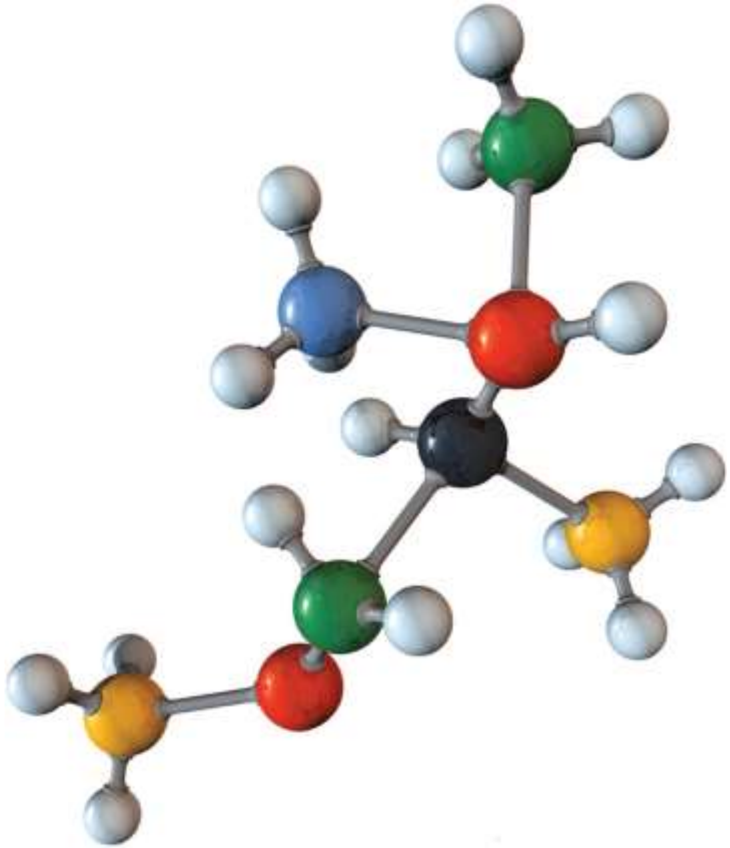
THE BIG IDEA

Atoms are the building blocks of most matter.

Atoms are the building blocks of most matter. Everything you see, hear, taste, feel, or smell in the world around you is made of atoms. Shoes, ships, mice, lead, and people are all made of atoms.



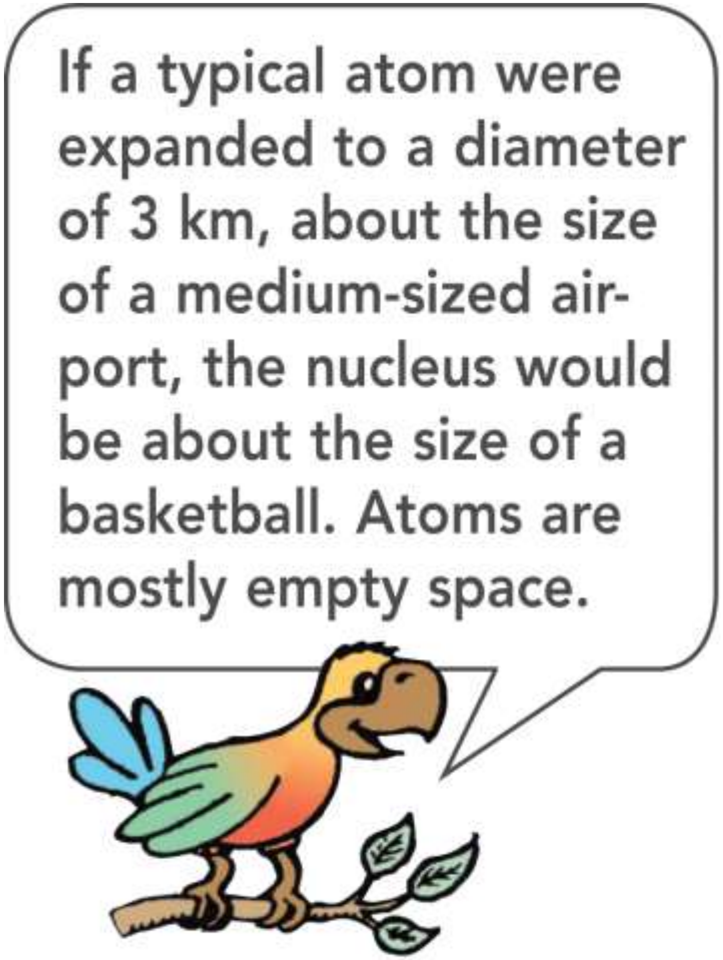
17.1 Elements

Every simple, complex, living, or nonliving substance in the known universe is put together from a pantry containing less than 100 elements.

17.1 Elements

Atoms are the building blocks of matter.

A material composed of only one kind of atom is called an **element.**



17.1 Elements

To date about 115 elements are known.

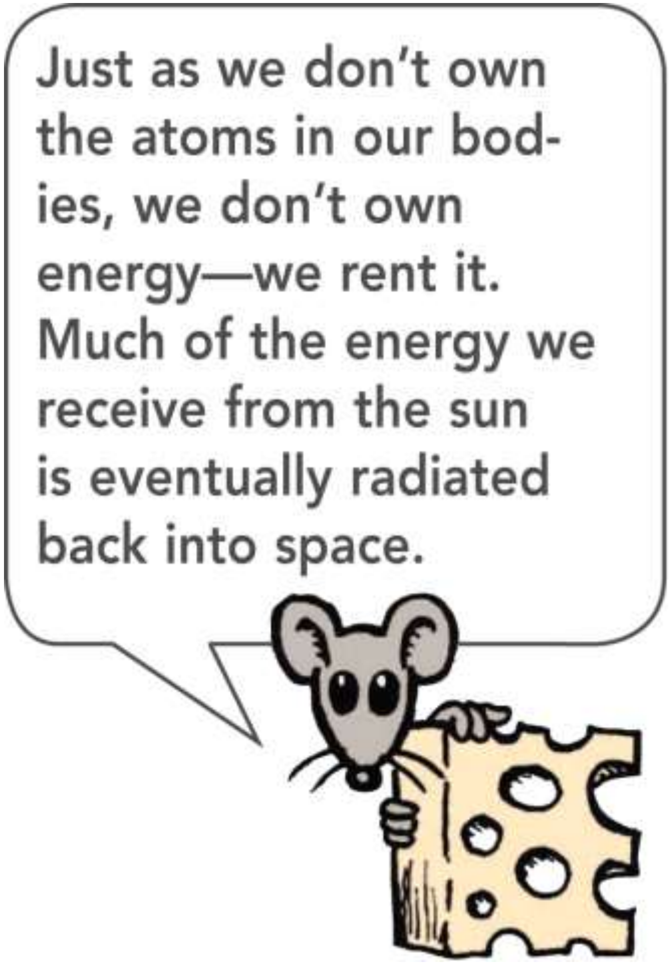
About 90 occur in nature. The others are made in the laboratory with high-energy atomic accelerators and nuclear reactors.

These laboratory-produced elements are too unstable (radioactive) to occur naturally in appreciable amounts.

17.1 Elements

More than 99% of the material on Earth is formed from only about a dozen of the elements.

Living things, for example, are composed primarily of five elements: oxygen (O), carbon (C), hydrogen (H), nitrogen (N), and calcium (Ca).



17.1 Elements

Most of the 16 most common elements on Earth are critical for life.

Table 17.1 The 16 Most Common Elements on Earth

Aluminum (Al)	Fluorine (F)	Nitrogen (N)	Silicon (Si)
Calcium (Ca)	Hydrogen (H)	Oxygen (O)	Sodium (Na)
Carbon (C)	Iron (Fe)	Phosphorus (P)	Sulfur (S)
Chlorine (Cl)	Magnesium (Mg)	Potassium (K)	Titanium (Ti)

17.1 Elements

The lightest element of all is hydrogen. Over 90% of the atoms in the known universe are hydrogen.

Helium, the second-lightest element, makes up most of the remaining atoms in the universe, although it is rare on Earth.

The heavier atoms that we find about us were manufactured by fusion reactions in the hot, high-pressure environments of stars.

17.1 Elements

Elements heavier than iron are formed when huge stars implode and then explode—an event called a supernova.

The heaviest elements are formed when pairs of neutron stars, the super-dense cores of supernovas, collide.

Nearly all the atoms on Earth are remnants of stars that exploded long before the solar system came into being.

17.1 Elements

The carbon, oxygen, nitrogen, and other atoms that make up your body originated in the deep interior of ancient stars, which have long since exploded.

17.1 Elements

All of the matter that we encounter in our daily lives, as well as matter in the sun and other stars, is made up of elements.

Twenty-three percent of the matter in the universe is composed of an unseen dark matter. Astrophysicists believe this dark matter is made up of particles not yet detected.

17.1 Elements

CONCEPT CHECK

What do all substances have in common?

17.2 Atoms Are Small

Atoms are so small that there are about 10^{23} atoms in a gram of water (a thimbleful).

17.2 Atoms Are Small

The number 10^{23} is an enormous number.

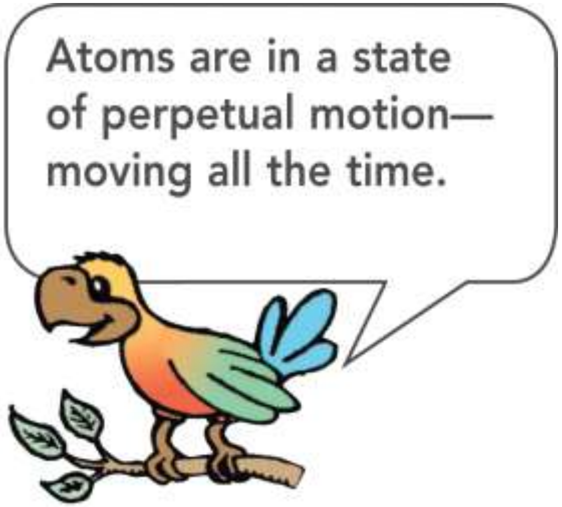
There are more atoms in a thimbleful of water than there are drops of water in the world's lakes and rivers.

17.2 Atoms Are Small

Atoms are perpetually moving and they migrate from one location to another.

In solids the rate of migration is low, in liquids it is greater, and in gases migration is greatest.

Drops of food coloring in a glass of water spread to the entire glass of water. Toxic materials in an ocean spread to every part of the world's oceans.



17.2 Atoms Are Small

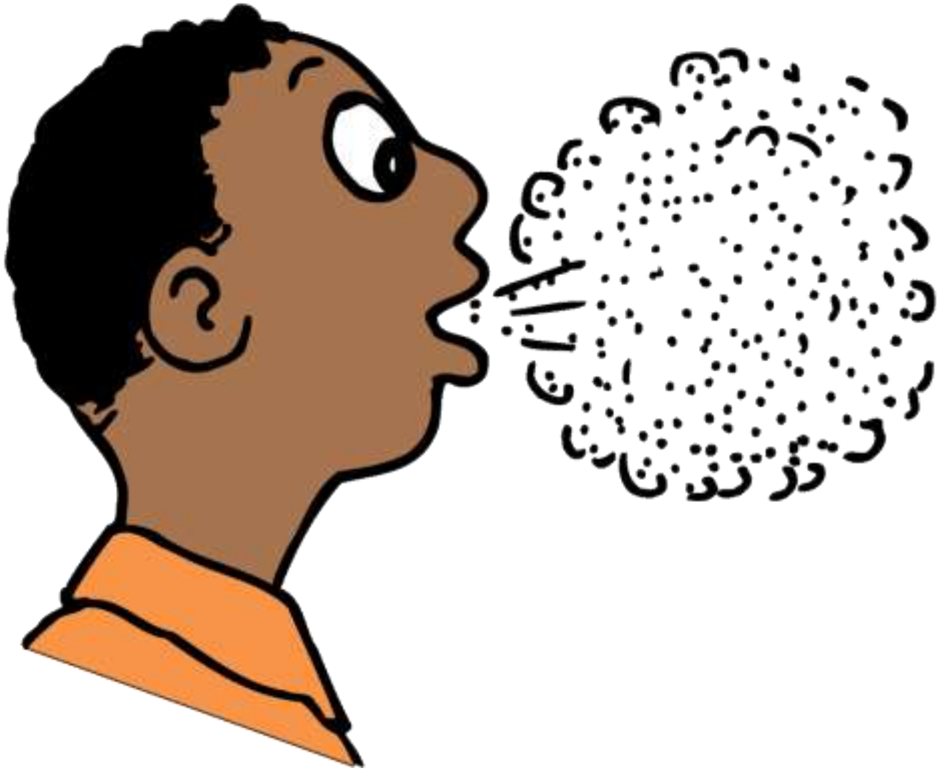
In about six years, one of your exhaled breaths becomes evenly mixed in the atmosphere.

At that point, every person in the world inhales an average of one of your exhaled atoms in a single breath.

And this occurs for *each* breath you exhale!

17.2 Atoms Are Small

There are as many atoms in a normal breath of air as there are breathfuls of air in the atmosphere of the world.



17.2 Atoms Are Small

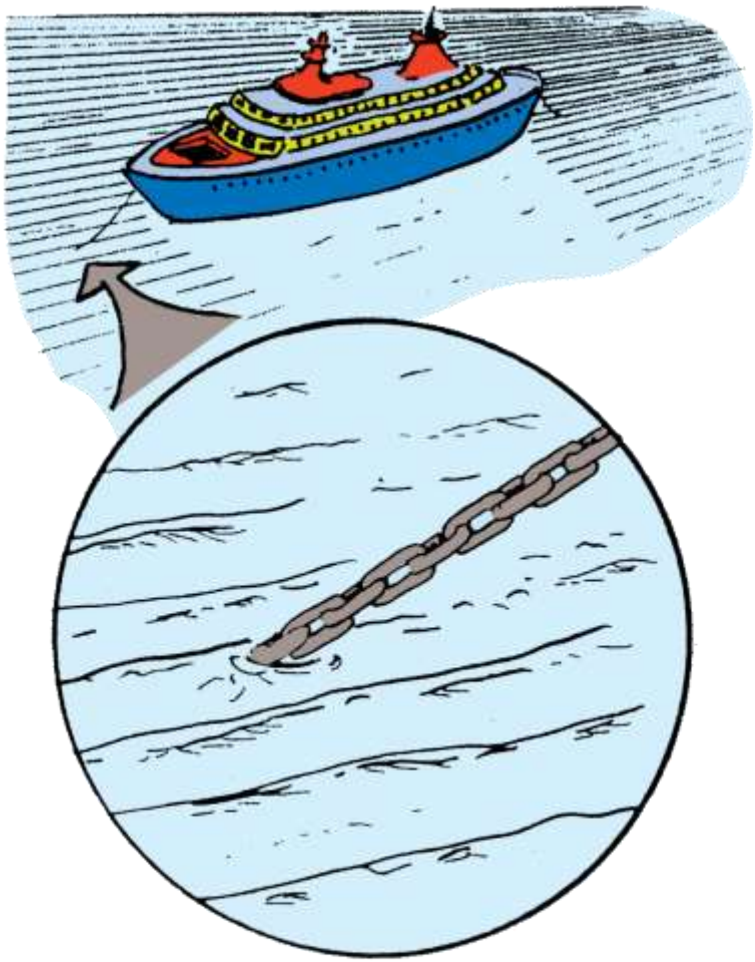
Atoms are too small to be seen—at least with visible light.

Light is made up of waves, and atoms are smaller than the wavelengths of visible light.

The size of a particle visible under the highest magnification must be larger than the wavelengths of visible light.

17.2 Atoms Are Small

Information about the ship is revealed by passing waves. The passing waves reveal nothing about the chain.



17.2 Atoms Are Small

A ship is much larger than the water waves that roll on by it.

Water waves can reveal features of the ship. They *diffract* as they pass the ship, while there is no diffraction for waves that pass the anchor chain.

Waves of visible light are too coarse compared with the size of an atom to show details of the atom's size and shape.

17.2 Atoms Are Small

think!

Does your brain contain atoms that were once part of Albert Einstein? Explain.

17.2 Atoms Are Small

think!

Does your brain contain atoms that were once part of Albert Einstein? Explain.

Answer:

Yes. However, these atoms are combined differently than they were before. Many of the atoms that compose you will be part of the bodies of all the people on Earth who are yet to be! In this sense, at least, our atoms *are* immortal.

17.2 Atoms Are Small

CONCEPT CHECK

How small are atoms?

17.3 Atoms Are Recyclable

Atoms in your body have been around since long before the solar system came into existence, more than 4.6 billion years ago.

17.3 Atoms Are Recyclable

Atoms are much older than the materials they compose.

Some atoms are nearly as old as the universe itself.

Most atoms that make up our world are at least as old as the sun and Earth.

17.3 Atoms Are Recyclable

Atoms cycle and recycle among innumerable forms, both living and nonliving.

Every time you breathe, some of the atoms that you inhale are exhaled in your next breath; others become part of you.

Most leave your body sooner or later.

Most people know we are all made of the same *kinds* of atoms, but we are actually made of the *same* atoms.

17.3 Atoms Are Recyclable

think!

World population grows each year. Does this mean the mass of Earth increases each year? Explain.

17.3 Atoms Are Recyclable

think!

World population grows each year. Does this mean the mass of Earth increases each year? Explain.

Answer:

The mass of Earth does increase by the addition of roughly 40,000 tons of interplanetary dust each year. But the increasing number of people does not increase the mass of the Earth. The atoms that make up our body are the same atoms that were here before we were born.

17.3 Atoms Are Recyclable

CONCEPT CHECK

For how long have the atoms in your body been around?

17.4 Evidence for Atoms

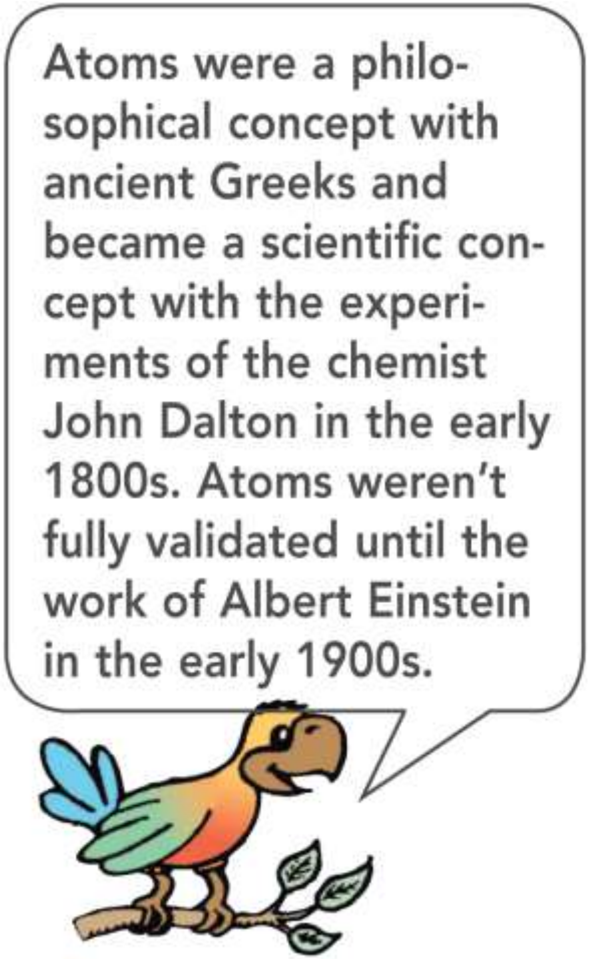
Brownian motion is evidence that atoms exist, as it results from the motion of neighboring atoms and molecules. They bump into the larger particles we can see.

17.4 Evidence for Atoms

The idea that matter is made of atoms goes back to the Greeks in the 400s B.C.

It was revived in the early 1800s by John Dalton, who explained the nature of chemical reactions by proposing that all matter is made of atoms.

However, he had no direct evidence for their existence.



17.4 Evidence for Atoms

A Scottish botanist, Robert Brown, found the first fairly direct evidence for the existence of atoms in 1827.

Looking through a microscope at pollen grains floating in water, he noticed that the grains were in a constant state of agitation.

Brownian motion is the perpetual jiggling of particles that are just large enough to be seen.

17.4 Evidence for Atoms

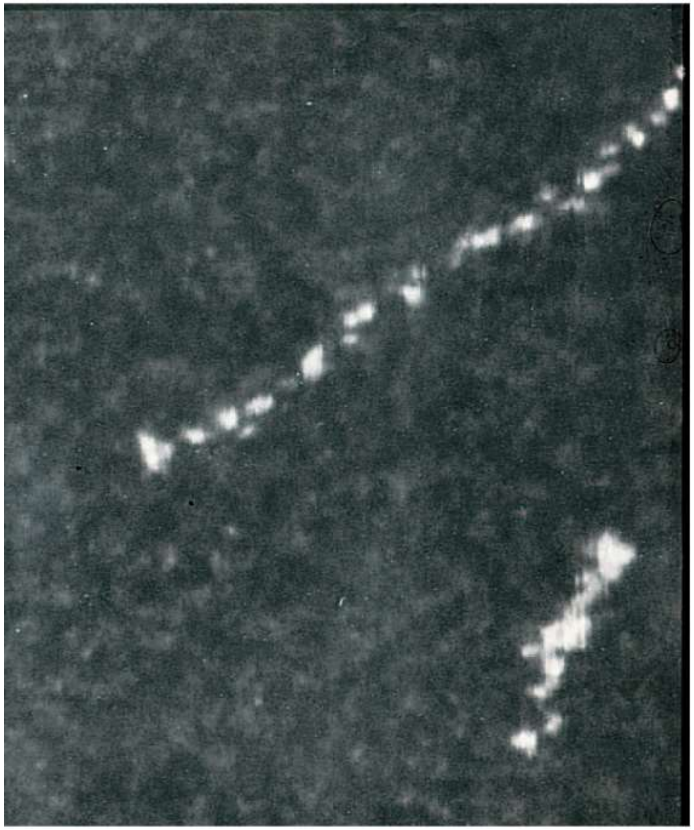
More direct evidence for the existence of atoms is available today.

Images of atoms can be made with an electron beam, not with visible light.

Although an electron beam is a stream of tiny particles (electrons), it has wave properties, with a wavelength more than a thousand times smaller than the wavelength of visible light.

17.4 Evidence for Atoms

The strings of dots are chains of thorium atoms imaged with a scanning electron microscope.

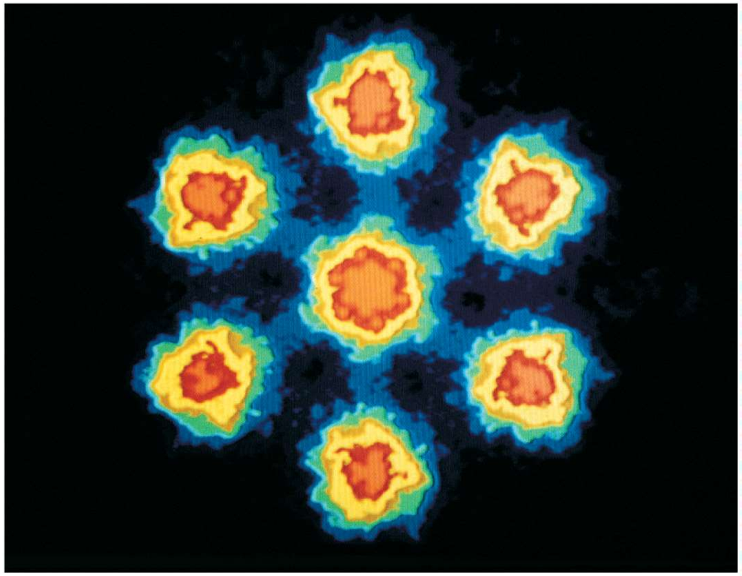


17.4 Evidence for Atoms

With a different kind of microscope—the scanning tunneling microscope—you can see individual atoms.

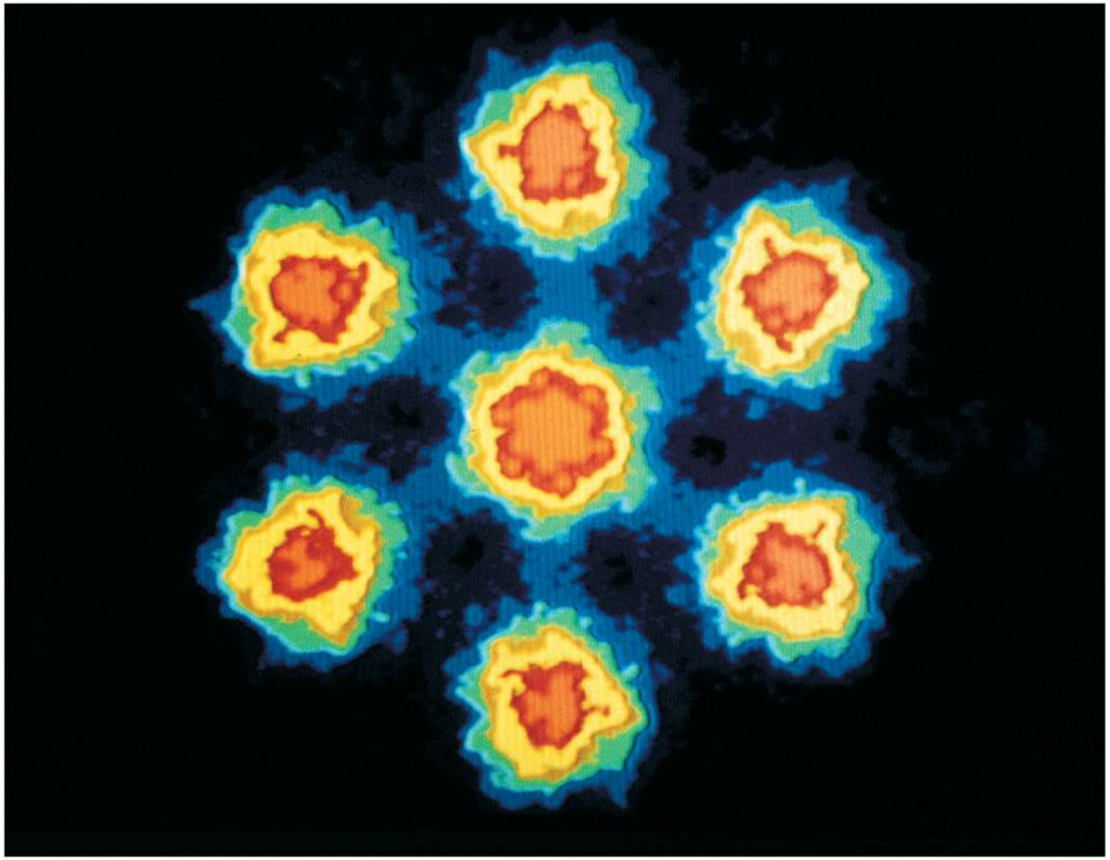
Even greater detail is possible with newer types of imaging devices that are presently revolutionizing microscopy.

Images with today's devices help us to construct better models of the atom and make predictions about the natural world.



17.4 Evidence for Atoms

A scanning tunneling microscope created this image of uranium atoms.



17.4 Evidence for Atoms

CONCEPT CHECK

How does Brownian motion provide evidence for the existence of atoms?

17.5 Molecules

Molecules can be made up of atoms of the same element or of different elements.

17.5 Molecules

Atoms can combine to form larger particles called *molecules*.

A **molecule** is the smallest particle of a substance consisting of two or more atoms that bond together by sharing electrons.

For example, two atoms of hydrogen (H) combine with a single atom of oxygen (O) to form a water molecule (H_2O).

17.5 Molecules

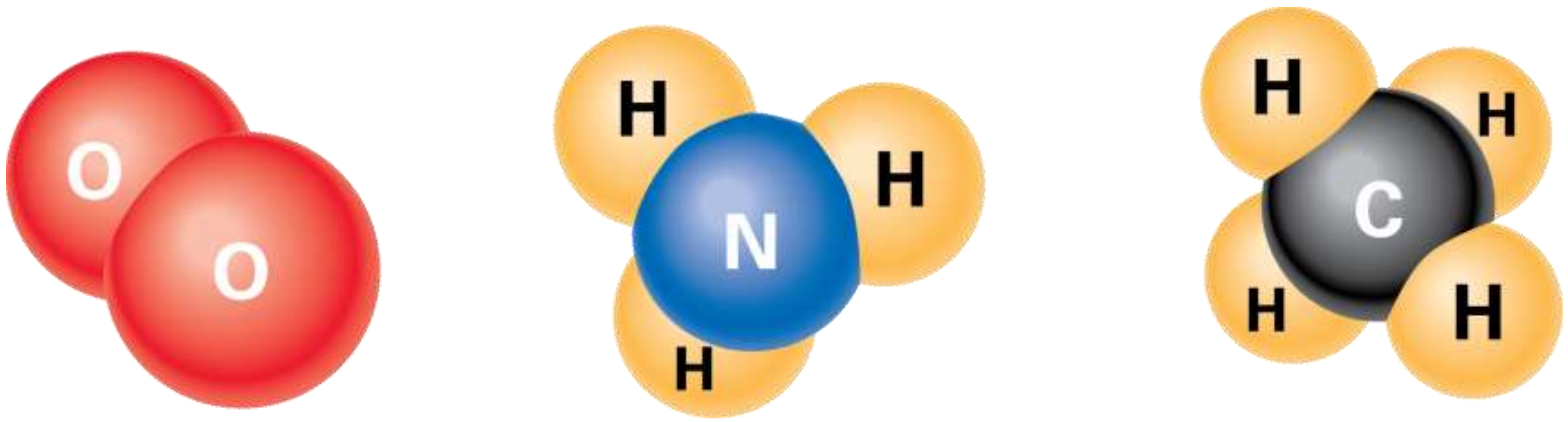
Matter that is a gas or liquid at room temperature is usually made of molecules.

Matter made of molecules may contain all the same kind of molecule, or it may be a mixture of different kinds of molecules.

Purified water contains almost entirely H_2O molecules, but clean air contains molecules belonging to several different substances.

17.5 Molecules

Models of the simple molecules O_2 (oxygen gas), NH_3 (ammonia), and CH_4 (methane) show their structure. The atoms that compose a molecule are not just mixed together, but are bonded in a well-defined way.



17.5 Molecules

Like atoms, individual molecules are too small to be seen with optical microscopes.

More direct evidence of tiny molecules is seen in electron microscope photographs.

Virus molecules, composed of thousands of atoms, are visible with an electron beam, but are still too small to be seen with visible light.

17.5 Molecules

A scientist used an electron microscope to take this photograph of rubella virus molecules. The white dots are the virus erupting on the surface of an infected cell.

17.5 Molecules

We are able to detect some molecules through our sense of smell.

The smell of perfume is the result of molecules that jostle around in the air until some of them accidentally get inhaled.

The perfume molecules are certainly not attracted to our noses! They wander aimlessly in all directions from the liquid perfume.

17.5 Molecules

CONCEPT CHECK

What are molecules made of?

17.6 Compounds

Compounds have properties different from those of the elements of which they are made.

17.6 Compounds

A **compound** is a substance that is made of atoms of different elements combined in a fixed proportion.

The **chemical formula** of the compound tells the proportions of each kind of atom.

For example, in the gas carbon dioxide, the formula CO_2 indicates that for every carbon (C) atom there are two oxygen (O) atoms.

17.6 Compounds

Water, table salt, and carbon dioxide are all compounds.

Air, wood, and salty water are not compounds, because the proportions of their atoms vary.

17.6 Compounds

A compound may or may not be made of molecules.

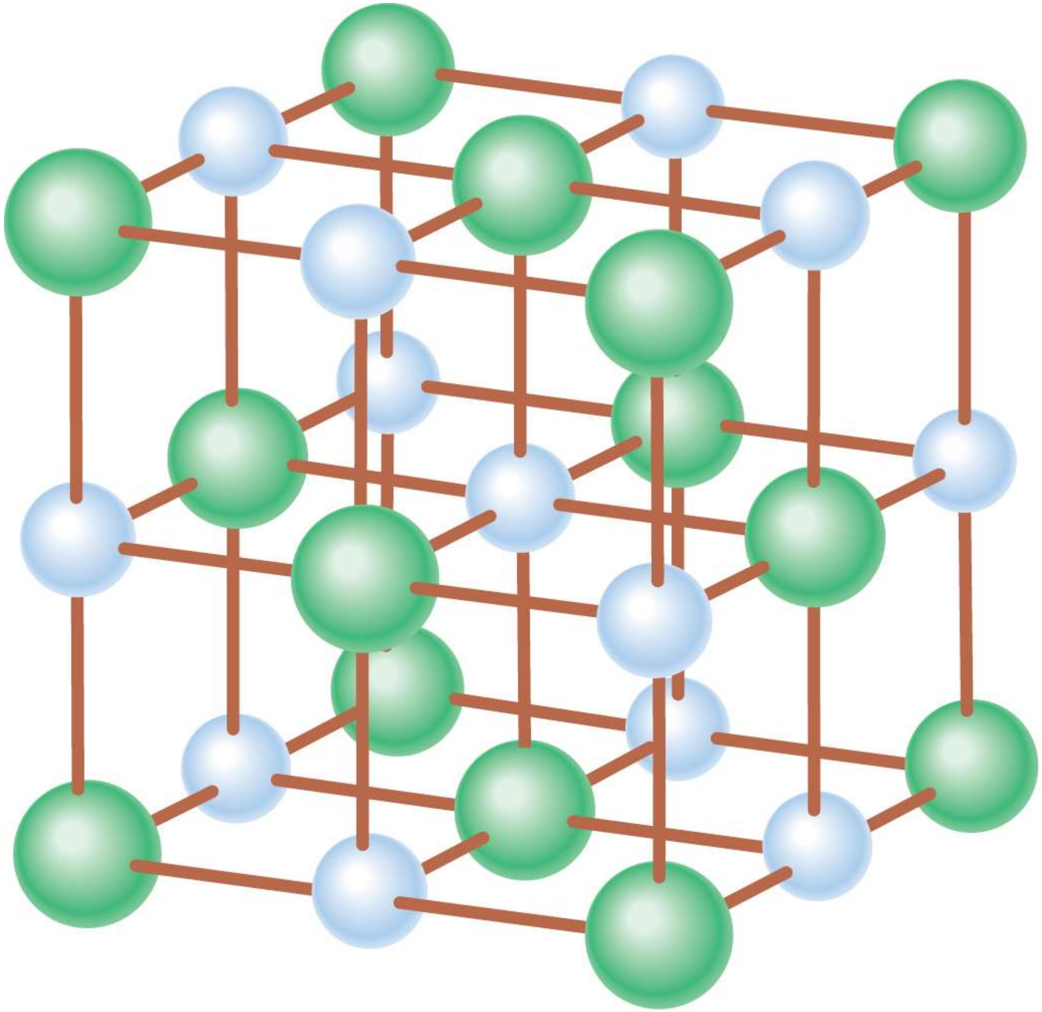
- Water and carbon dioxide are made of molecules.
- Table salt (NaCl) is made of different kinds of atoms arranged in a regular pattern.

Every chlorine atom in table salt is surrounded by six sodium atoms. Every sodium atom is surrounded by six chlorine atoms.

There is one sodium atom for each chlorine atom, but there are no separate groups that can be labeled molecules.

17.6 Compounds

Table salt (NaCl) is a compound that is not made of molecules. The sodium and chlorine ions are arranged in a repeating pattern. Each ion is surrounded by six ions of the other kind.



17.6 Compounds

CONCEPT CHECK

How are compounds different from their component elements?

17.7 The Atomic Nucleus

The mass of an atom is primarily concentrated in the nucleus.

17.7 The Atomic Nucleus

An atom is mostly empty space.

Almost all of an atom's mass is packed into the dense central region called the **nucleus.**

This was demonstrated in Ernest Rutherford's now-famous gold foil experiment.

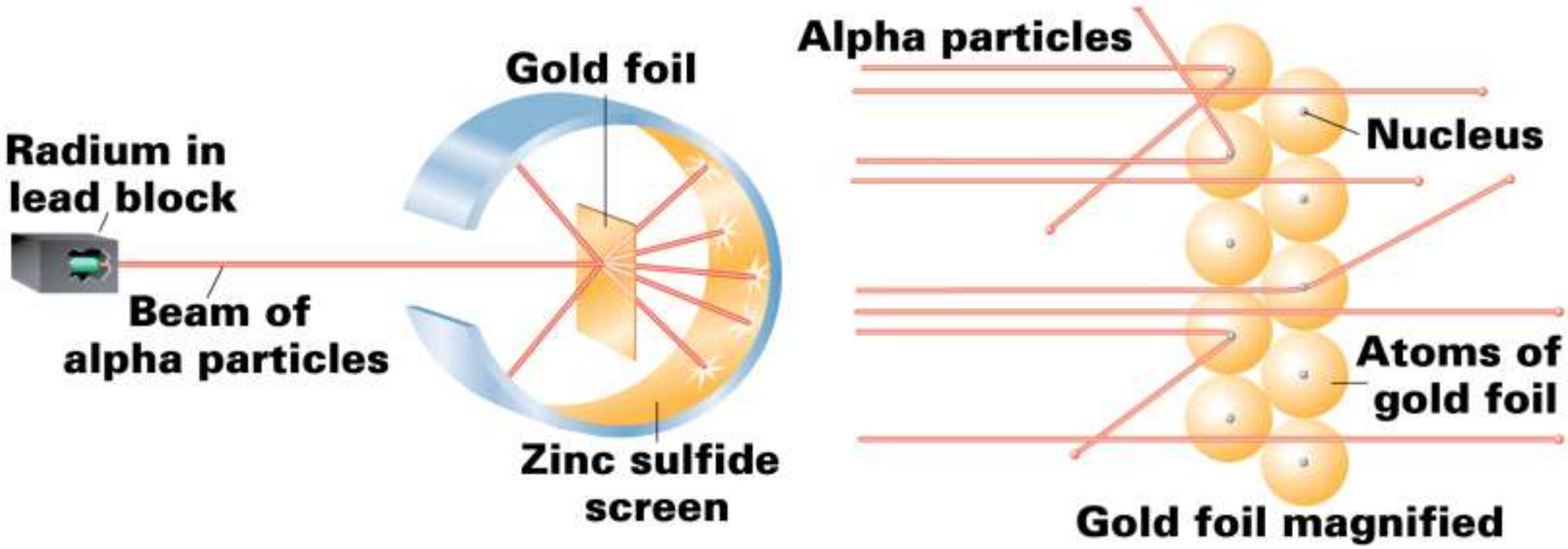
17.7 The Atomic Nucleus

When a beam of charged particles was shot through a thin gold foil, most particles went straight through the thin foil.

However, some particles were widely deflected.

Some were even scattered back almost along their incoming path.

17.7 The Atomic Nucleus



The occasional large-angle scattering of alpha particles from the gold atoms led Rutherford to the discovery of the small, very massive nuclei at their centers.

17.7 The Atomic Nucleus

Rutherford reasoned that within the atom there had to be a positively charged object with two special properties.

- It had to be very small compared with the size of the atom.
- It had to be massive enough to resist being shoved aside by heavy alpha particles.

Rutherford had discovered the atomic nucleus.

17.7 The Atomic Nature of Nucleus

The nucleus occupies less than a trillionth of the volume of an atom.

Atomic nuclei are extremely compact and extremely dense.

If bare atomic nuclei could be packed against one another into a lump 1 cm in diameter, it would weigh about a billion tons!

17.7 The Atomic Nucleus

Electrical repulsion prevents such close packing of atomic nuclei. Each nucleus is electrically charged and repels the other nuclei.

Only under special circumstances are the nuclei of two or more atoms squashed into contact. When this happens, the violent reaction known as nuclear fusion takes place.

Fusion occurs in the core of stars and in a hydrogen bomb.

17.7 The Atomic Nucleus

Nucleons

The principal building blocks of the nucleus are **nucleons.**

- Nucleons in an electrically neutral state are **neutrons.**
- Nucleons in an electrically charged state are **protons.**
- Atoms differ from one another by the numbers of protons.
- Atoms with the same number of protons are atoms of the same element.

17.7 The Atomic Nature of Nucleus

Isotopes

For a given element, the number of neutrons will vary.

Atoms of the same element having different numbers of neutrons are called **isotopes** of that element.

17.7 The Atomic Nucleus

The nucleus of the hydrogen atom has a single proton.

- When this proton is accompanied by a neutron, we have *deuterium*, an isotope of hydrogen.
- When two neutrons are in a hydrogen nucleus, we have the isotope *tritium*.

Every element has a variety of isotopes. Lighter elements usually have an equal number of protons and neutrons, and heavier elements usually have more neutrons than protons.

17.7 The Atomic Nucleus

Atomic Number

Atoms are classified by their **atomic number,** which is the number of protons in the nucleus.

- The nucleus of a hydrogen atom has one proton, so its atomic number is 1.
- Helium has two protons, so its atomic number is 2.
- Lithium has three protons, so its atomic number is 3, and so on.

17.7 The Atomic Nucleus

Electric Charge

Electric charge comes in two kinds, positive and negative.

- Protons in the atom's nucleus are positive.
- Electrons orbiting the nucleus are negative.

Positive and negative refer to a basic property of matter—electric *charge.*

17.7 The Atomic Nucleus

Like kinds of charge repel one another and unlike kinds attract one another.

- Protons repel protons but attract electrons.
- Electrons repel electrons but attract protons.

Inside the nucleus, protons are held to one another by a *strong nuclear force*, which is extremely intense but acts only across tiny distances.

17.7 The Atomic Nature of Matter

CONCEPT CHECK

Where is the mass of an atom primarily concentrated?

17.8 Electrons in the Atom

The arrangement of electrons in the shells about the atomic nucleus dictates the atom's chemical properties.

17.8 Electrons in the Atom

Electrons that orbit the atomic nucleus are identical to the electrons that flow in the wires of electric circuits.

They are negatively charged subatomic particles.

The electron's mass is less than $\frac{1}{1800}$ the mass of a proton or neutron, so electrons do not significantly contribute to the atom's mass.

17.8 Electrons in the Atom

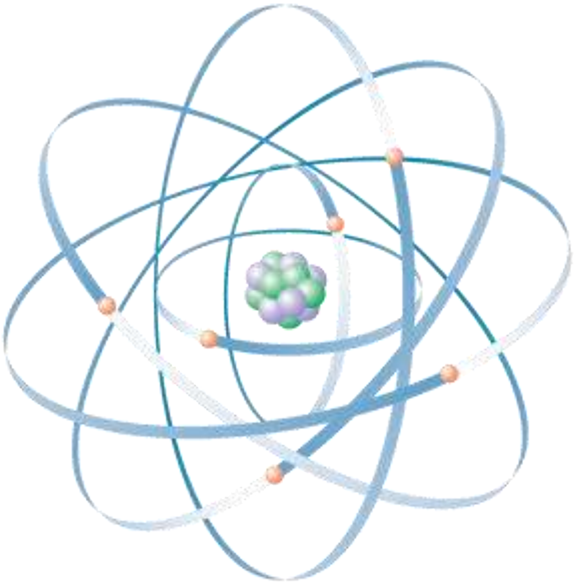
In an electrically neutral atom, the number of negatively charged electrons always equals the number of positively charged protons.

When the number of electrons in an atom differs from the number of protons, the atom is no longer neutral and has a net charge.

An atom with a net charge is an **ion.**

17.8 Electrons in the Atom

The classic model of the atom consists of a tiny nucleus surrounded by orbiting electrons.



17.8 Electrons in the Atom

Attraction between a proton and an electron can cause a *bond* between atoms to form a molecule.

- Two atoms can be held together by the sharing of electrons (a covalent bond).
- Atoms also stick to each other when ions of opposite charge are formed, and these ions are held together by simple electric forces (an ionic bond).

17.8 Electrons in the Atom

Just like our solar system, the atom is mostly empty space.

The nucleus and surrounding electrons occupy only a tiny fraction of the atomic volume.

The electrons, because of their wave nature, form a kind of cloud around the nucleus.

Compressing this electron cloud takes great energy and means that when two atoms come close together, they repel each other.

17.8 Electrons in the Atom

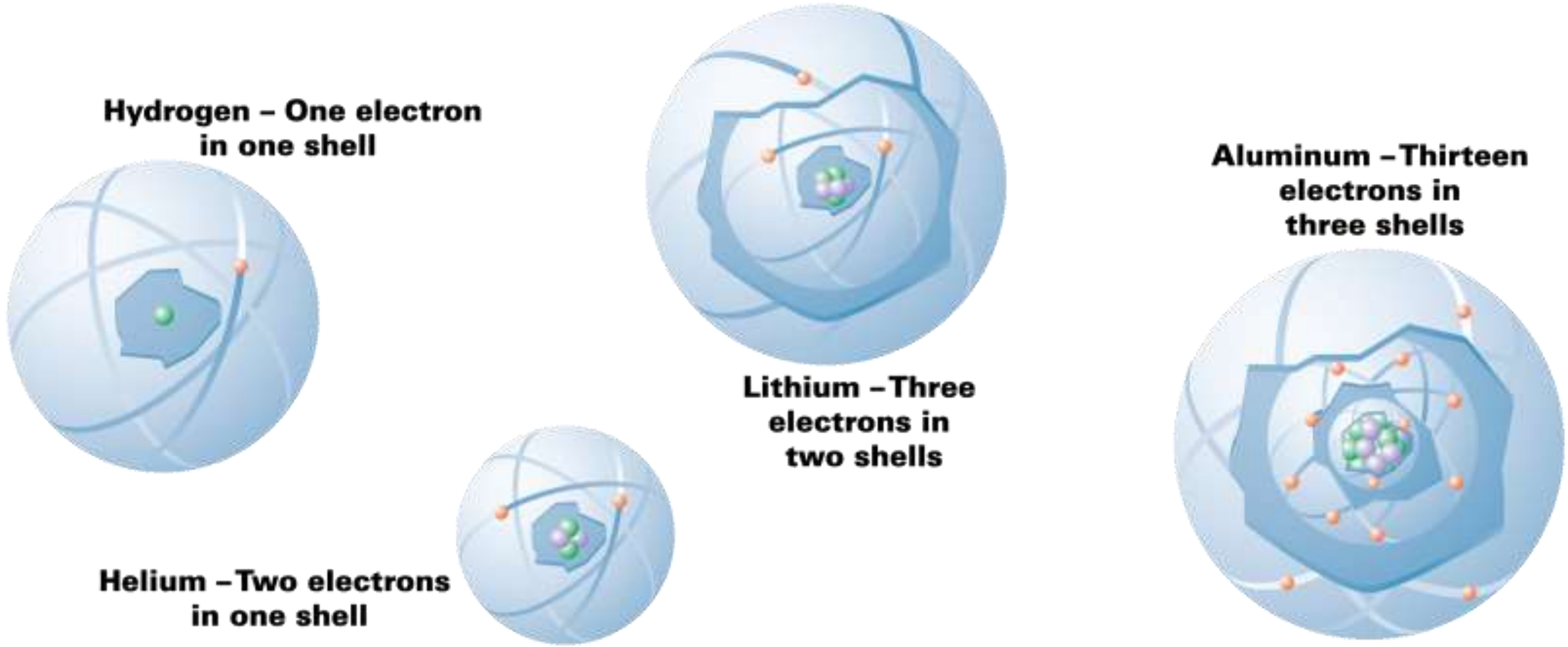
Scientists use a model to explain how atoms of different elements interact to form compounds.

The **shell model of the atom** depicts electrons as orbiting in spherical shells around the nucleus.

There are seven different shells, and each shell has its own capacity for electrons.

17.8 Electrons in the Atom

The shell model of the atom pictures the electrons orbiting in concentric, spherical shells around the nucleus.

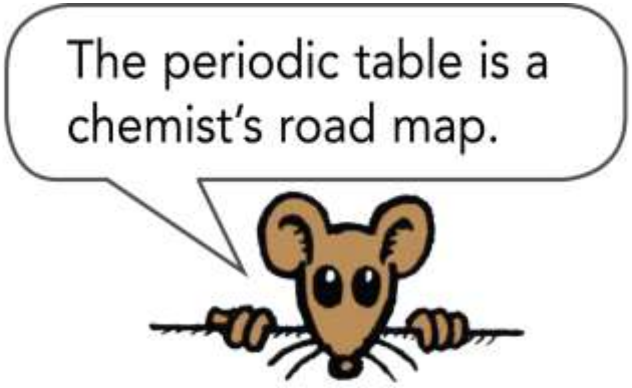


17.8 Electrons in the Atom

The **periodic table** is a chart that lists atoms by their atomic number and by their electron arrangements.

As you read across from left to right, each element has one more proton and electron than the preceding element.

As you go down, each element has one more shell filled to its capacity than the element above.



17.8 Electrons in the Atom

The atomic number, above the chemical symbol, is equal to the number of protons in the nucleus. The number below is the atomic mass.

1A	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.17
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.08	21 Sc Scandium 44.956	22 Ti Titanium 47.90	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.933	28 Ni Nickel 58.71	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.735	32 Ge Germanium 72.59	33 As Arsenic 74.992	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.467	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.22	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.30
55 Cs Cesium 132.905	56 Ba Barium 137.33	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.947	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (233)	88 Ra Radium (226)	103 Lr Lawrencium (262)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (264)	108 Hs Hassium (265)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (269)	111 Rg Roentgenium (272)	112 Uub Ununbium (272)		114 Uuq Ununquadium				

Rare Earths (Lanthanide series)	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04
Actinide series	89 Ac Actinium (227)	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	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)

17.8 Electrons in the Atom

Each row in the periodic table corresponds to a different number of electron shells in the atom.

Elements are arranged vertically on the basis of similarity in the arrangement of outer electrons.

Elements in the same column are said to belong to the same *group* or family of elements.

17.8 Electrons in the Atom

Elements of the same group have similar chemical properties because their outermost electrons are arranged in a similar fashion.

These properties include

- melting and freezing temperatures
- electrical conductivity
- the taste, texture, appearance, and color of substances
- how the element reacts with other substances

17.8 Electrons in the Atom

CONCEPT CHECK

What does the arrangement of electrons around the nucleus determine?

17.9 The Phases of Matter

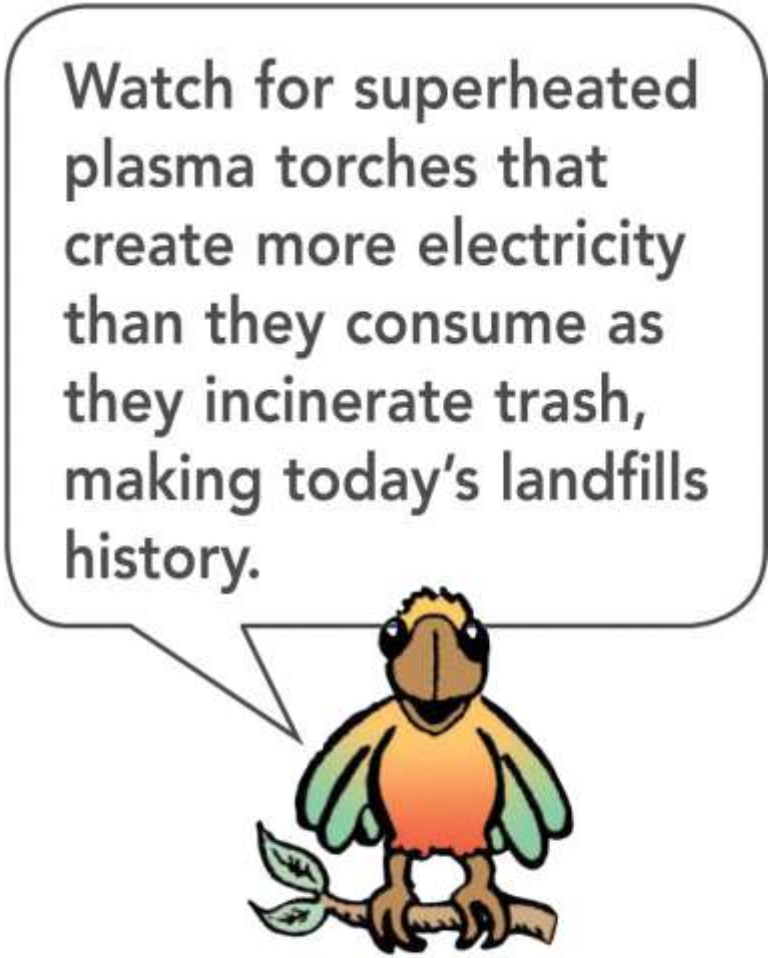
Matter exists in four phases: solid, liquid, gaseous, and plasma.

17.9 The Phases of Matter

In the **plasma** phase, matter consists of positive ions and free electrons.

Although the plasma phase is less common to our everyday experience, it is the predominant phase of matter in the universe.

The sun and other stars as well as much of the intergalactic matter are in the plasma phase.



17.9 The Phases of Matter

In the aurora borealis, high-altitude gases in the northern sky are transformed into glowing plasmas by the bombardment of charged particles from the sun.

17.9 The Phases of Matter

In all phases of matter, the atoms are constantly in motion.

- In the solid phase, the atoms and molecules vibrate about fixed positions.
- In the liquid phase, molecular vibration is increased so molecules shake apart, jostling in nonfixed positions.
- In the gas phase, more energy causes molecules to move about at even greater rates and break away from one another.

17.9 The Phases of Matter

All substances can be transformed from one phase to another.

- When H_2O is solid, it is ice.
- Heat the ice and the increased molecular motion jiggles the molecules out of their fixed positions, forming water.
- Heat the water and molecular motion results in a separation between water molecules, and makes steam.
- Continued heating causes the molecules to separate into atoms.
- At greater than 2,000°C, the atoms themselves come apart, making a gas of ions and free electrons—a plasma.

17.9 The Phases of Matter

CONCEPT CHECK

What are the four phases of matter?

Assessment Questions

1. The number of different elements known to humankind are
   - a. approximately 115.
   - b. more than a thousand.
   - c. in the millions.
   - d. in the billions.

Assessment Questions

1. The number of different elements known to humankind are
   a. approximately 115.
   b. more than a thousand.
   c. in the millions.
   d. in the billions.

Answer: A

Assessment Questions

2. Compared with the wavelength of visible light, atoms are
   a. about the same size.
   b. smaller.
   c. larger.
   d. fuzzier.

Assessment Questions

2. Compared with the wavelength of visible light, atoms are
   a. about the same size.
   b. smaller.
   c. larger.
   d. fuzzier.

Answer: B

Assessment Questions

3. Which of these statements is correct?
   a. Atoms that make up your body were formed in ancient stars.
   b. Atoms that make up your body were previously a part of your neighbors' bodies.
   c. Atoms that make up your body are in motion at all times.
   d. all of these

Assessment Questions

3. Which of these statements is correct?
   a. Atoms that make up your body were formed in ancient stars.
   b. Atoms that make up your body were previously a part of your neighbors' bodies.
   c. Atoms that make up your body are in motion at all times.
   d. all of these

Answer: D

Assessment Questions

4. Brownian motion has to do with the
   a. size of atoms.
   b. vibrations of atoms.
   c. random motions of atoms and molecules.
   d. rhythmic movements of Brownians.

Assessment Questions

4. Brownian motion has to do with the
   a. size of atoms.
   b. vibrations of atoms.
   c. random motions of atoms and molecules.
   d. rhythmic movements of Brownians.

Answer: C

Assessment Questions

5. Molecules are composed of
   a. atoms.
   b. electrons and protons.
   c. atomic nuclei.
   d. particles larger than atoms.

Assessment Questions

5. Molecules are composed of
   a. atoms.
   b. electrons and protons.
   c. atomic nuclei.
   d. particles larger than atoms.

Answer: A

Assessment Questions

6. A compound is composed of different kinds of atoms
   a. mixed together.
   b. moving at the same speed.
   c. in definite proportions.
   d. in the gaseous form.

Assessment Questions

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   a. mixed together.
   b. moving at the same speed.
   c. in definite proportions.
   d. in the gaseous form.

Answer: C

Assessment Questions

7. Most of the mass of an atom is in its
   a. isotopes.
   b. nucleus.
   c. electrons.
   d. electric charge.

Assessment Questions

7. Most of the mass of an atom is in its
   a. isotopes.
   b. nucleus.
   c. electrons.
   d. electric charge.

Answer: B

Assessment Questions

8. The shell model of the atom views electrons as occupying
   a. shells.
   b. three-dimensional orbitals.
   c. circular or elliptical orbits.
   d. standing waves.

Assessment Questions

8. The shell model of the atom views electrons as occupying
   a. shells.
   b. three-dimensional orbitals.
   c. circular or elliptical orbits.
   d. standing waves.

Answer: A

Assessment Questions

9. A plasma
   a. is an electrically charged mixture of ions and electrons.
   b. is a mixture of neutrons and protons with no charge.
   c. exists at very low temperatures.
   d. is another name for the solid phase of matter.

Assessment Questions

9. A plasma
   a. is an electrically charged mixture of ions and electrons.
   b. is a mixture of neutrons and protons with no charge.
   c. exists at very low temperatures.
   d. is another name for the solid phase of matter.

Answer: A