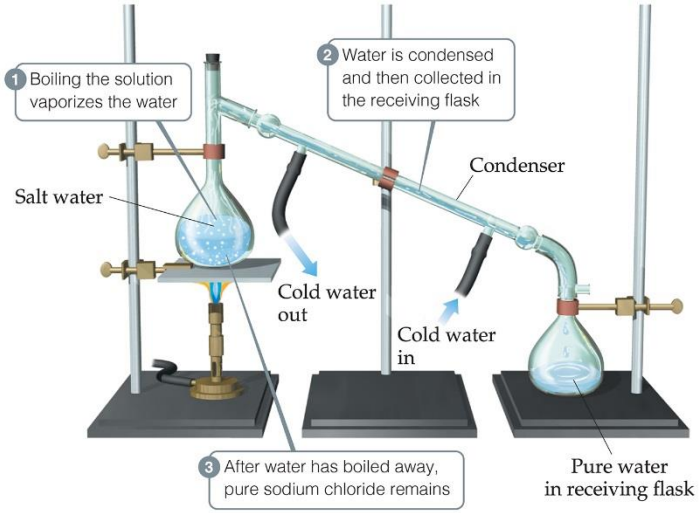
The average number of fibres found in each 500ml sample ranged from 4.8 in the US to 1.9 in Europe.

…people globally are drinking water contaminated by plastic particles.

…alarming numbers of tiny fibers from synthetic fabrics are making their way from your washing machine into aquatic animals…

How to purify water?

Purification/Separation



Distillation -uses differences in the boiling points of substances to separate a homogeneous mixture into its components.

Reverse Osmosis
Using a semipermeable membrane under the pressure

Distilled water, RO water and Deionized water

Are they different or not?

Q: Is it possible to obtain 100 percent pure water? Explain.

To purify water to meet our needs, we do it by take advantage of the differences in physical properties of water and the solutes of particulates it contains.

To improve the odor and flavor of the water, aerate the water is needed. Aeration removes many unpleasant-smelling volatile chemicals such as sulfur compound.

Q: What sulfur compound is likely to be present in water?