McGraw-Hill Ryerson

BC Science Connections 8

BC Science Connections 8

UNIT 2

The behaviour of matter can be explained by the kinetic molecular theory and atomic theory

TOPIC 2.2

What are some ways to describe matter?

Which one is real gold? Which is fake?

real gold

iron pyrite “Fool’s gold”

Link to properties

https://www.sciencephoto.com/media/169995/view/iron-pyrites

https://able2know.org/topic/360097-1

Topic 2.2: What are some ways to describe matter?

- Matter has different properties:
  - Physical properties
  - Chemical properties

Concept 1: Matter can be described by its physical properties.

- **Physical property**:
  - Characteristic of matter that can be observed or measured without changing its chemical identity
  - Can be quantitative or qualitative

Qualitative Physical Properties

- **Qualitative physical properties:**
  - Can be described and compared using words
  - Examples: colour, odour, texture, state

What are the qualitative physical properties of the items shown here?

Quantitative Physical Properties

- **Quantitative physical properties:**
  - Can be measured and assigned a numerical value
  - Examples: boiling point, melting point, mass, volume, density

The boiling point is the temperature at which a liquid becomes a gas. The boiling point of water is 100°C.

ConnectSchool Practice

Warm-up:

Why do kids wear pool floaties when they swim?

Mass and Volume

- All matter (including air!) has two things in common: mass and volume.
- **Mass**: quantity of matter in an object or sample
  - Units:
    - kilogram (kg)
    - gram (g)
    - milligram (mg)

A digital balance showing the mass of a grape.

Mass and Volume

- All matter (including air!) has two things in common: mass and volume.
- **Volume**: amount of space that a material takes up
  - Units:
    - Solid:
      - cubic metres (m^3)
      - cubic centimetres (cm^3)
    - Gas or liquid:
      - litres (L)
      - millilitres (mL)

Are you drinking hot chocolate wrong?

http://foodology.ca/how-to-properly-drink-a-hot-chocolate/

Density: A Physical Property Related to Mass and Volume

- **Density**: quantity of mass in a certain volume of material
  - Units: solid – grams per cubic centimetre (g/cm^3); liquids and gases – grams per millilitre (g/mL)

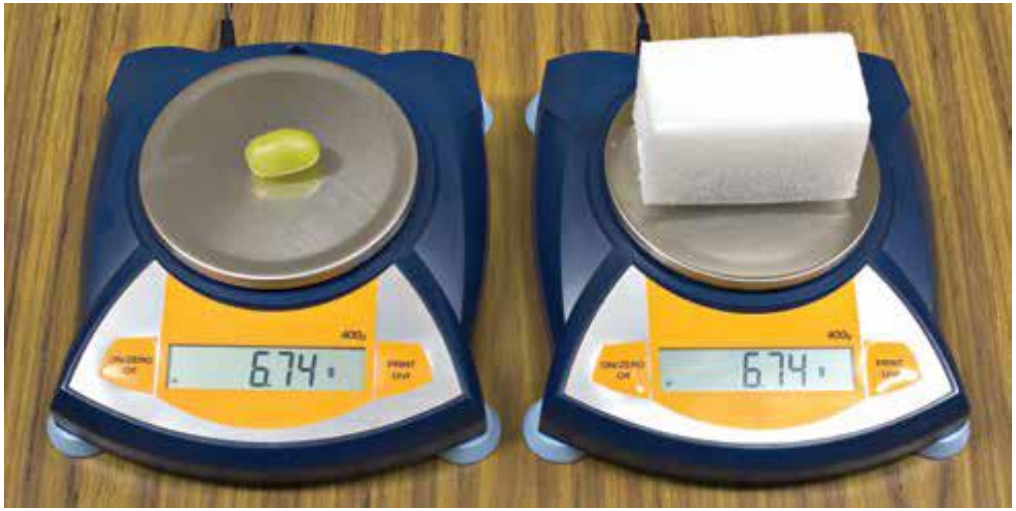


Figure 2.6: The grape and foam have the same mass but different volumes.

Which substance has the greater density? Explain why.

Density: A Physical Property Related to Mass and Volume

Discuss:

1) What is more dense, a gold ring or the entire Pacific ocean?
2) Compare the mass, volume, and density of a bottle of water to a swimming pool.

Determining Density

- Water has a density of 1g/mL
- More dense objects will sink (e.g. gold 19g/cm^3 sinks in water)
- Less dense objects will float (e.g. vegetable oil 0.92g/mL floats in water)

Practice:

1) In water, will copper (9g/cm^3) sink or float?
2) In honey (1.42g/mL), will coal (1.2g/cm^3) sink or float?

Determining Density

Figure 2.7 These liquids have different densities. (Dyes were added to the liquids to help you see the layers.)

List the liquids in the order of most dense to least dense.

https://www.youtube.com/watch?v=-CDkJuo_LYs&ab_channel=SickScience%21

Determining Density

- To determine density, measure the mass and volume and then calculate using this equation:

Density Equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Determining Density

- **Example**: If a sample of jet fuel has a mass of 8.30 g and a volume of 10.3 mL, what is its density?

$$\text{mass} = 8.30\ \text{g}$$

$$\text{volume} = 10.3\ \text{mL}$$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$= \frac{8.30\ \text{g}}{10.3\ \text{mL}}$$

$$= 0.806\ \text{g/mL}$$

The density of water is about 1 g/mL. Therefore the density of jet fuel is less than the density of water (it will float on top of water).

Determining Density

1) The 355 mL cola beverage you are drinking has a mass of 371 grams. What is its density?

mass = 371g volume = 355mL density=?

$$density = \frac{mass}{volume} = \frac{371g}{355mL} = 1.04\frac{g}{mL}$$

2) You have a rock with a volume of 15cm^3 and a mass of 45 grams. What is its density?

volume = 15cm^3 mass = 45g density=?

$$density = \frac{mass}{volume} = \frac{45g}{15cm^3} = 3\frac{g}{cm^3}$$

Determining Density

3) A mystery liquid in the graduated cylinder weighs 24.3 g.

a. What is its density?

Mass=24.3g
Volume=30mL

$$density = \frac{mass}{volume} = \frac{24.3g}{30mL} = 0.81\frac{g}{mL}$$

Density of Various Liquids

Liquid	Density (g/cm^3)
acetone	0.792
alcohol (ethyl)	0.791
alcohol (methyl)	0.810
gasoline	0.66-0.69
corn syrup	1.38
castor oil	0.969
olive oil	0.918
linseed oil	0.942
vegetable oil	0.91-0.93
turpentine	0.87
water	1.00

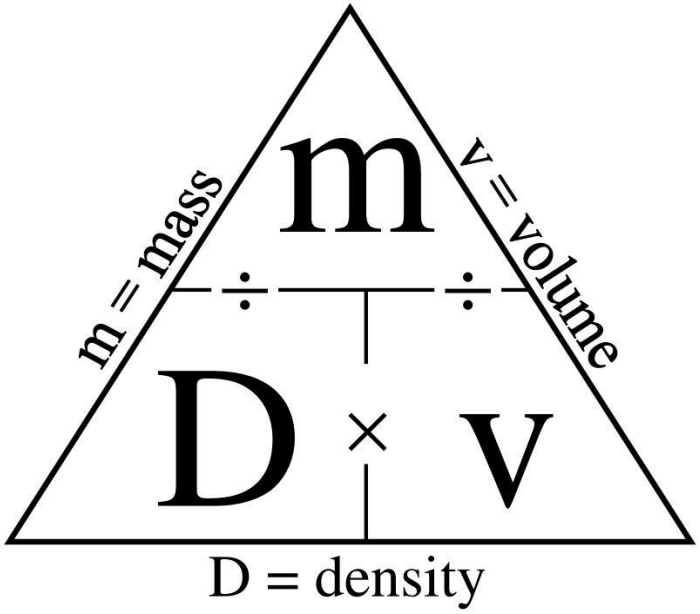
b. What is the identity of the liquid?

methyl alcohol

Other Density Calculations

Density Triangle:

- If you know two of the three values, then you can calculate the third.
- Cover up the unknown; triangle will tell you the formula to use!
  - $density = mass \div volume$
  - $volume = mass \div density$
  - $mass = density \times volume$



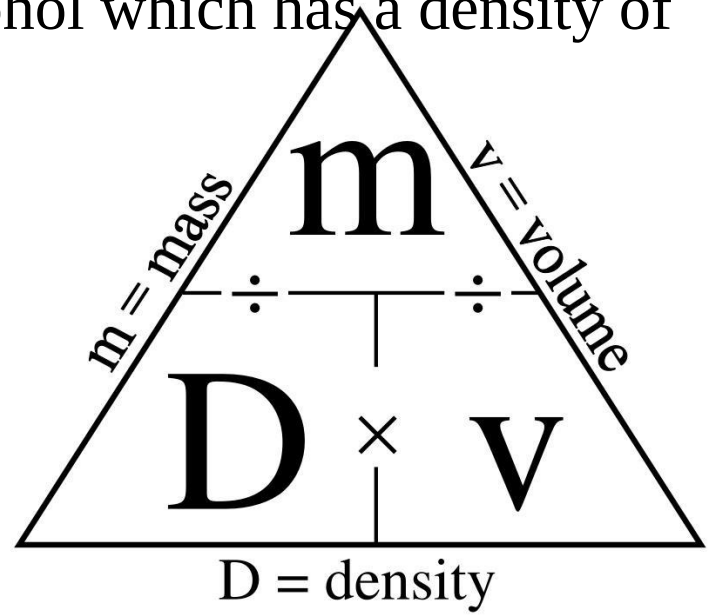
Other Density Calculations

Note on units: dividing a unit by the same unit will 'cancel' them out.

4) Suppose you have a piece of chalk with a density of 2.5g/cm^3. The chalk weighs 10g. What is the volume of your piece of chalk?

5) What is the mass of 150 mL of alcohol which has a density of 0.8g/mL?

6) Calculate the density of a ring that weighs 6.5g and has a volume of 1.2cm^3.



Other Density Calculations

Note on units: dividing a unit by the same unit will 'cancel' them out.

4) Suppose you have a piece of chalk with a density of $2.5\,\frac{g}{cm^3}$. The chalk weighs 10g. What is the volume of your piece of chalk?

1. Write knowns and unknowns. $density = 2.5\,\frac{g}{cm^3}$ $mass = 10g$ $volume = ?$

2. Write formula. $volume = mass \div density$

3. Plug in values (with units). $= 10g \div \frac{2.5g}{cm^3}$

$= 10g \times \frac{cm^3}{2.5g}$

4. Write answer (with units). $= 4cm^3$

Think: dividing by fraction… multiply by reciprocal!

g divided by g 'cancels out'; left with cm^3 only, which is a unit of volume!

Other Density Calculations

Note on units: dividing a unit by the same unit will 'cancel' them out.

5) What is the mass of 150 mL of alcohol which has a density of 0.8g/mL?

1. Write knowns and unknowns. $density = 0.8\frac{g}{mL}$ $mass = ?$ $volume = 150mL$
2. Write formula. $mass = density \times volume$
3. Plug in values (with units). $= 0.8\frac{g}{mL} \times 150mL$
4. Write answer (with units). $= 120g$

mL divided by mL 'cancels out'; left with g only, which is a unit of mass!

Other Density Calculations

Note on units: dividing a unit by the same unit will 'cancel' them out.

6) Calculate the density of a ring that weighs 6.5g and has a volume of 1.2cm^3.

1. Write knowns and unknowns. $density = ?$ $mass = 6.5g$ $volume = 1.2cm^3$

2. Write formula. $density = mass \div volume$

3. Plug in values (with units). $= 6.5g \div 1.2cm^3$

4. Write answer (with units). $= 5.42 \frac{g}{cm^3}$

Discussion Questions

- What is a physical property? Give three examples as part of your answer.

- What is the difference between a qualitative property and a quantitative property?

Concept 2: Matter can be described by its chemical properties.

- **Chemical property**:
  - Ability of matter to react with another substance to form one or more new substances
  - Can only be observed when a substance chemically interacts with another substance

Reactivity with acids is a chemical property. A gas forms when baking soda is mixed with vinegar (acid).

Chemical Properties: Examples

- **Reactivity with acids**:
  - Some substances react vigorously with acids and others do not
  - Example: baking soda and vinegar produce a gas

- **Reactivity with oxygen**:
  - Substances in some foods react with oxygen when exposed to air
  - Example: avocadoes turning brown

Chemical Properties: Examples

- **Combustibility**:
  - Ability of material to catch fire and burn in the air
  - Example: burning wood

- **Lack of reactivity**:
  - Substances that do not react with other substances are "inert"
  - Example: helium in balloons

Chemical and Physical Properties

[link to 'quiz']

Is the example below a chemical property or a physical property?

Iron rusts

Chemical Property

Physical Property

Discussion Questions

- What is the main difference between physical and chemical properties?

- Explain why melting point is not a chemical property.

Concept 3: Matter can be described based on physical and chemical changes.

- Matter can be described based on:
  - Physical changes
  - Chemical changes

Figure 2.10: Preparing a meal involves many physical and chemical changes.

Physical Changes

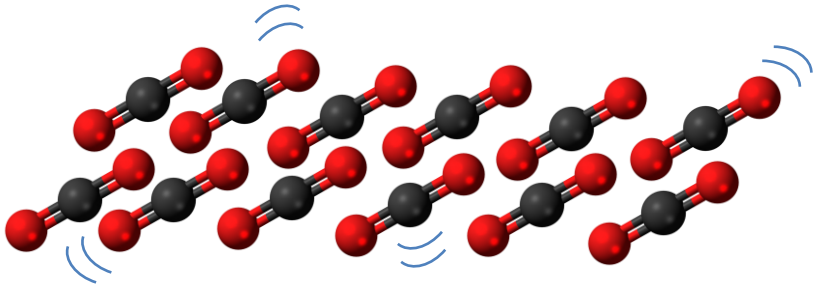
- **Physical change**:
  - Change of matter that does not alter its chemical identity or composition
  - Example: freezing of water (liquid) to form ice (solid)

Figure 2.9: Freezing is a physical change

Physical Changes

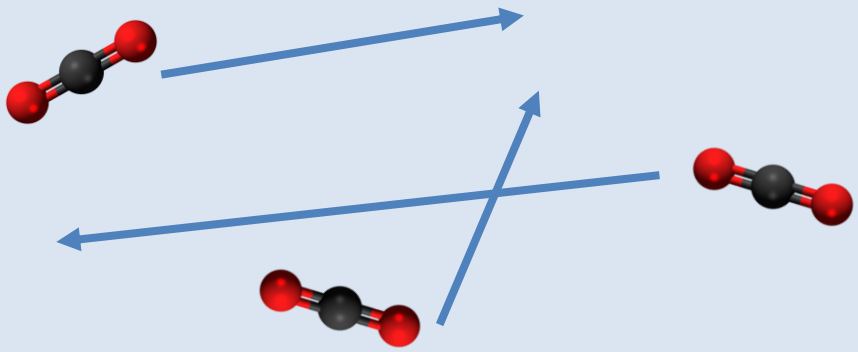
E.g. carbon dioxide (CO_2) sublimating

Before Dry ice
(solid CO_2)



(in a solid, molecules vibrate: low energy)

After Carbon dioxide gas
(gaseous CO_2)

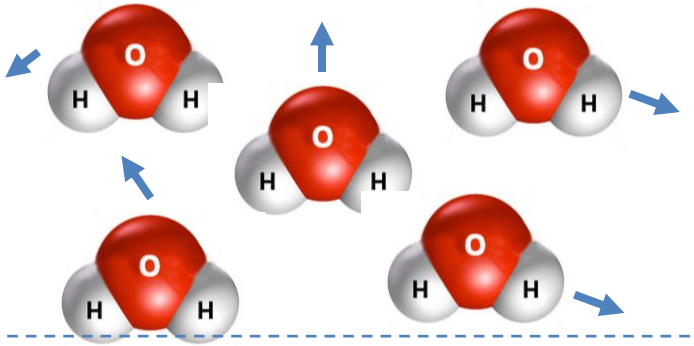


(in a gas, molecules move very fast: high energy)

Physical Changes

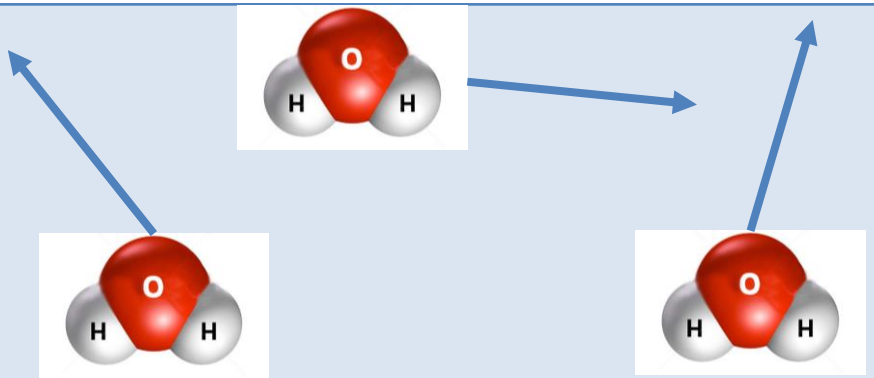
E.g. water (H_2O) evaporating

Before Water (liquid H_2O)



(in a liquid, molecules slip past each other: medium energy)

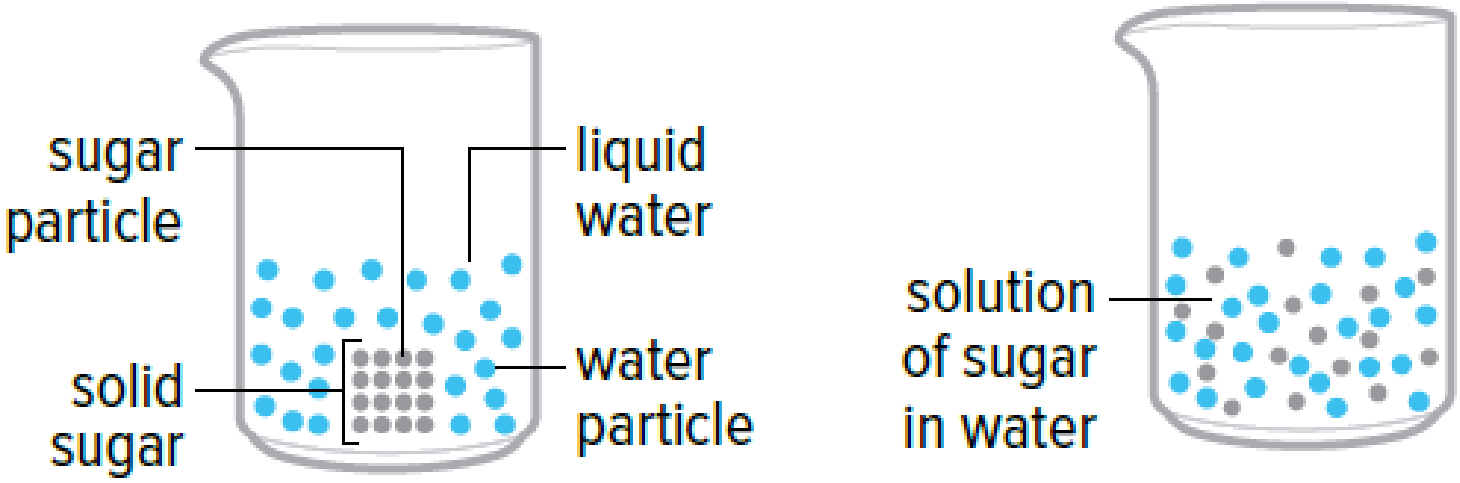
After Water vapour (gaseous H_2O)



(in a gas, molecules move very fast: high energy)

Physical Changes

E.g. sugar dissolving in water (H_2O)

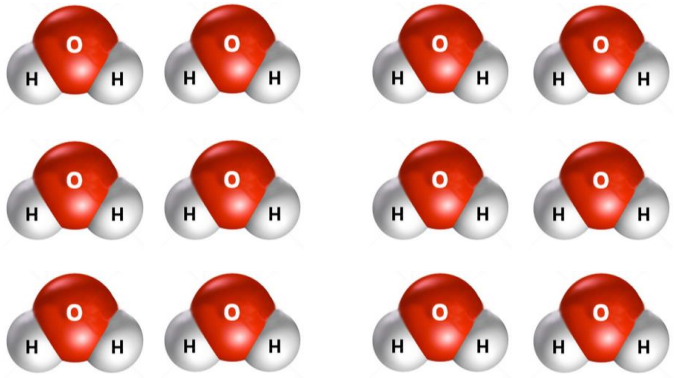


Physical Changes

E.g. breaking things into smaller pieces

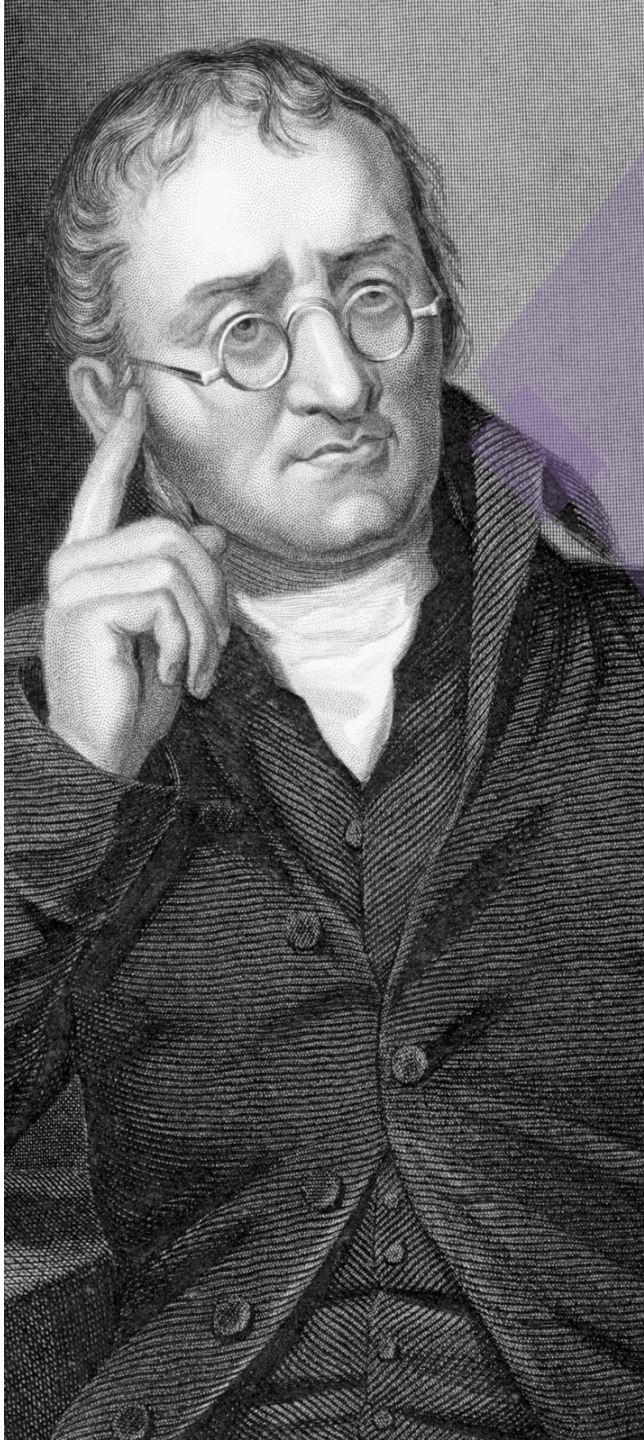
Physical Changes

E.g. breaking things into smaller pieces



Review from 2.4: (Dalton's Atomic Theory)

1. All matter is made of extremely small particles called atoms.
2. Atoms cannot be created, destroyed, or divided.
3. All atoms of the same element are identical in size, mass, and chemical properties. Atoms of a specific element are different from those of another element.
4. Different elements combine in simple whole-number ratios to form compounds. **In a chemical reaction, atoms are separated, combined, or rearranged.**



Chemical Changes

- **Chemical change**
  - Change of matter that produces new substances
  - Example: toasting bread (evidence of new substances forming: colour, texture, and smell of bread change when you toast it)

Toasting bread involves chemical changes.

Chemical Changes

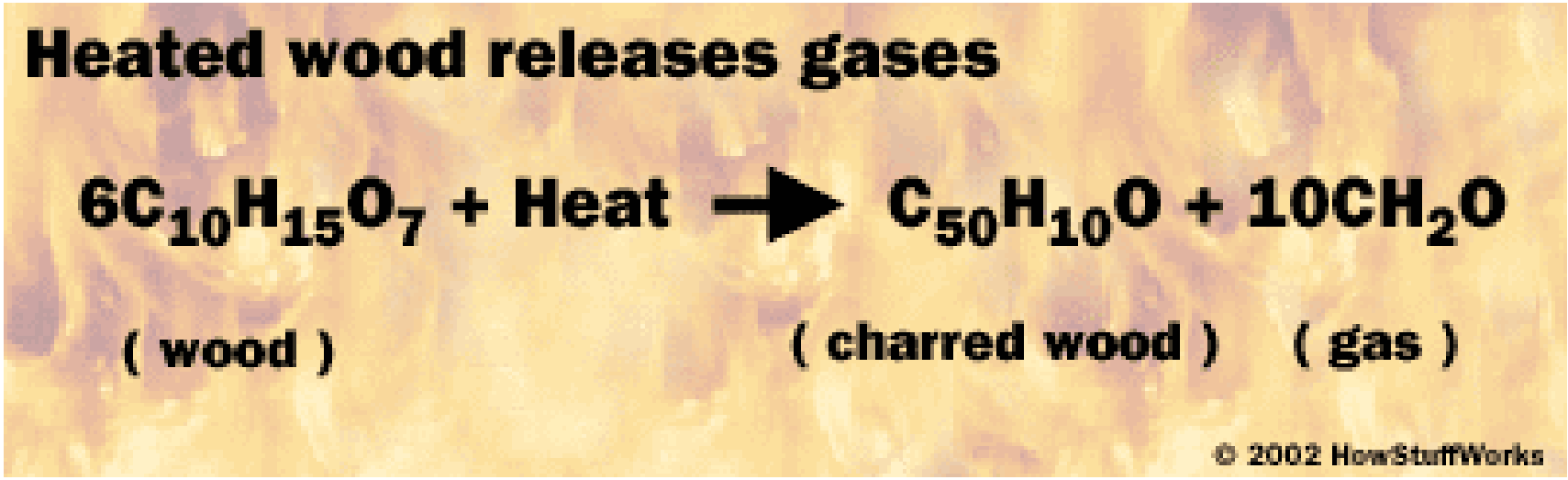
Signs of Chemical Change:*

- *Impossible to 'get back' starting ingredients*
- Permanent change in physical properties:
  - Smell
  - Taste
  - Colour
  - Texture
- Bubbling (gas produced)
- Formation of solid
- Release of heat or light

*Chemical changes will often have multiple things on this list. However, physical changes (especially change of state) may sometimes show some of these signs: so be careful.

Chemical Changes

E.g. wood burning



Chemical Changes

E.g. hydrogen peroxide (H_2O_2) decomposing

https://www.youtube.com/watch?v=3Tn-7JcZJuQ&ab_channel=ISTscience

Chemical or Physical Changes? [link]

The Law of Conservation of Mass

- **Antoine and Marie-Anne Lavoisier**
  - Carried out many chemical reactions where they measured the mass of the substances before (reactants) and after (products)
  - Mass did not change when a chemical reaction took place

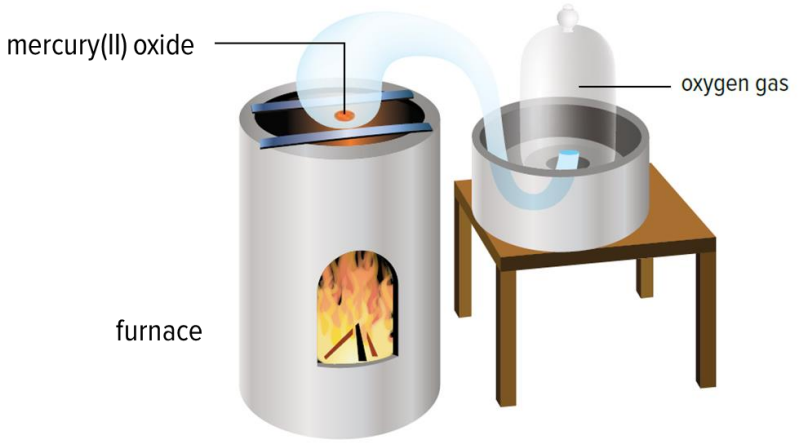


Figure 2.11 Lavoisier's experiment.

Lavoisier's Experiment

- **Reactants**: Sealed mercury(II) oxide (red powder) in a container
- **Products (after heating)**: Liquid mercury and oxygen gas
- Mass of the reactants always equaled the mass of the products

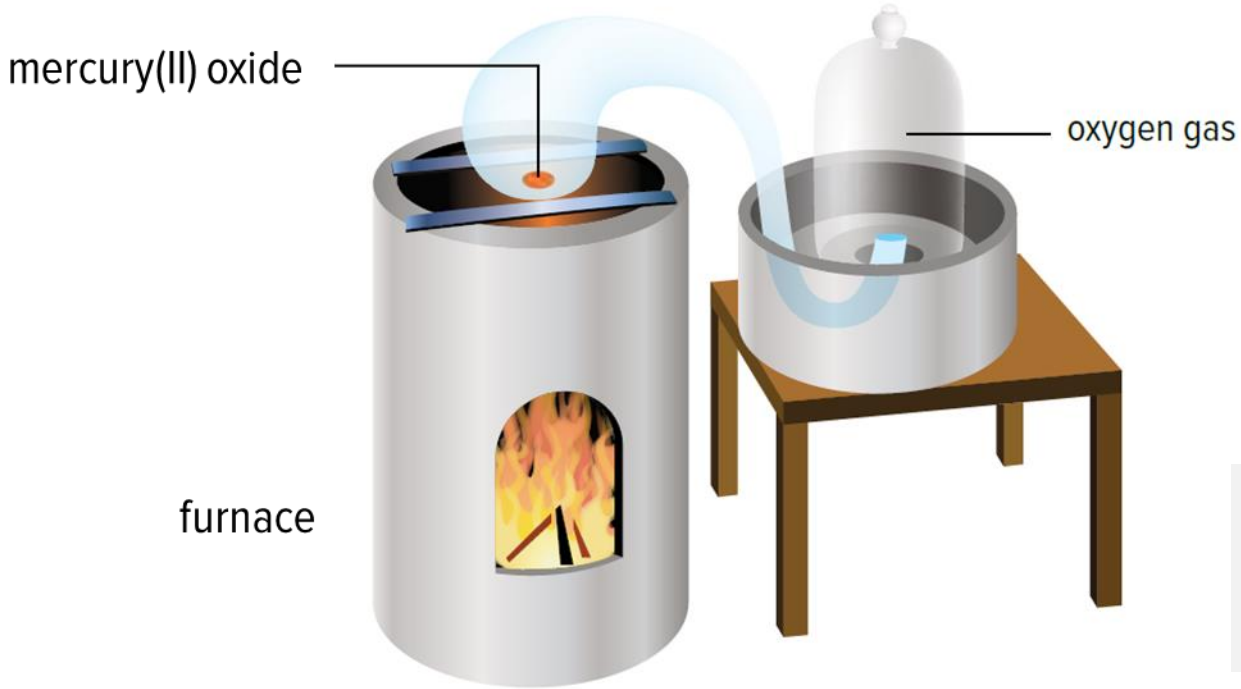


Figure 2.11 Lavoisier's experiment.

The Law of Conservation of Mass

mass of reactants = mass of products

- In any chemical reaction, the total mass of the products is the same as the total mass of the reactants

Discussion Questions

- What is the main difference between a physical change and chemical change?

- State the law of conservation of mass in your own words.

Discussion Questions

- In Lavoisier's experiments, why was it important that the container be sealed? Explain your answer.

Concept 4: Matter can be classified based on how it responds to physical and chemical changes.

- Matter can be either a
  - Mixture
  - Pure substance
    - Compounds
    - Elements

A mixture of iron filings and sand (top); Lights that contain neon gas, an element (bottom)

Mixtures

- Mixtures
  - Can be separated into parts by physical changes

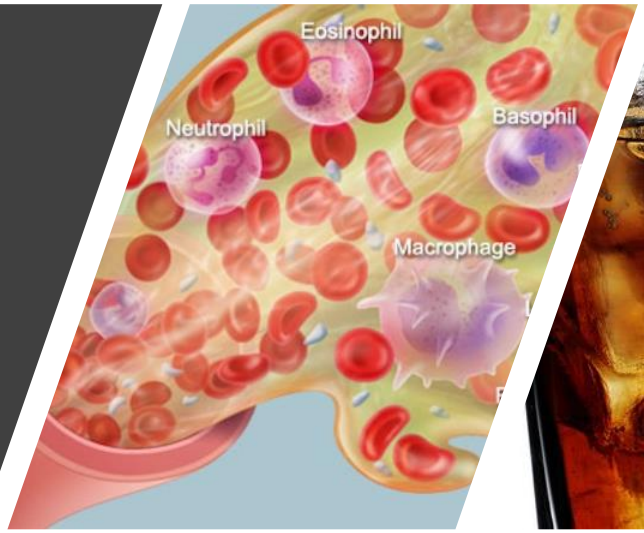
Example: a mixture of iron filings and sand can be separated using a magnet

Mixtures

- Mixtures
  - Can be separated into parts by physical changes
    - Parts have different identities
  - Combination of two or more pure substances
  - Components retain their chemical and physical properties

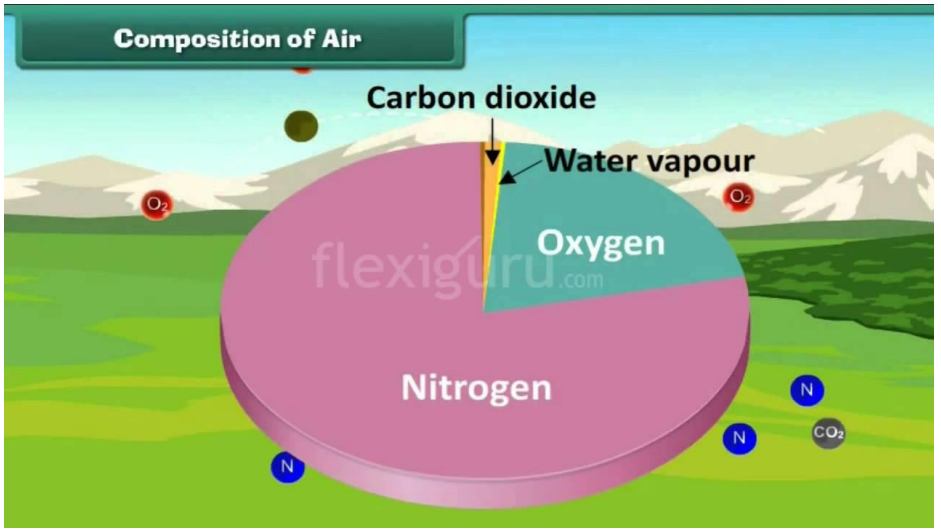
Heterogeneous Mixtures

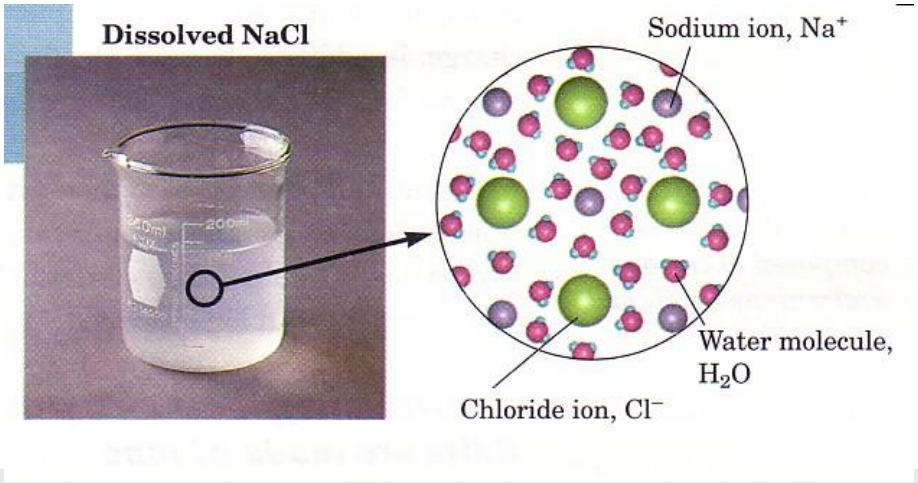
- Non-uniform composition
- Can tell apart different components by looking with human eye or microscope



Homogenous Mixtures

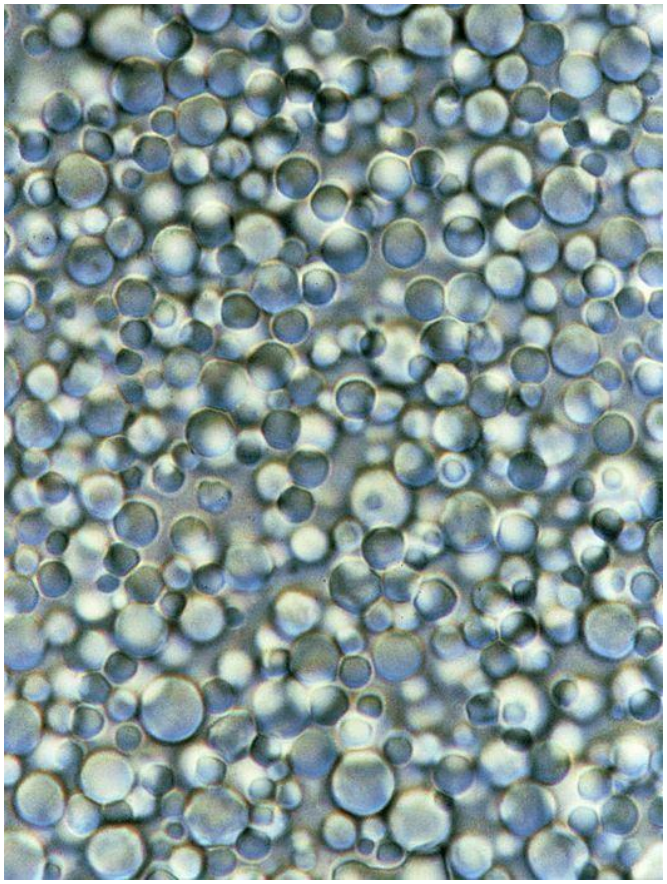
- Uniform composition
- Small particles, evenly distributed; cannot see particles even with a microscope
- E.g. solutions, alloys





Practice: Homogenous or Heterogeneous?

Practice: Homogenous or Heterogeneous?



Milk under light microscope, 2800x

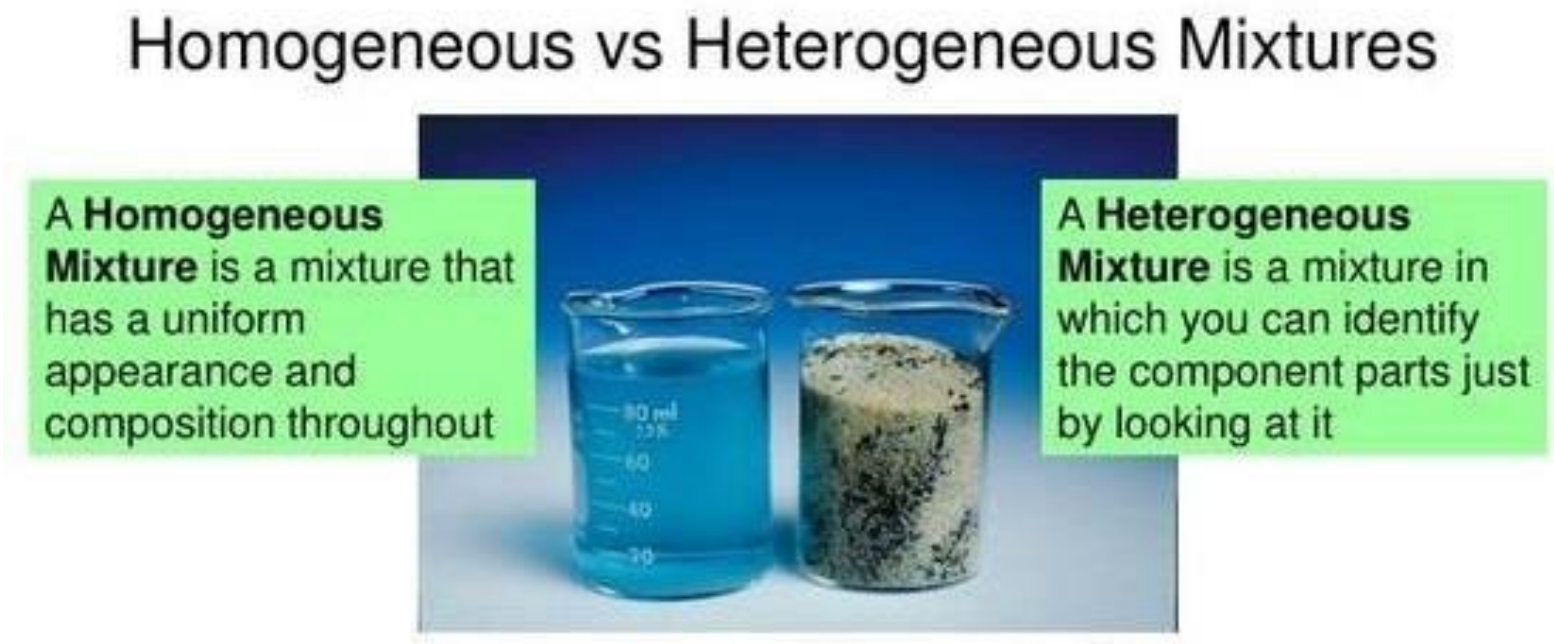
Summary

Homogenous

- Uniform composition
- Small particles, evenly distributed

Heterogeneous

- Non-uniform composition



Pure Substances: Compounds

- Pure substances: Compounds
  - Can be broken down into two or more elements by chemical changes but not physical changes

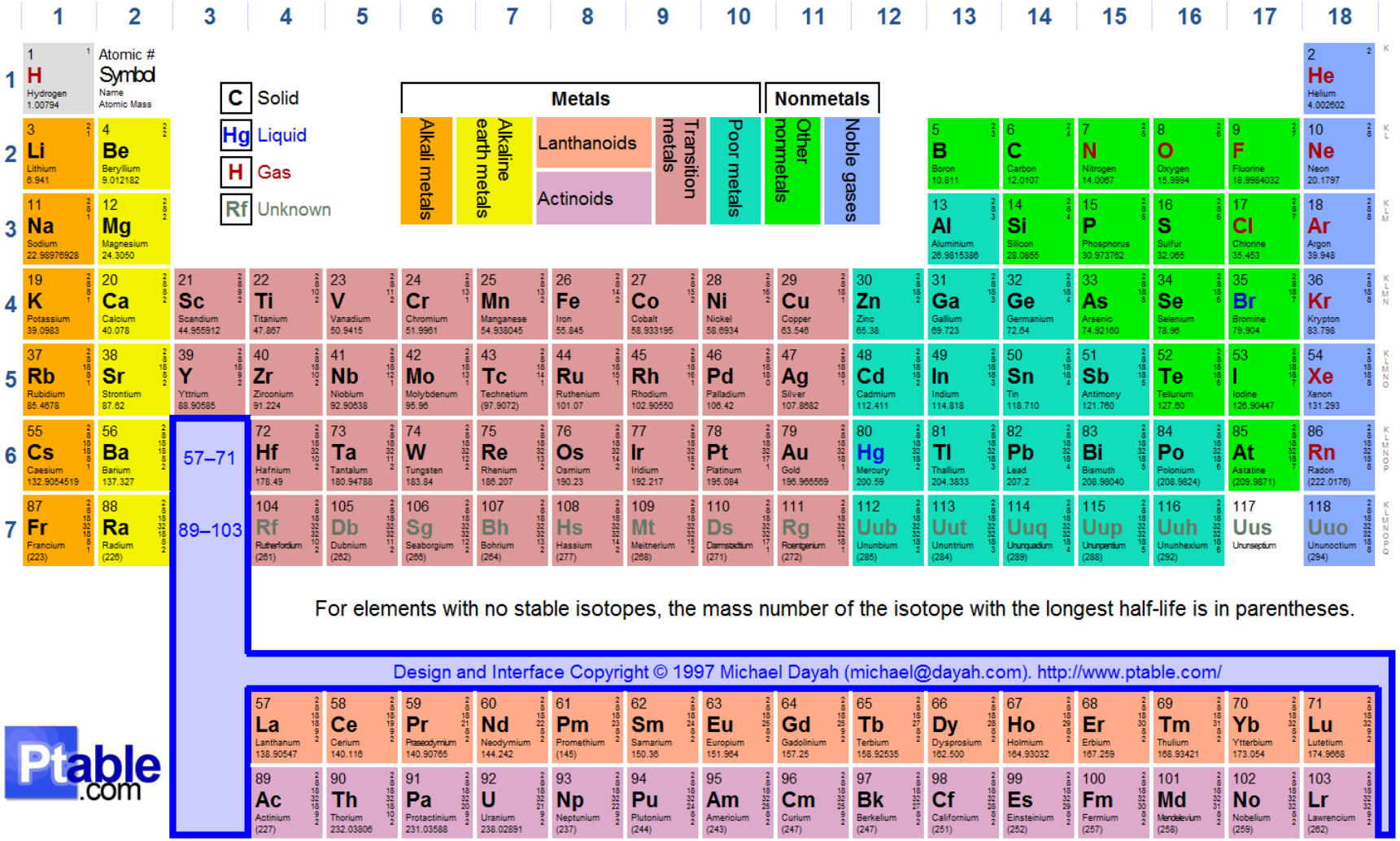
Example: Passing an electric current through water produces the elements hydrogen and oxygen.

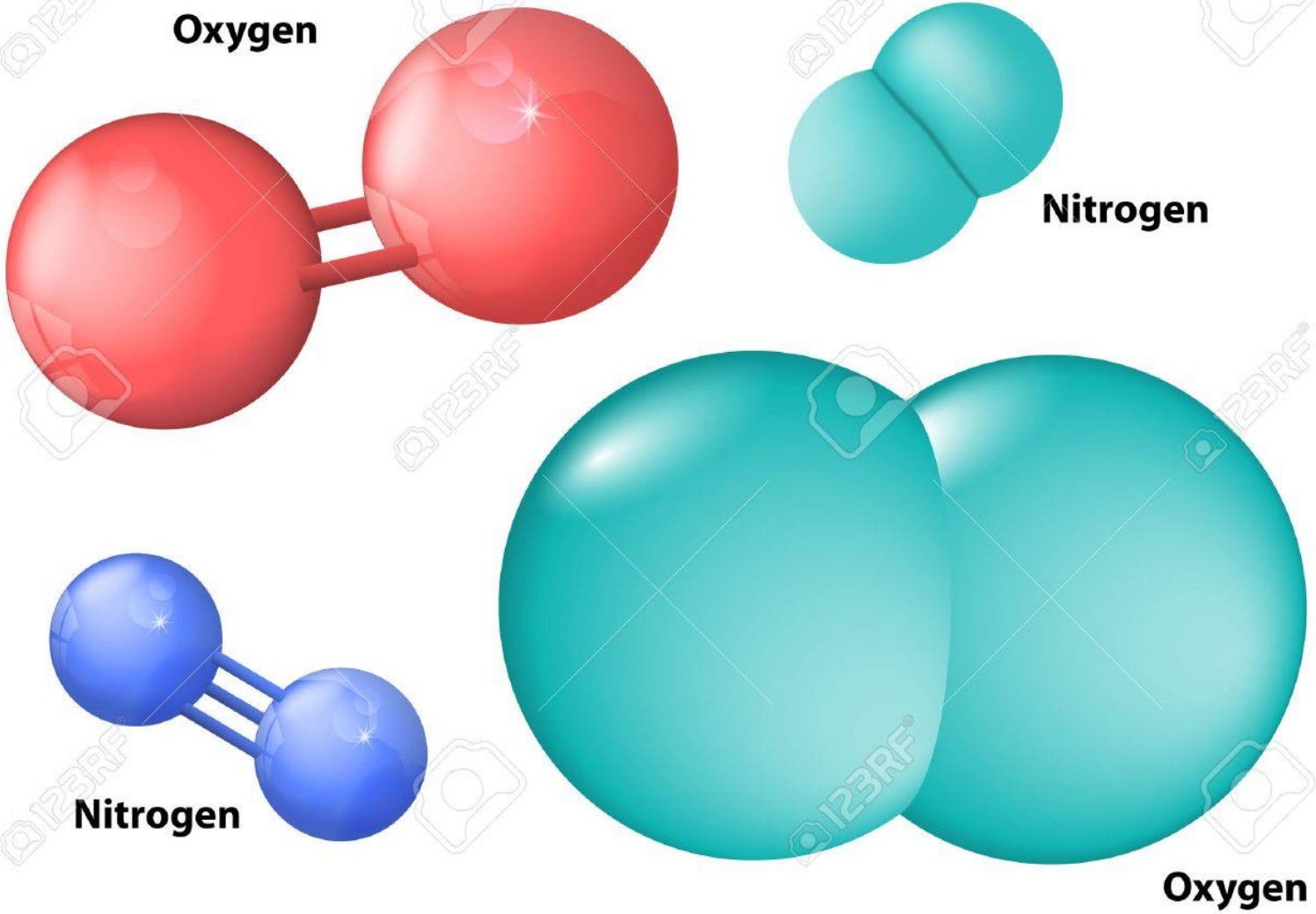
Pure Substances: Elements

- Pure substances: Elements
  - Cannot be separated or broken down by physical or chemical changes

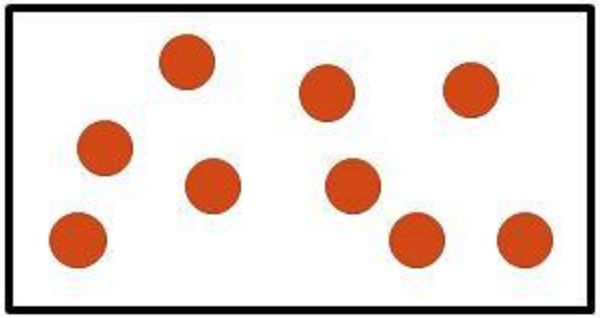
Example: These lights contain neon gas, an element.

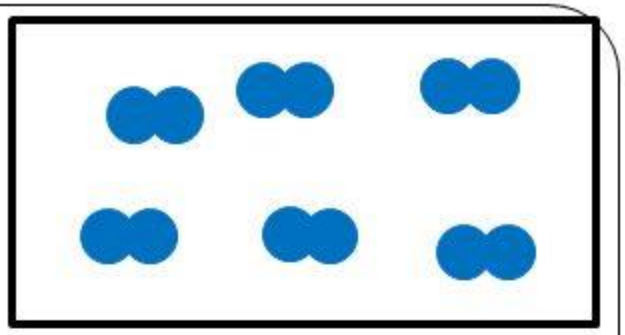
Periodic Table of Elements



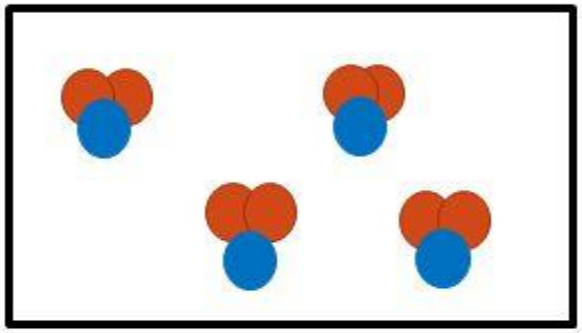


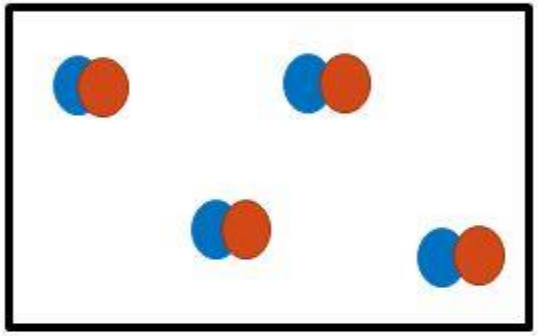
ELEMENTS:



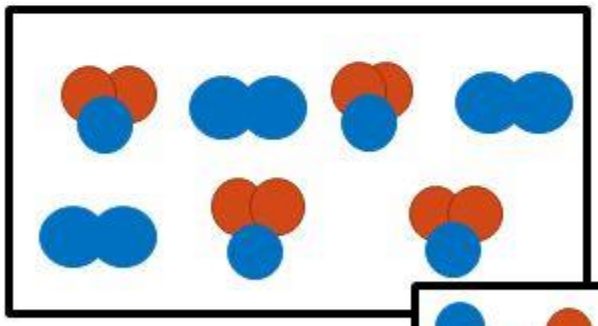


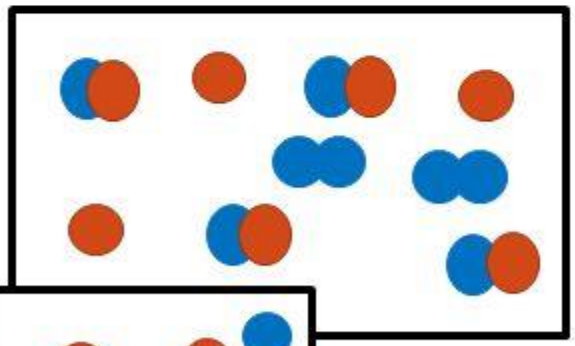
COMPOUNDS:

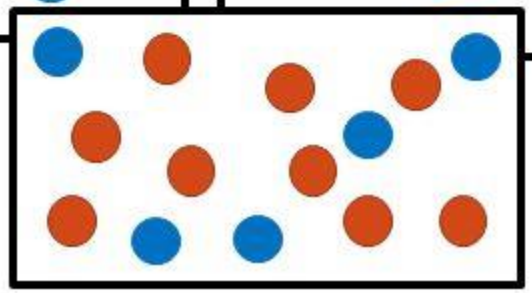


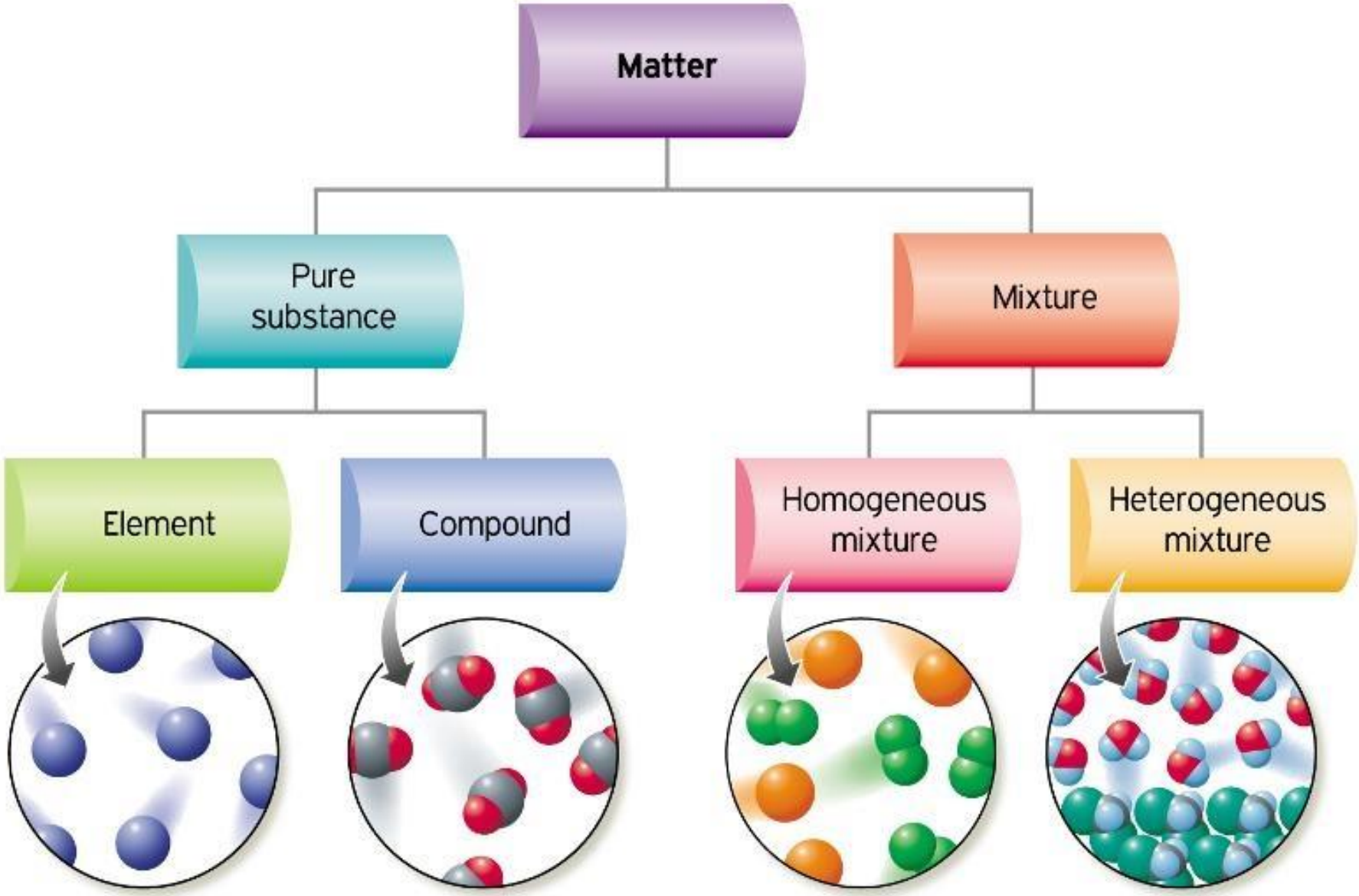


MIXTURES:








Matter
Pure substance
Mixture
Element
Compound
Homogeneous mixture
Heterogeneous mixture

Discussion Questions

- Classify each of the following as a mixture or a pure substance:
  a) oxygen
  b) lemonade
  c) mercury(ii) oxide

Summary: What are some ways to describe matter?

- Matter can be described by its physical properties.
- Matter can be described by its chemical properties.
- Matter can be described by on physical and chemical changes.
- Matter can be classified based on how it responds to physical and chemical catches.