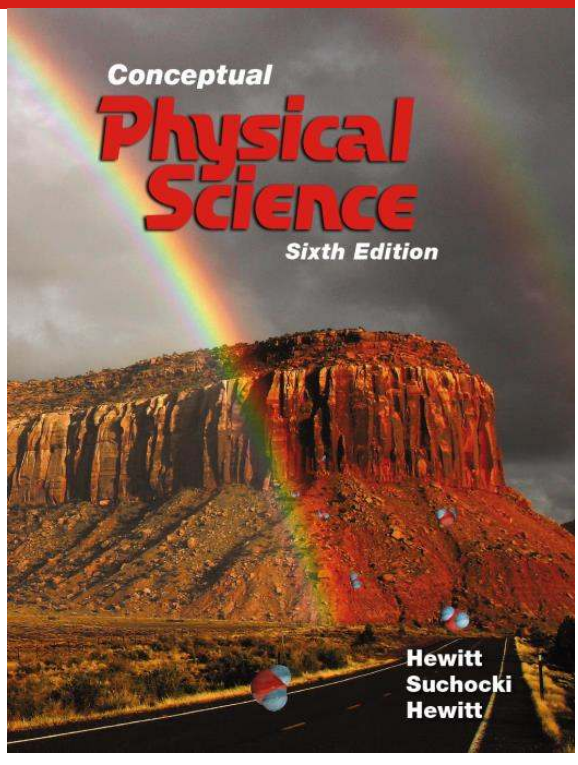
Chapter 12 Lecture

Chapter 12: Atoms and the Periodic Table



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1

Atoms Are Ancient and Empty

- Atoms are
  - ancient
    - origin of most atoms goes back to birth of universe
  - mostly empty space
- Elements heavier than hydrogen and much of the helium were produced in the interiors of stars.

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2

Atoms Are Ancient and Empty
CHECK YOUR NEIGHBOR

Which of the following are incorrect statements about the atom?

A. Atoms have been around since the beginning of the universe.
B. Atoms are mostly empty space.
C. Atoms are perpetually moving.
D. Atoms are manufactured in plants, and in humans during pregnancy.

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3

Atoms Are Ancient and Empty
CHECK YOUR ANSWER

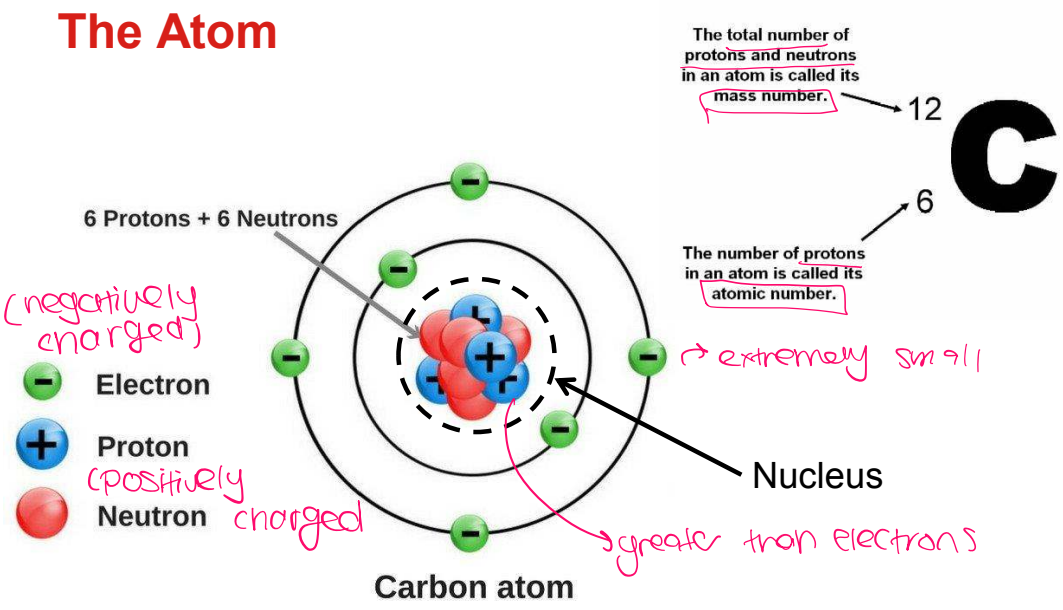
Which of the following are incorrect statements about the atom?

A. Atoms have been around since the beginning of the universe.
B. Atoms are mostly empty space. → at OK they stop
C. Atoms are perpetually moving.
D. Atoms are manufactured in plants, and in humans during pregnancy.

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4

The Atom



- Protons and neutrons are called **nucleons**
- Protons and neutrons form the ***nucleus***

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5

The Elements

- Element: A material made of only one kind of atom. Pure gold is an example as it is made of only gold atoms.
- Atom: The fundamental unit of an element.

The term "element" is used when referring to macroscopic quantities.
The term "atom" is used when discussing the submicroscopic.

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6



Z = atomic number
number of protons
= in neutral atom
number of electrons

A = mass number

Z + N

number of protons + number of neutrons

The Elements

- Atoms:
  - make up all matter around us
  - to date, 115 distinct kinds of atoms—90 found in nature, remainder synthesized
- Element
  - any material consisting of only one type of atom

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7

Protons and Neutrons

- Protons:
  - carry a positive charge—same quantity of charge as electrons
  - are about 1800 times as massive as an electron
  - An electrically neutral atom has the same number of electrons surrounding the nucleus as the number of protons in the nucleus

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8

Protons and Neutrons

- Electrons:
  - are identical
  - repel electrons of neighboring atoms
  - have electrical repulsion that prevents atomic closeness

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Protons and Neutrons

- Atomic number:
  - is the number of protons in each element listed in the periodic table.
- Neutrons:
  - accompany protons in the nucleus
  - have about the same mass as protons but no charge, so are electrically neutral

Both protons and neutrons are *nucleons*.

form nucleus

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Isotopes and Atomic Mass

- Isotopes:
  - refers to atoms of the same element that contain the same number of protons but different numbers of neutrons in the nucleus
  - identified by mass number, which is the total number of protons and neutrons in the nucleus
  - differ only in mass and not by electric charge; therefore, isotopes share many characteristics

Total number of neutrons in isotope = mass number − atomic number

11

Isotopes and Atomic Mass

- Atomic mass:
  - total mass of the atom(s) [protons, neutrons, and electrons]
  - listed in periodic table as atomic mass unit

One atomic mass unit is equal to
1.661×10^{-24} gram or 1.661×10^{-27} kg

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Isotopes and Atomic Mass
CHECK YOUR NEIGHBOR

The atomic number of an element matches the number of

A. protons in the nucleus of an atom.
B. electrons in a neutral atom.
C. both of the above.
D. none of the above.

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Isotopes and Atomic Mass
CHECK YOUR ANSWER

The atomic number of an element matches the number of

A. protons in the nucleus of an atom.
B. electrons in a neutral atom.
C. both of the above.
D. none of the above.

***Comment*:**

When the atomic number doesn't match the number of electrons, the atom is an ion.

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Isotopes and Atomic Mass
CHECK YOUR NEIGHBOR

A nucleus with an atomic number of 44 and a mass number of 100 must have

A. 44 neutrons.
B. 56 neutrons.
C. 100 neutrons.
D. none of the above.

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Isotopes and Atomic Mass
CHECK YOUR ANSWER

A nucleus with an atomic number of 44 and a mass number of 100 must have

A. 44 neutrons.
B. 56 neutrons.
C. 100 neutrons.
D. none of the above.

***Comment*:**

Be sure to distinguish between *neutron* and *nucleon*. Of the 100 nucleons in the nucleus, 56 are neutrons. A neutron *is* a nucleon, as is a proton.

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The Periodic Table

- The Periodic Table is a listing of all the known elements.
- It is NOT something to be memorized.
- Instead, we learn how to READ the Periodic Table.
- A chemist uses the Periodic Table much like a writer uses a dictionary. NEITHER need be memorized!

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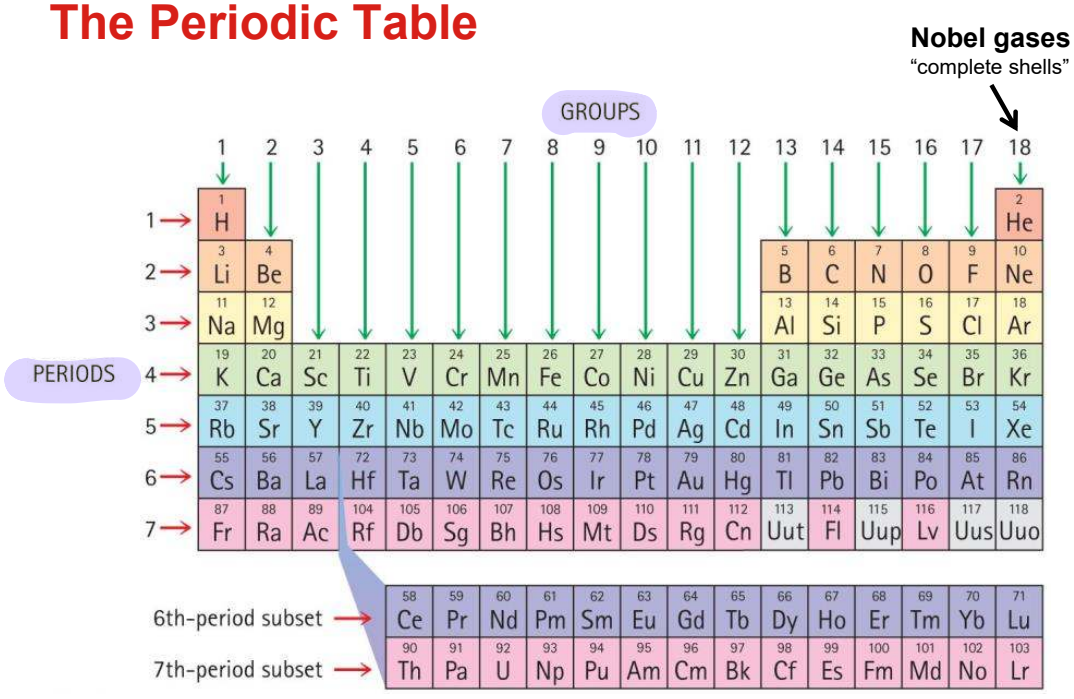
The Periodic Table

- The elements are highly organized within the Periodic Table.
- Each vertical column is called a "group."
- Each horizontal row is called a "period."

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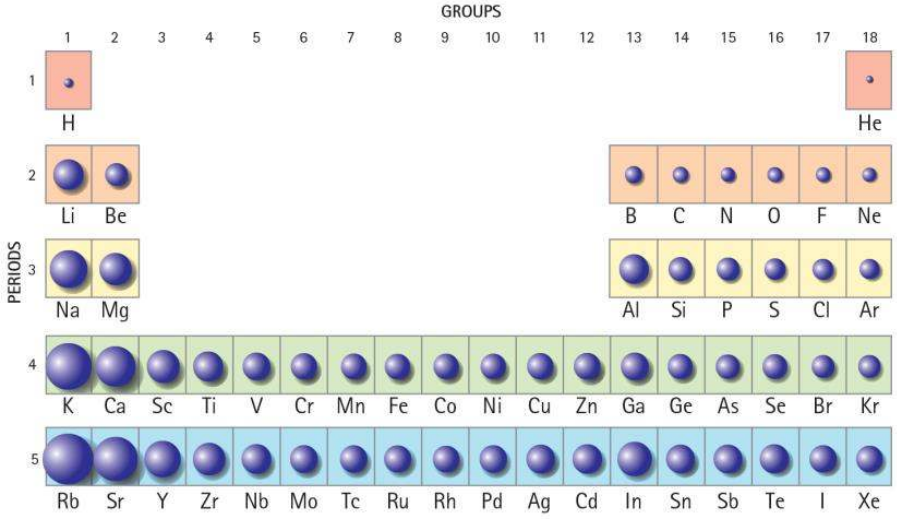
The Periodic Table



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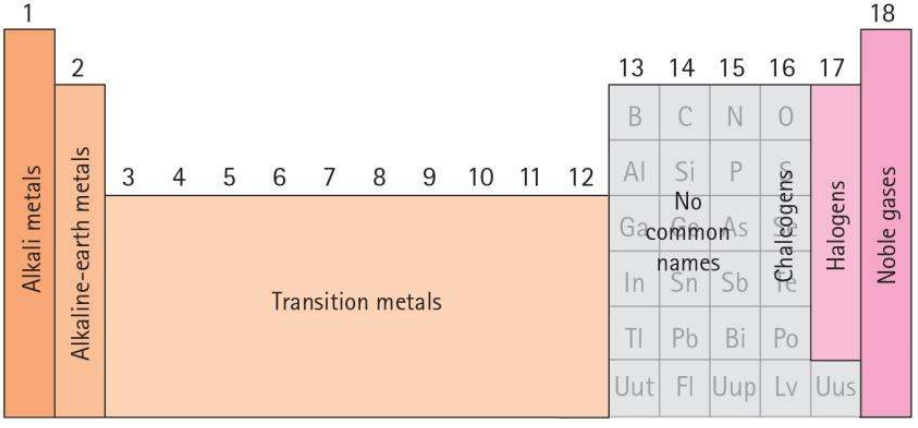
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The Periodic Table



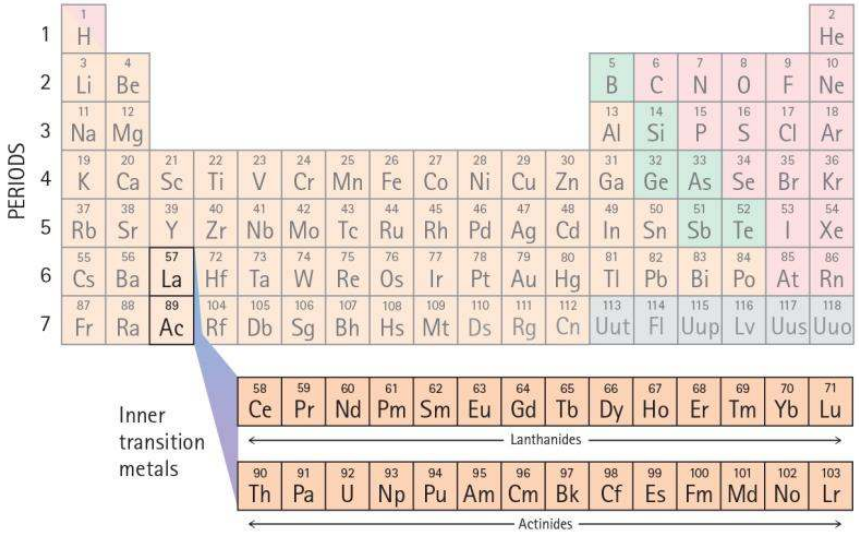
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The Periodic Table



22

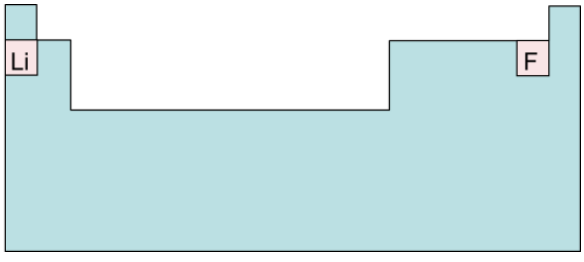
The Periodic Table



23

The Periodic Table
Check Your Neighbor

Which is larger: a lithium atom or a fluorine atom?



A. A lithium atom

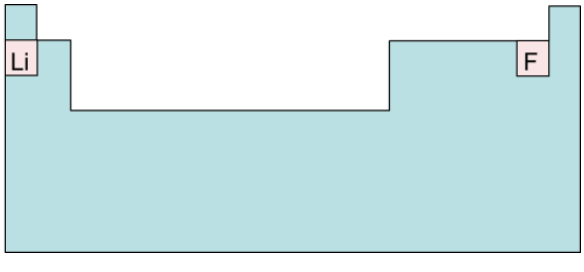
B. A fluorine atom

C. There is no way to tell without memorizing the periodic table.

24

The Periodic Table
Check Your Answer (1 of 2)

Which is larger: a lithium atom or a fluorine atom?

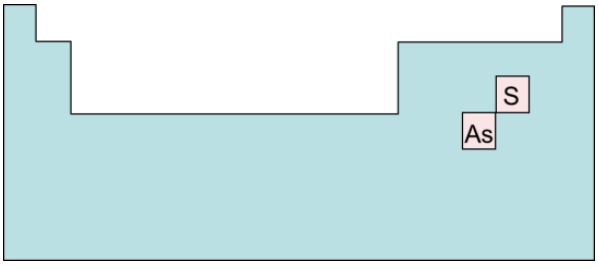


A. **A lithium atom**

25

The Periodic Table
Check Your Neighbor (2 of 2)

Which is larger: an arsenic atom or a sulfur atom?

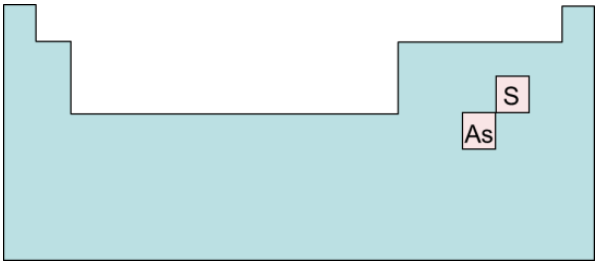


A. An arsenic atom
B. A sulfur atom
C. There is no way to tell without memorizing the periodic table.

26

The Periodic Table
Check Your Answer (2 of 2)

Which is larger: an arsenic atom or a sulfur atom?

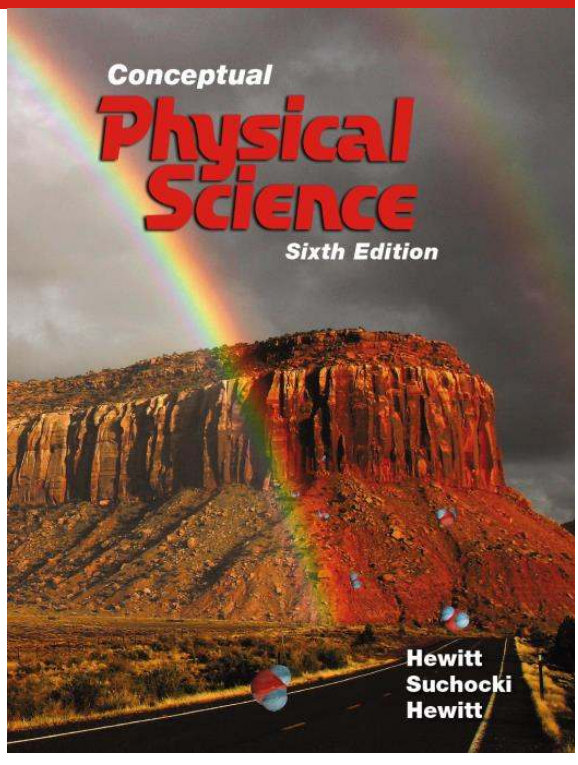


A. An arsenic atom

27

Chapter 15 Lecture

Chapter 15: How Atoms Bond and Molecules Attract



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Electron-Dot Structures

- Atoms bond together through their electrons. To learn about bonding, therefore, we need to know something about how the electrons within an atom are organized.
- Electrons behave as though they are contained within a series of seven concentric shells.

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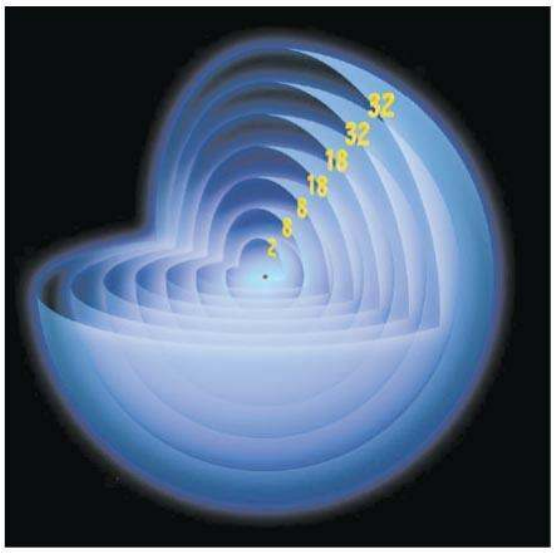
29

Electron-Dot Structures

- The numbers indicate the maximum number of electrons each shell may contain.

Note:

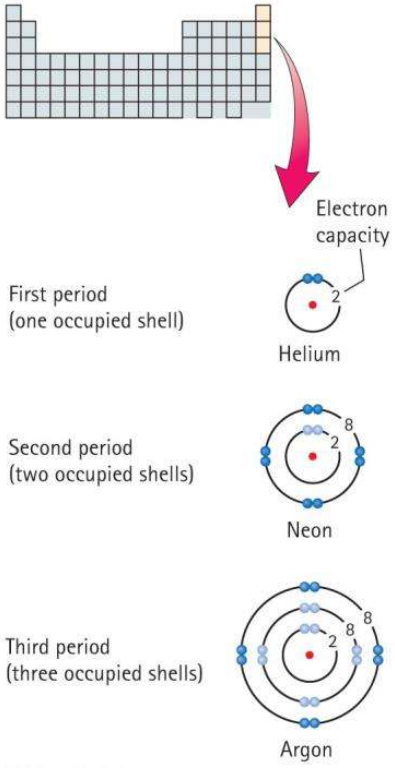
- This is a "conceptual model" and not a representation of what an atom "looks like."
- Rather, it helps us to understand how the electrons within atoms *behave*.



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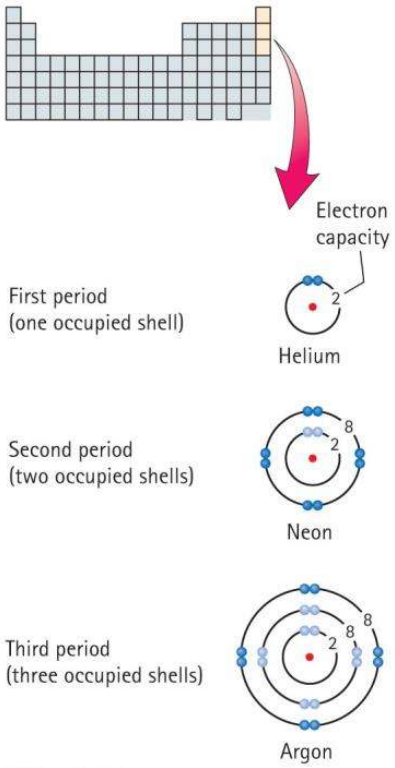
- The shells are more easily drawn in two dimensions.



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- The shells are more easily drawn in two dimensions.
- Each atom has its own configuration of electrons. Elements in the same group have similar configurations, which is why they have similar properties.



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Na +11

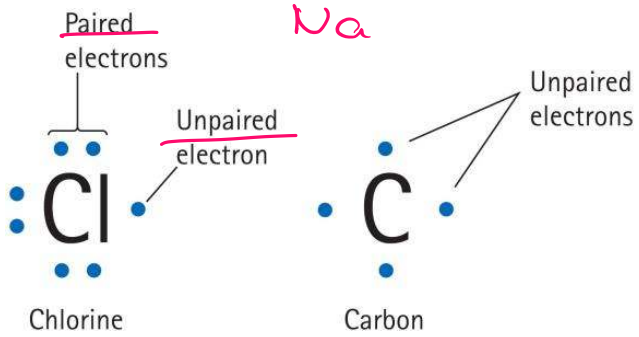
Electron-Dot Structures

→ outermost shell

- Valence electrons: Electrons in the outermost shell of an atom. These are the ones that can participate in chemical bonding.
- Electron-dot structure: A notation showing the valence electrons surrounding the atomic symbol.

only incl. valence

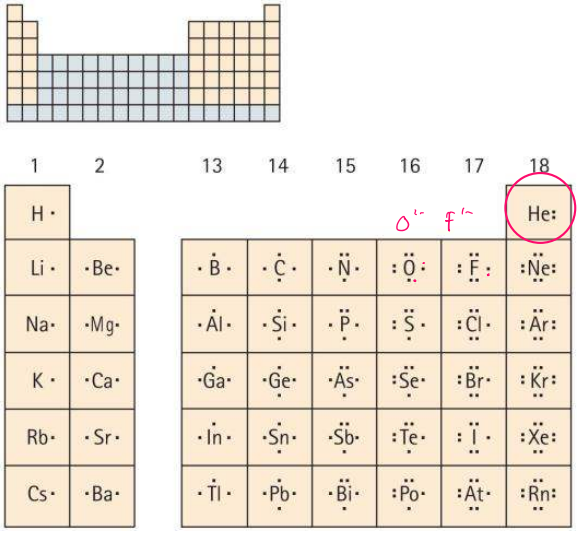
Na



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Electron-Dot Structures



Note that elements within the same group have the same electron-dot structure.

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Electron-Dot Structures Check Your Neighbor

Sodium, Na, atomic number 11, has only one valence electron. Upon losing this electron, what other atom in the periodic table does the sodium thus resemble?

A. Neon, Ne, atomic number 10
B. Magnesium, Mg, atomic number 12
C. Lithium, Li, atomic number 3
D. Sodium can only resemble sodium.

Electron-Dot Structures
Check Your Answer

Sodium, Na, atomic number 11, has only one valence electron. Upon losing this electron, what other atom in the periodic table does the sodium thus resemble?

A. Neon, Ne, atomic number 10

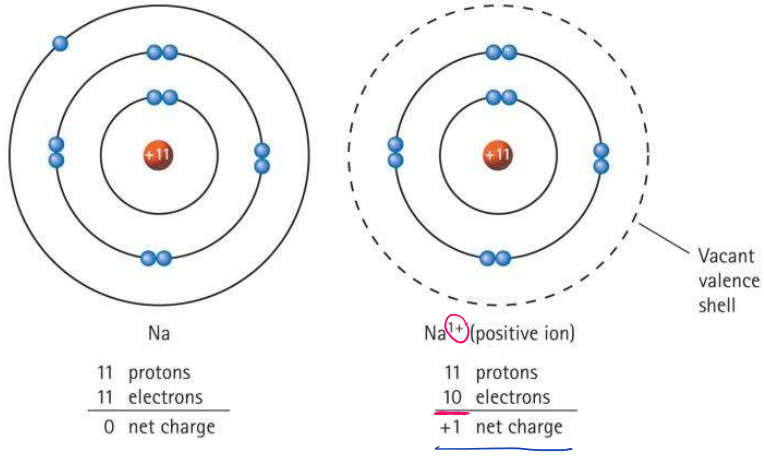
Explanation:

With 10 electrons, the sodium has enough electrons to fill the first and second shells, just like neon, Ne.

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The Formation of Ions

- Ion: An atom that has lost or gained one or more electrons. (negatively charged)



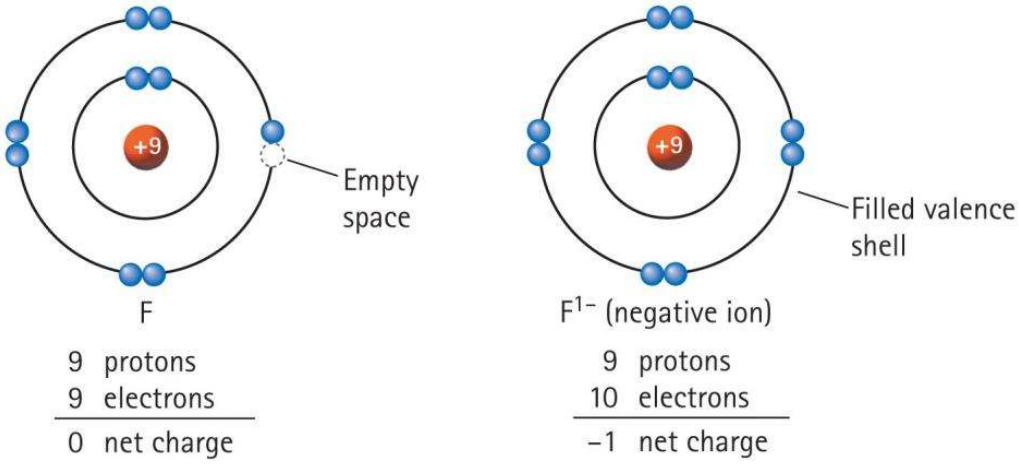
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Na^{1+}

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The Formation of Ions

- Ion: An atom that has lost or gained one or more electrons.



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lost 2 electrons = X^{2+}
gained 2 electrons = X^{2-}

Ionic Bonds

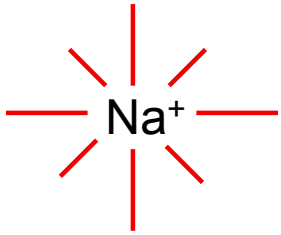
- Ion: An atom that has lost or gained one or more electrons.
- Ionic Bond: The electrical force of attraction between oppositely charged ions.

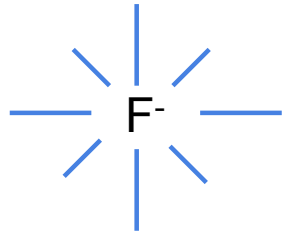
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Ionic Bonds

- Ion: An atom that has lost or gained one or more electrons.
- Ionic Bond: The electrical force of attraction between oppositely charged ions.



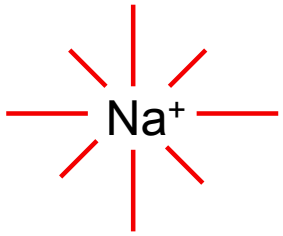


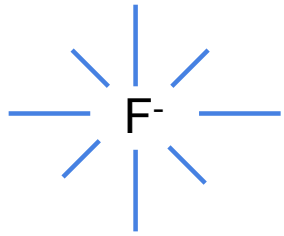
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40

Ionic Bonds

- Ion: An atom that has lost or gained one or more electrons.
- Ionic Bond: The electrical force of attraction between oppositely charged ions.



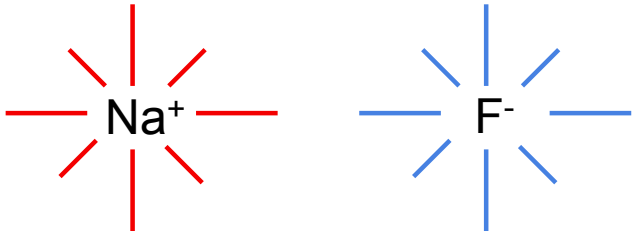


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Ionic Bonds

- Ion: An atom that has lost or gained one or more electrons.
- Ionic Bond: The electrical force of attraction between oppositely charged ions.

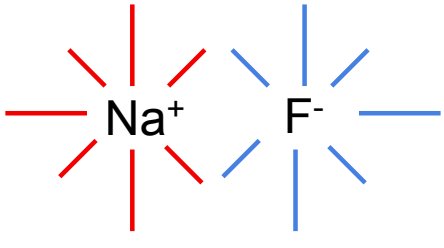


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Ionic Bonds

- Ion: An atom that has lost or gained one or more electrons.
- Ionic Bond: The electrical force of attraction between oppositely charged ions.



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Metallic Bonds

- Outer electrons in metal atoms are held only weakly by the nucleus.
- This weak attraction allows the electrons to move about quite freely.
- This mobility of electrons accounts for many metallic properties.
- An alloy is a mixture of metallic elements.

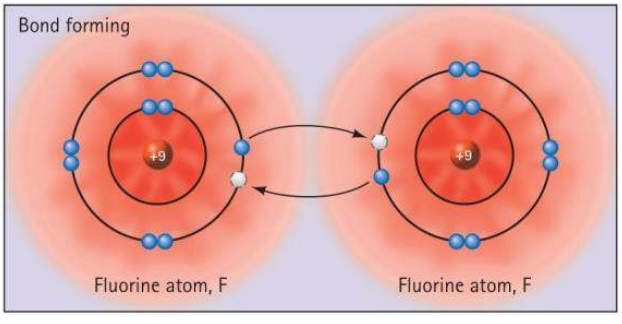


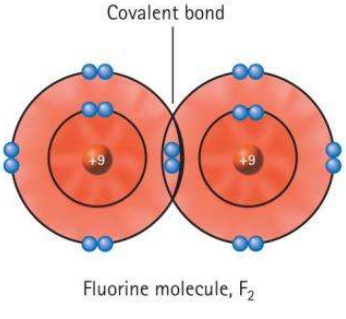
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Covalent Bonds

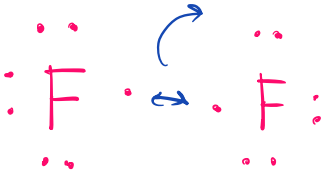
- The type of electrical attraction in which atoms are held together by their mutual attraction for shared electrons.

single covalent bond





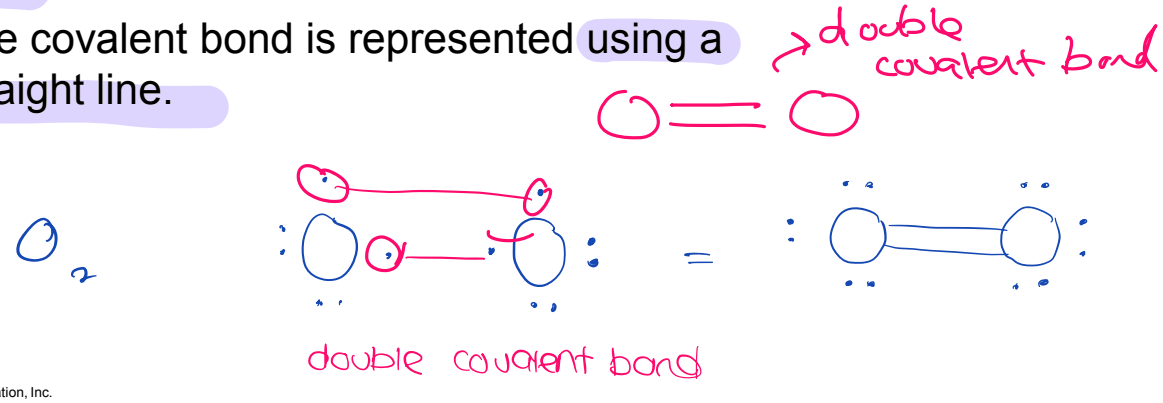
share electrons to form a covalent bond



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Covalent Bonds

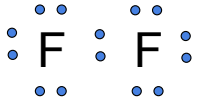
- The type of electrical attraction in which atoms are held together by their mutual attraction for shared electrons.
- There are two electrons within a single covalent bond.
- The covalent bond is represented using a straight line.



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Covalent Bonds

- The type of electrical attraction in which atoms are held together by their mutual attraction for shared electrons.
- There are two electrons within a single covalent bond.
- The covalent bond is represented using a straight line.



F — F

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Covalent Bonds

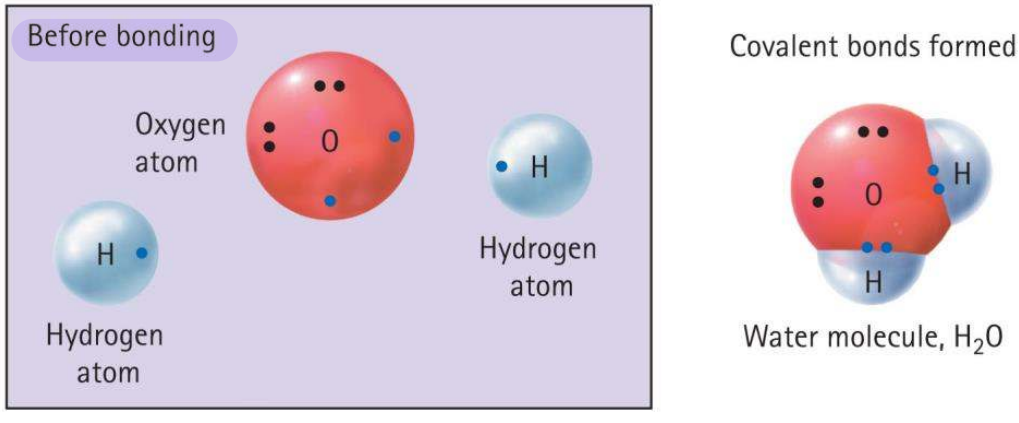
- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.

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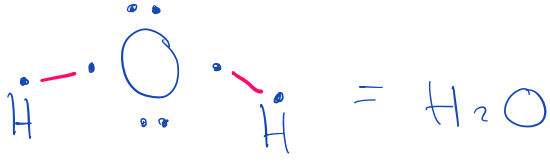
Covalent Bonds

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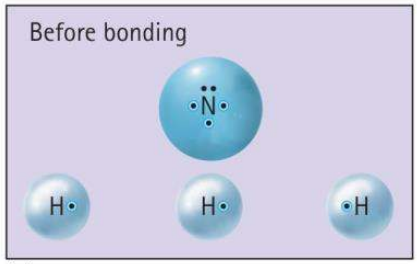
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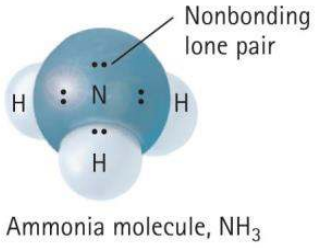


Covalent Bonds

- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.



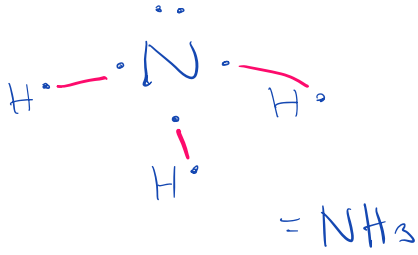
(a)



Ammonia molecule, NH_3

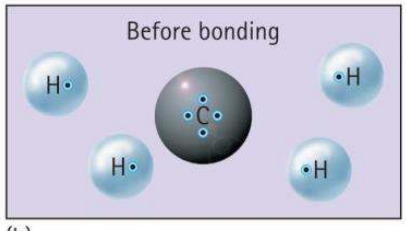


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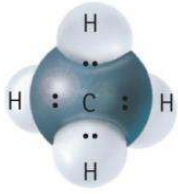


Covalent Bonds

- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.

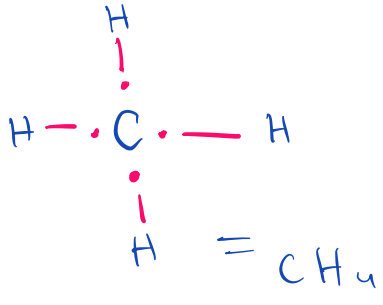


(b)



Methane molecule, CH_4





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Covalent Bonds

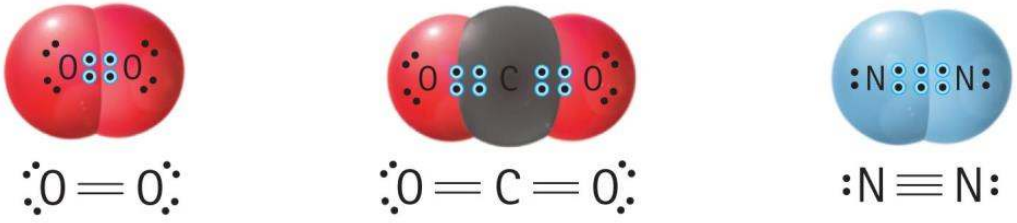
- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.
- Multiple covalent bonds are possible.

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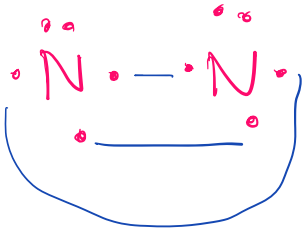
Covalent Bonds

- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.
- Multiple covalent bonds are possible.



Oxygen, O_2 | Carbon dioxide, CO_2 | Nitrogen, N_2

double covalent



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