

McGraw-Hill Ryerson

**BC Science
CONNECTIONS**

A large, light purple number '8' is positioned on the right side of the page, partially overlapping the word 'CONNECTIONS'.

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](#)

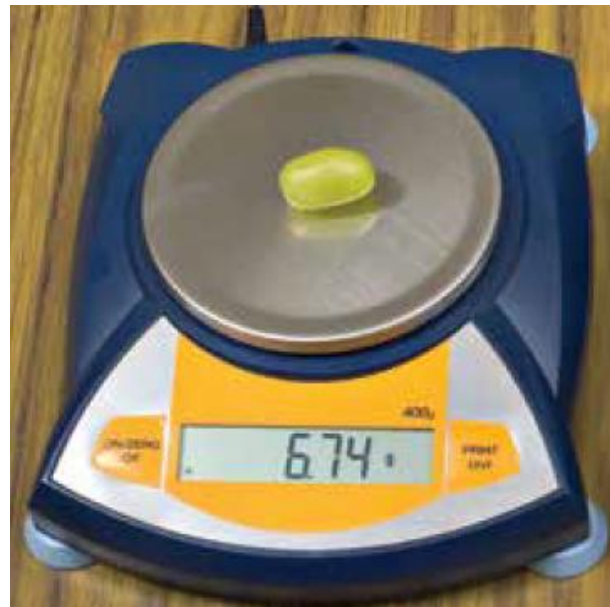
Warm-up:

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)



36L

28L

W's 26L

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/cm³ 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/cm³) sink or float?
- 2) In honey (1.42g/mL), will coal (1.2g/cm³) 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?

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

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

$$\begin{aligned} \text{density} &= \frac{\text{mass}}{\text{volume}} \\ &= \frac{8.30 \text{ g}}{10.3 \text{ mL}} \\ &= 0.806 \text{ g/mL} \end{aligned}$$

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?

$$\text{mass} = 371\text{g} \qquad \text{volume} = 355\text{mL} \qquad \text{density}=?$$

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

- 2) You have a rock with a volume of 15cm³ and a mass of 45 grams. What is its density?

$$\text{volume} = 15\text{cm}^3 \qquad \text{mass} = 45\text{g} \qquad \text{density}=?$$

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

Determining Density

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

a. What is its density?

Mass=24.3g

Volume=30mL

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

b. What is the identity of the liquid?

methyl alcohol



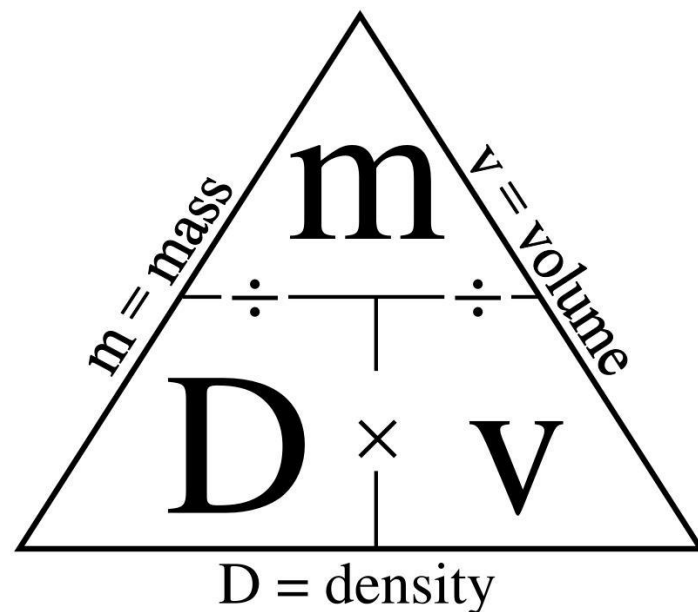
Density of Various Liquids

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

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!
 - $\text{density} = \text{mass} \div \text{volume}$
 - $\text{volume} = \text{mass} \div \text{density}$
 - $\text{mass} = \text{density} \times \text{volume}$



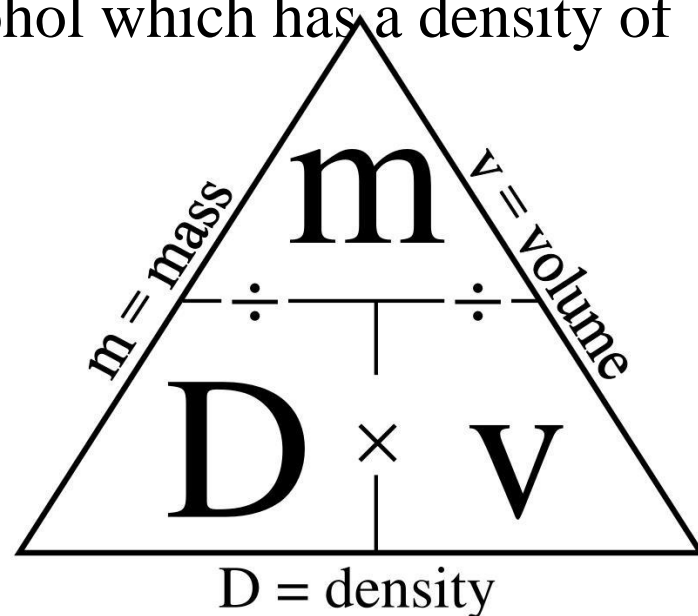
Other Density Calculations

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 $2.5\text{g}/\text{cm}^3$. 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 $0.8\text{g}/\text{mL}$?


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?

- Write knowns and unknowns. $density = 2.5 \frac{g}{cm^3}$ $mass = 10g$ $volume = ?$
- Write formula. $volume = mass \div density$
- Plug in values (with units). $= 10g \div \frac{2.5g}{cm^3}$
 $= 10g \times \frac{cm^3}{2.5g}$
 $= 4cm^3$


Think: dividing by fraction... multiply by reciprocal!

g divided by g 'cancels out'; left with cm^3 only, which is a unit of volume!
- Write answer (with units).

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 1.2cm³.

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: avocados 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)

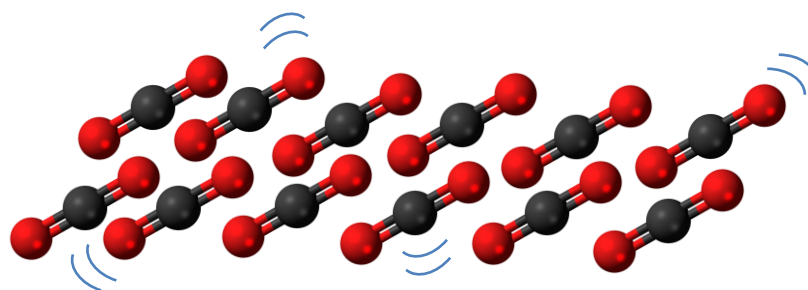


Figure 2.9: Freezing is a physical change

Physical Changes

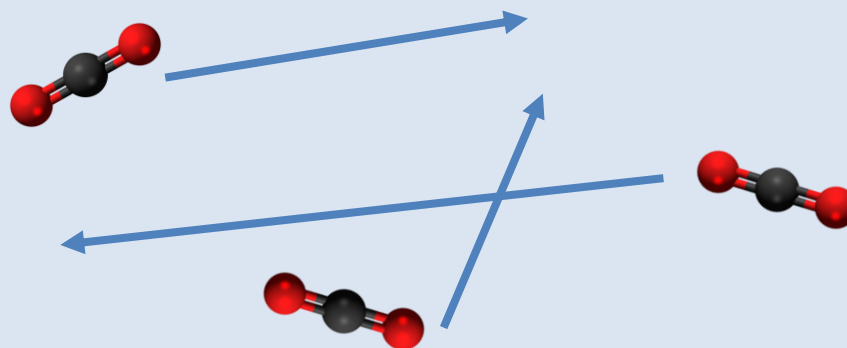
E.g. carbon dioxide (CO_2) sublimating

Before Dry ice
(solid CO_2)



(in a solid, molecules vibrate: low energy)

After Carbon dioxide gas
(gaseous CO_2)

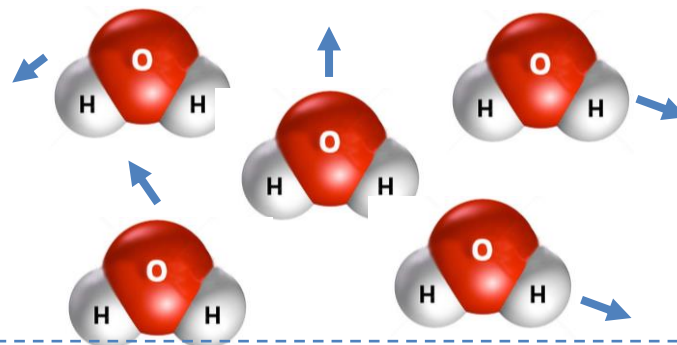


(in a gas, molecules move very fast: high energy)

Physical Changes

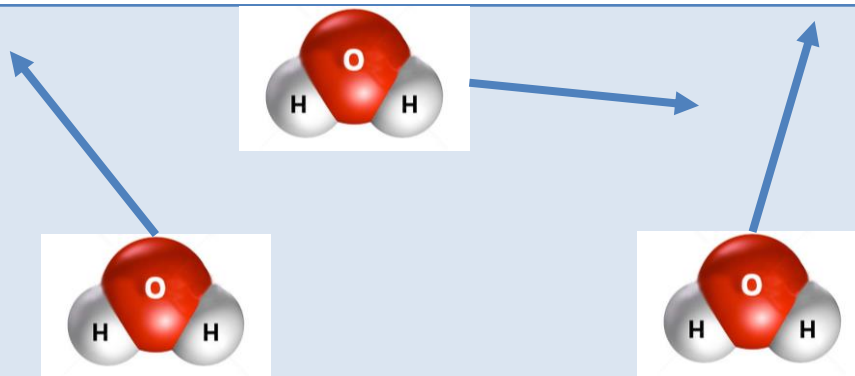
E.g. water (H_2O) evaporating

Before Water
(liquid H_2O)



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

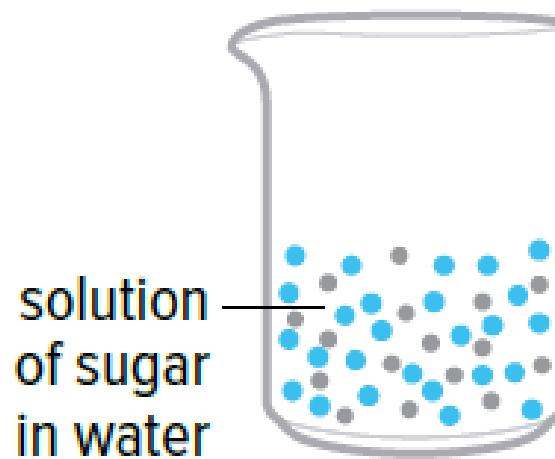
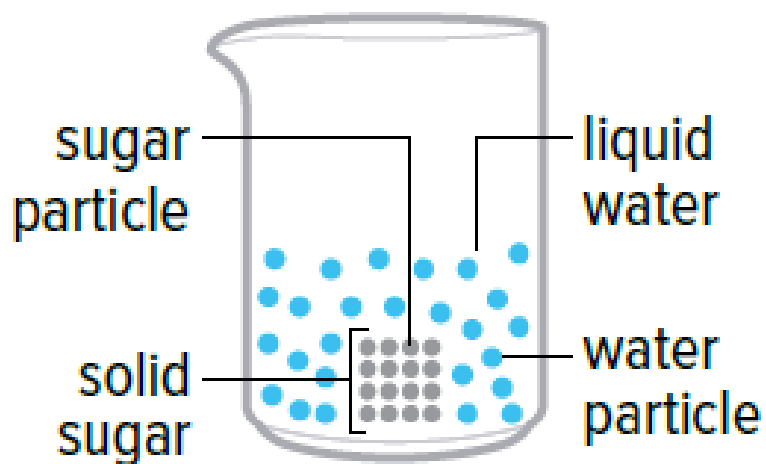
After Water vapour
(gaseous H_2O)



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

Physical Changes

E.g. sugar dissolving in water (H_2O)



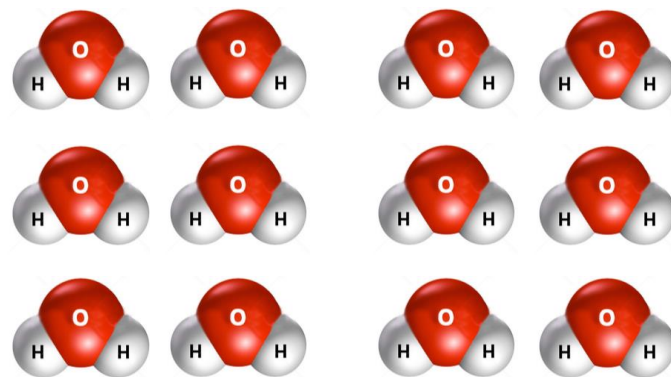
Physical Changes

E.g. breaking things into smaller pieces



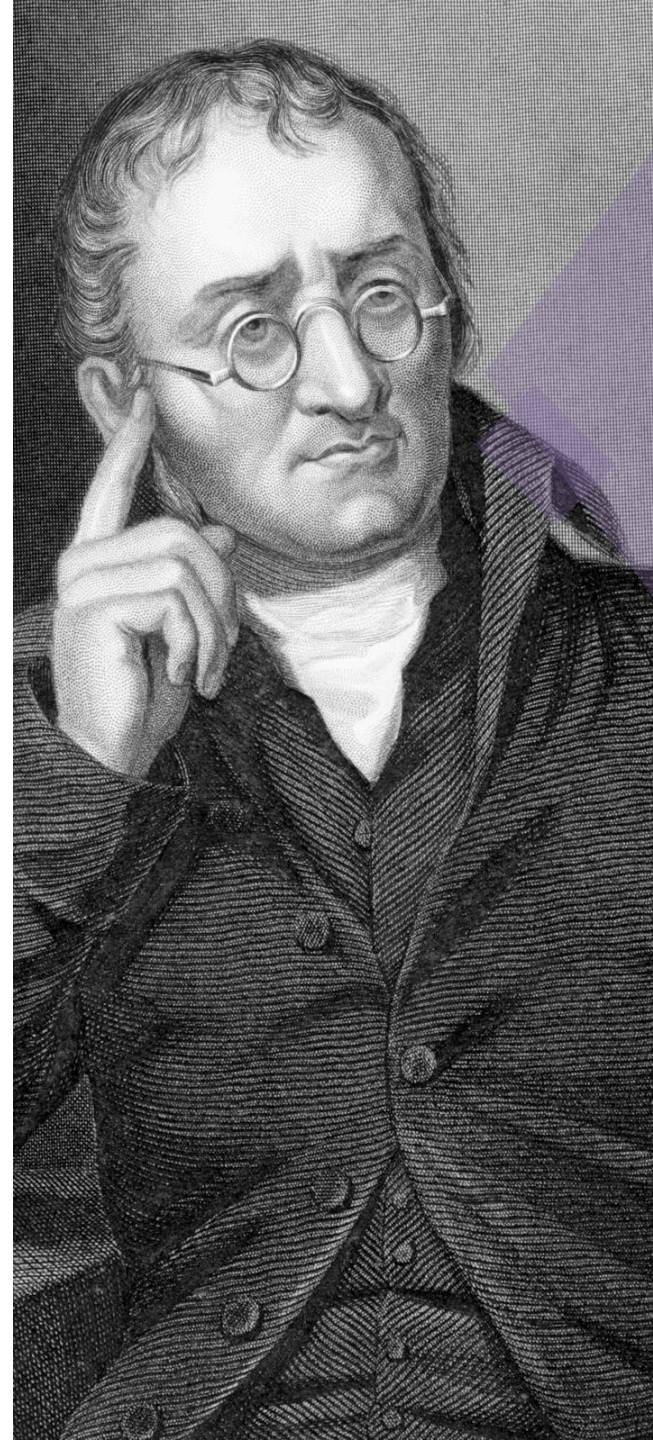
Physical Changes

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

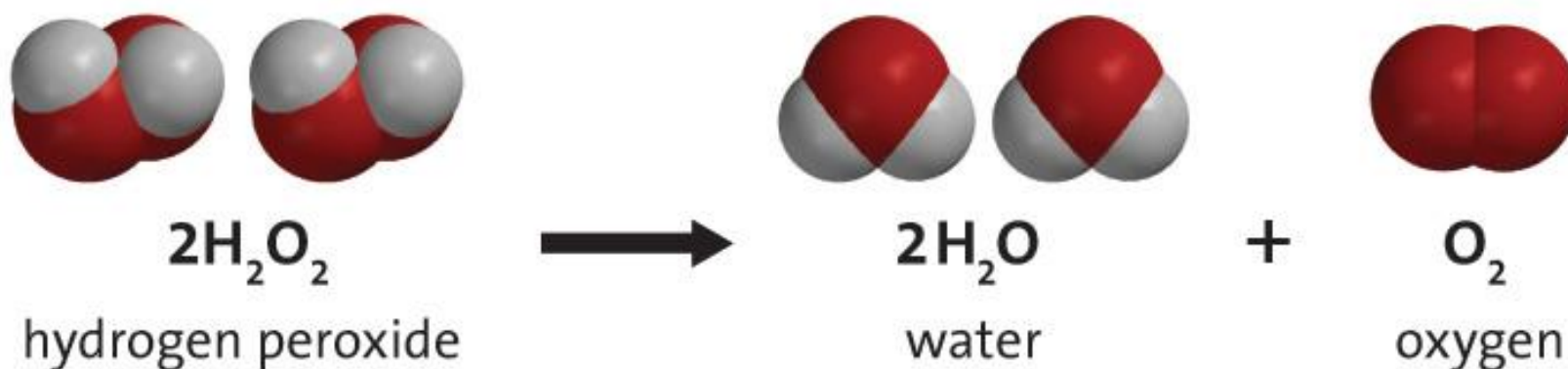
Signs of Chemical Change:*

- *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. 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

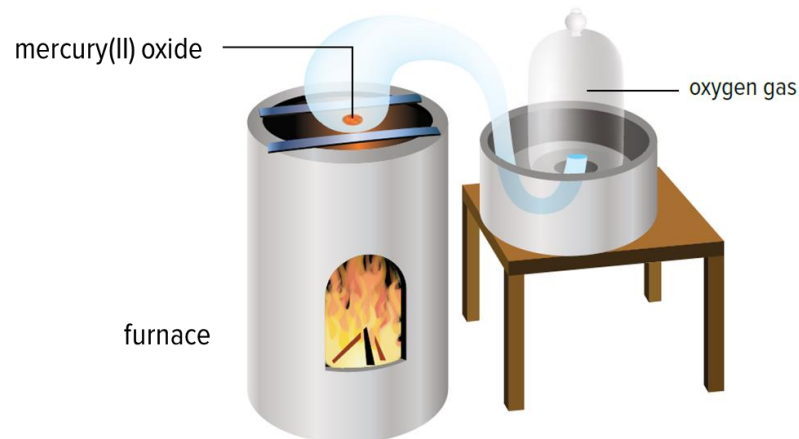


Figure 2.11 Lavoisier's experiment.

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

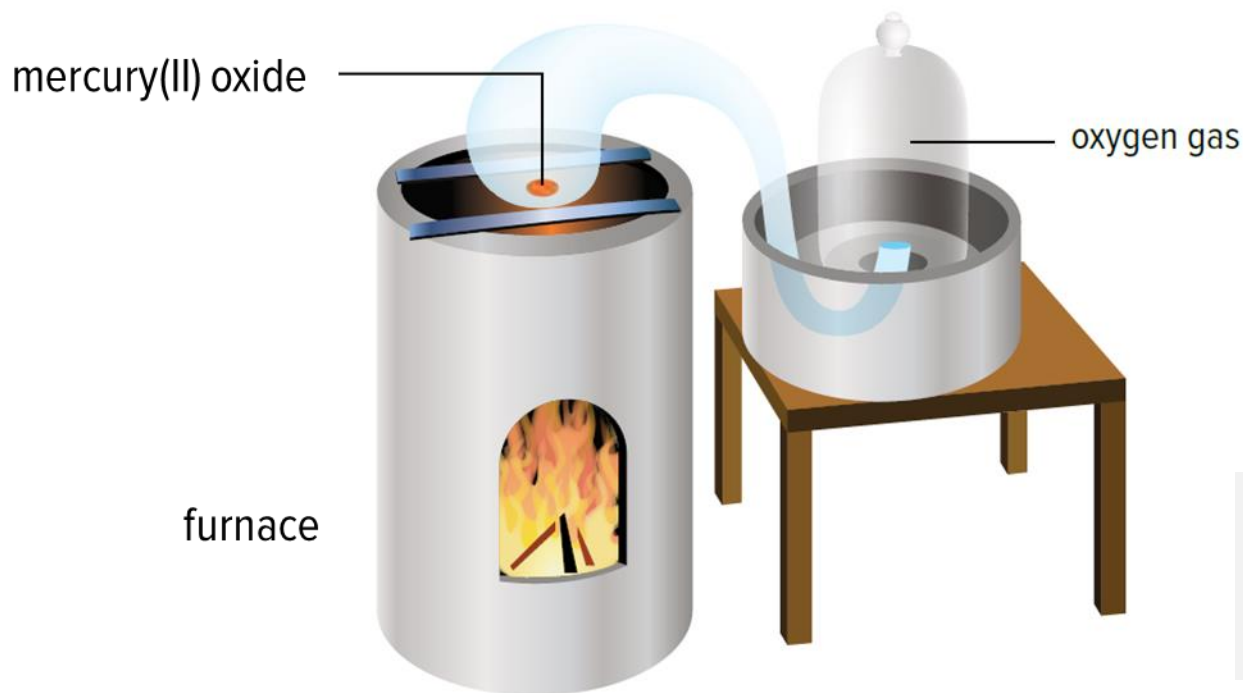


Figure 2.11
Lavoisier's
experiment.

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

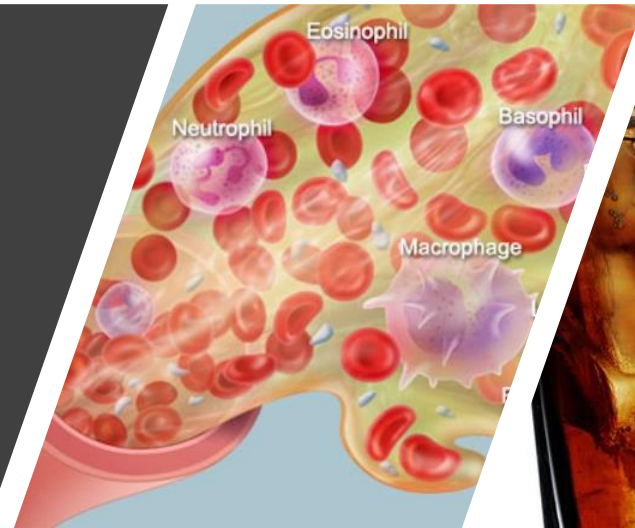


Mixtures

- 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

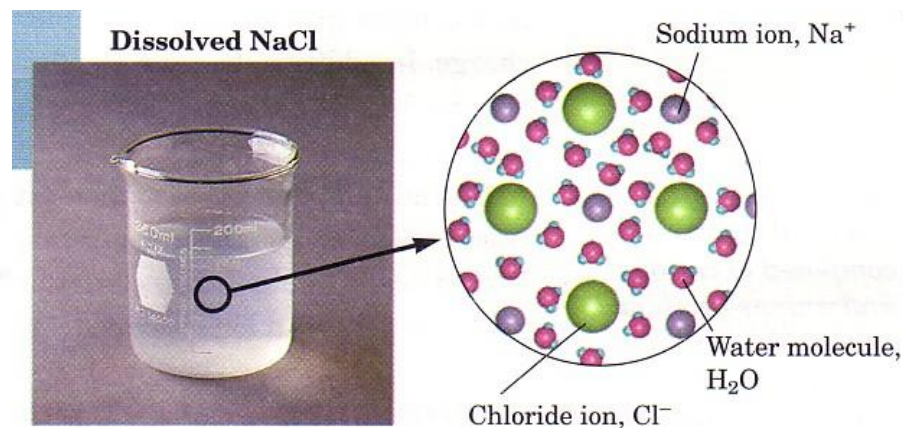
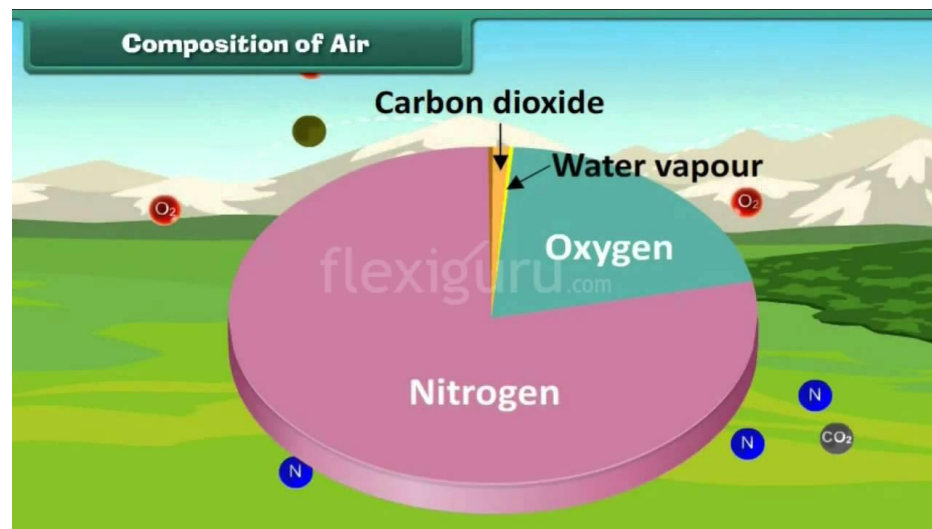
Heterogeneous Mixtures

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



Homogenous Mixtures

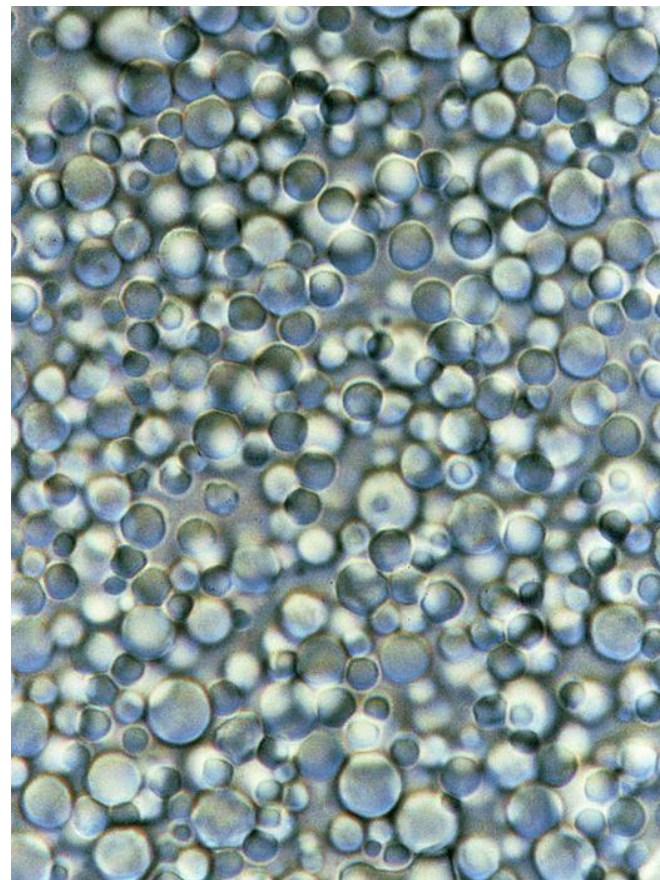
- Uniform composition
- Small particles, evenly distributed; cannot see particles even with a microscope
- E.g. solutions, alloys



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

Homogeneous vs Heterogeneous Mixtures

A **Homogeneous Mixture** is a mixture that has a uniform appearance and composition throughout



A **Heterogeneous Mixture** is a mixture in which you can identify the component parts just by looking at it

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

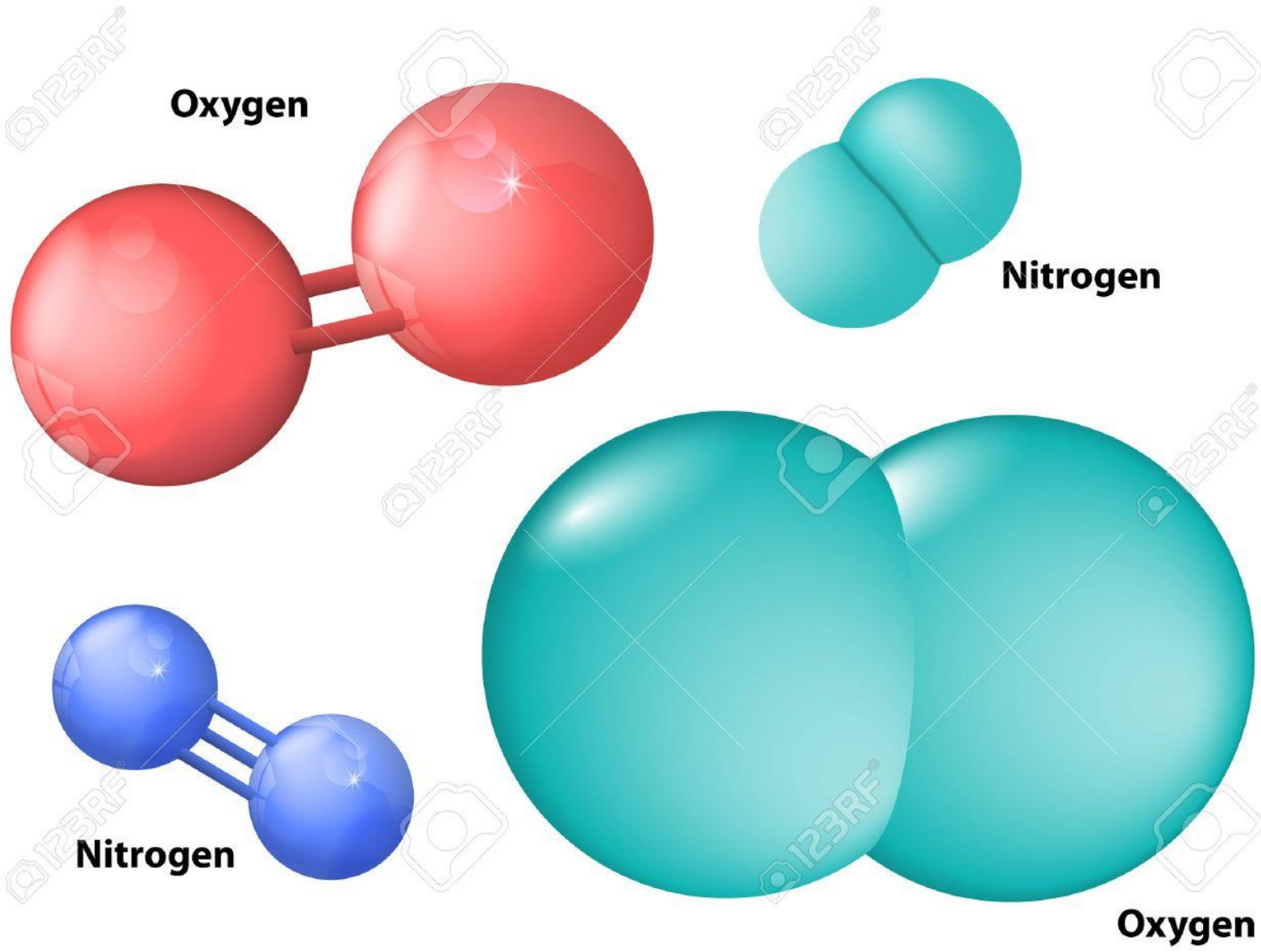
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18														
1 H Hydrogen 1.00794	<table border="1"> <tr> <td>C Solid</td> <td>Hg Liquid</td> <td>H Gas</td> <td>Rf Unknown</td> </tr> </table>																C Solid	Hg Liquid	H Gas	Rf Unknown	2 He Helium 4.002602										
C Solid	Hg Liquid	H Gas	Rf Unknown																												
3 Li Lithium 6.941	4 Be Beryllium 9.012182	<table border="1"> <tr> <td>Alkali metals</td> <td>Alkaline earth metals</td> <td>Lanthanoids</td> <td>Transition metals</td> <td>Poor metals</td> <td>Other nonmetals</td> <td>Noble gases</td> </tr> <tr> <td></td> <td></td> <td>Actinoids</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>										Alkali metals	Alkaline earth metals	Lanthanoids	Transition metals	Poor metals	Other nonmetals	Noble gases			Actinoids					5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
Alkali metals	Alkaline earth metals	Lanthanoids	Transition metals	Poor metals	Other nonmetals	Noble gases																									
		Actinoids																													
11 Na Sodium 22.98976928	12 Mg Magnesium 24.3050	13 Al Aluminium 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948																								
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.887	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798														
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (97.9072)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293														
55 Cs Caesium 132.9054519	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (208.9824)	85 At Astatine (209.9871)	86 Rn Radon (222.0176)														
87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (288)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (282)	117 Uus Ununseptium	118 Uuo Ununoctium (294)														

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

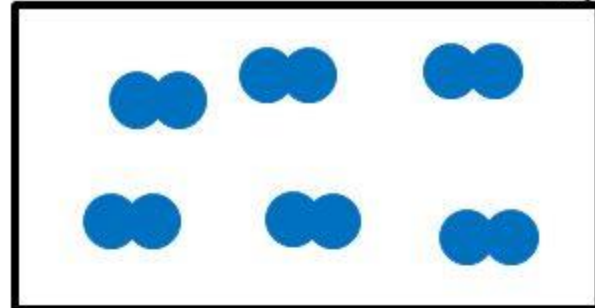
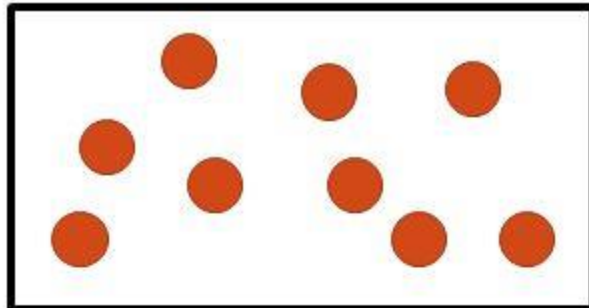
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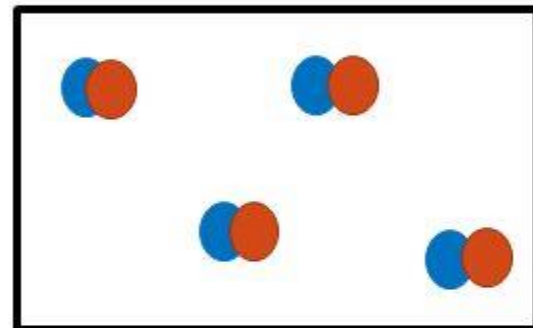
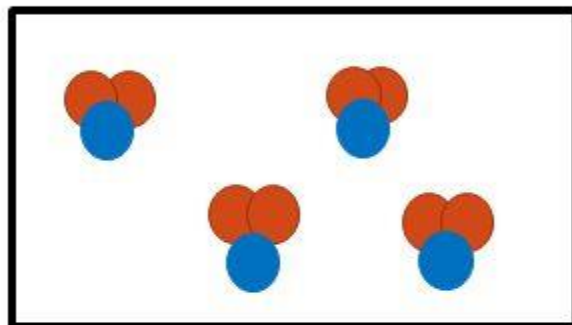
57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.968
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)



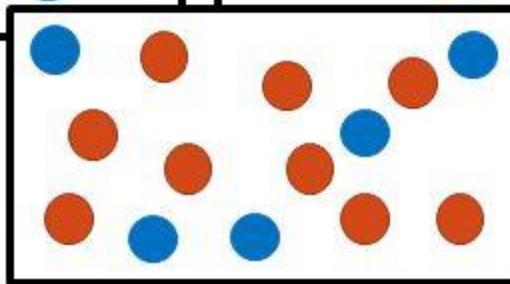
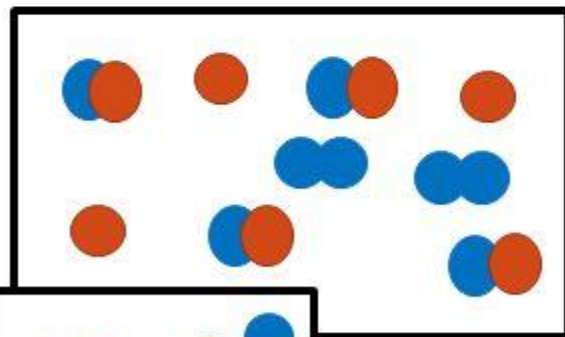
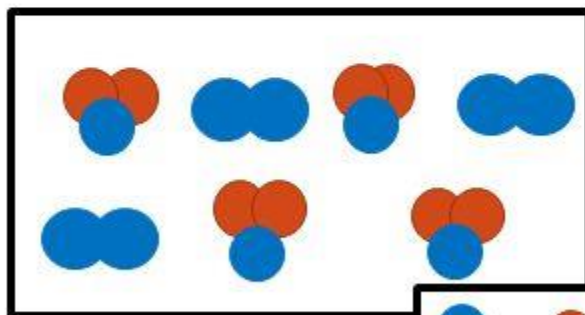
ELEMENTS:



COMPOUNDS:



MIXTURES:



Matter

Pure substance

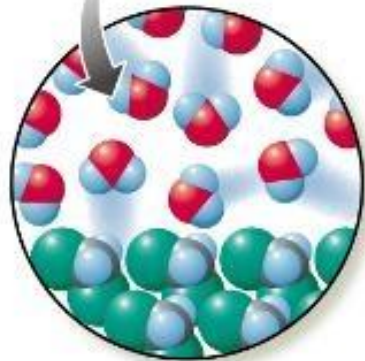
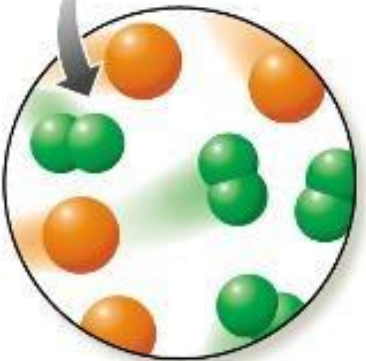
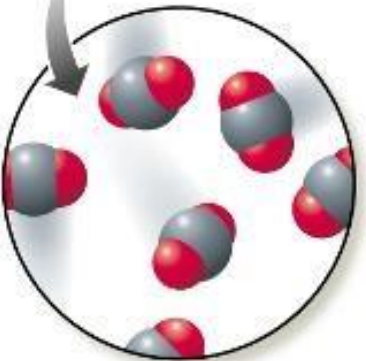
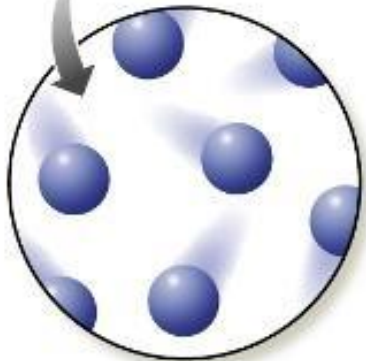
Mixture

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.

