Chemical bonding

p 48 curriculum guide

Chemical Bonding

Valence electrons

electrons in the highest occupied energy level of an element's atoms.

- determines the chemical properties of an element
- only electrons used in chemical bonds
- for a representative element, the number of valence electrons corresponds to the group number

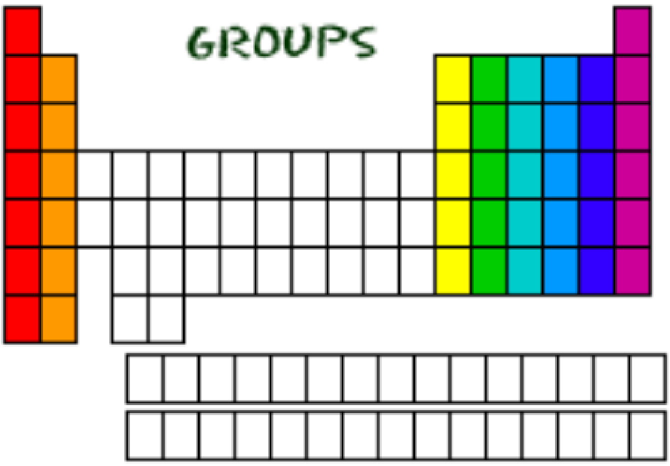
Electron dot structure

diagrams showing the valence electrons as dots

- all the elements within a given group (except Helium,) have the same number of dots in their structure

Table 7.1

Groups - Review



- Each column is called a "group"
- Each period represents an energy level within the atom (where electrons reside).
- Each element in a group has the same number of electrons in their outer energy level (the valence level).
- The electrons in the outer shell are called "valence electrons"

Electron Dot Structure or Lewis Dot Diagram (Gilbert Lewis)

A notation showing the valence electrons surrounding the atomic symbol.

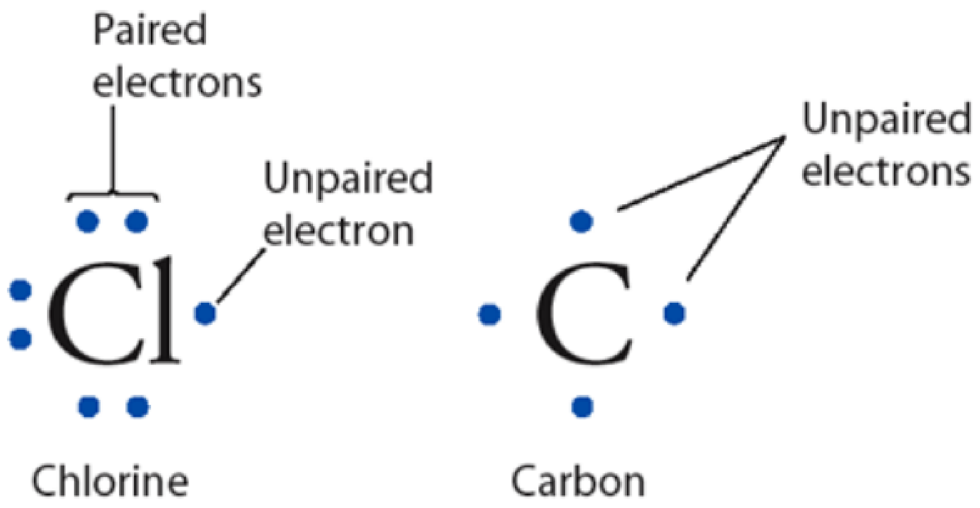
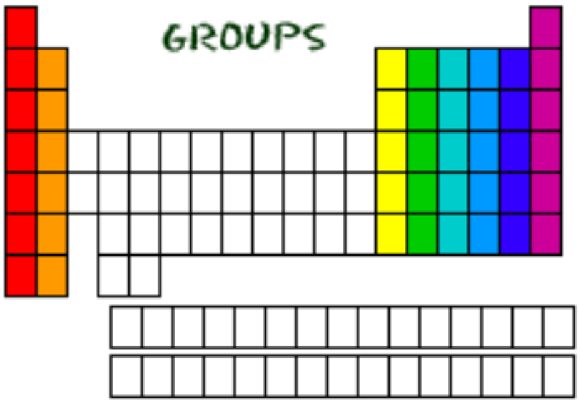


Table 7.1

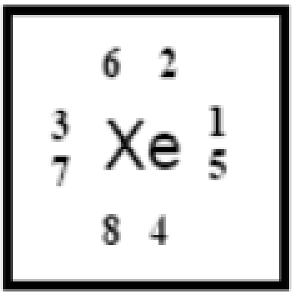
Electron Dot Structure of Some Group A Elements

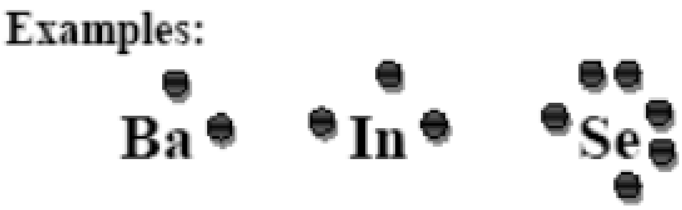
Period	Group							
	1A	2A	3A	4A	5A	6A	7A	8A
1	H							He
2	Li	Be	B	C	N	O	F	Ne
3	Na	Mg	Al	Si	P	S	Cl	Ar
4	K	Ca	Ga	Ge	As	Se	Br	Kr

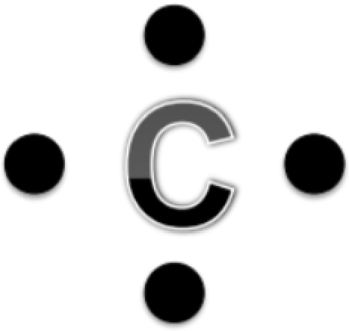
Lewis Structures



- Find out which group (column) your element is in.
- This will tell you the number of valence electrons your element has.
- You will only draw the valence electrons.



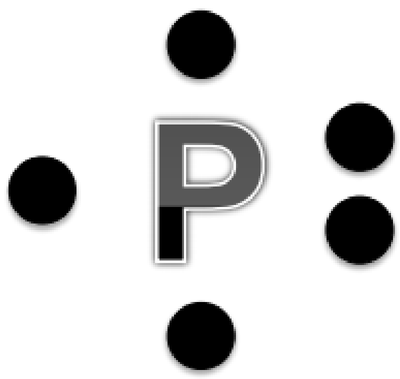




1) Write the element symbol.
2) Carbon is in the 4th group, so it has 4 valence electrons.
3) Starting at the right, draw 4 electrons, or dots, counter-clockwise around the element symbol.

draw dot diagram for phosphorus

P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Octet Rule

To form compounds, atoms usually achieve the electron configuratio of a noble gas.
At the highest occupied energy level: ns^2np^6

Formation of Cations

Cations **lose valence electrons** to form positively charged ions

$Na\ 1s^22s^22p^63s^1 \xrightarrow{-e^-} Na^+\ 1s^22s^22p^6$

Ionization:

$Na \longrightarrow Na^+ + e^-$

$Mg \longrightarrow Mg^{+2} + 2e^-$

Transition Metals will attempt to form a pseudo noble-gas configuration.

Cu (I) → $1s^22s^22p^63s^23p^6[4s^1]3d^{10}$

Cu^{+1} ion → $1s^22s^22p^63s^23p^63d^{10}$

Formation of Anions

Anions **gain electrons to produce a negatively** charged ion.

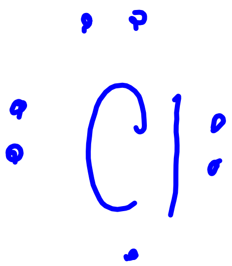
Cl $1s^2 2s^2 2p^6 3s^2 3p^5$ $\xrightarrow{+\ e^-}$ Cl^- $1s^2 2s^2 2p^6 3s^2 3p^6$

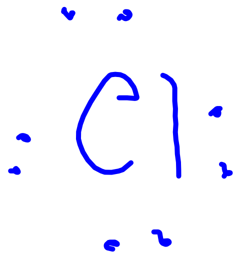
Ionization:

Cl + e^- $\rightarrow$ Cl^-

O + $2e^-$ $\longrightarrow$ O^{-2}

draw dot diagram of both





Chlorine atom

Cl

Chloride ion

Cl

Assignment

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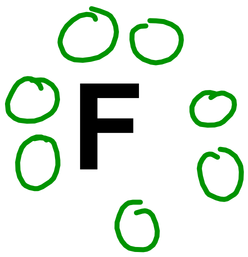
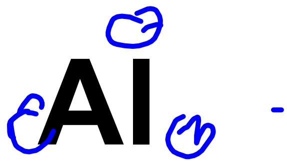
Complete guided reading for section 7.1, 7.2

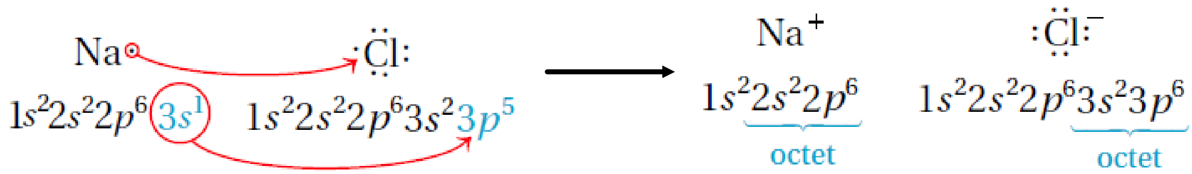
Warm up - Lewis Dot diagram for Fluorine & aluminium





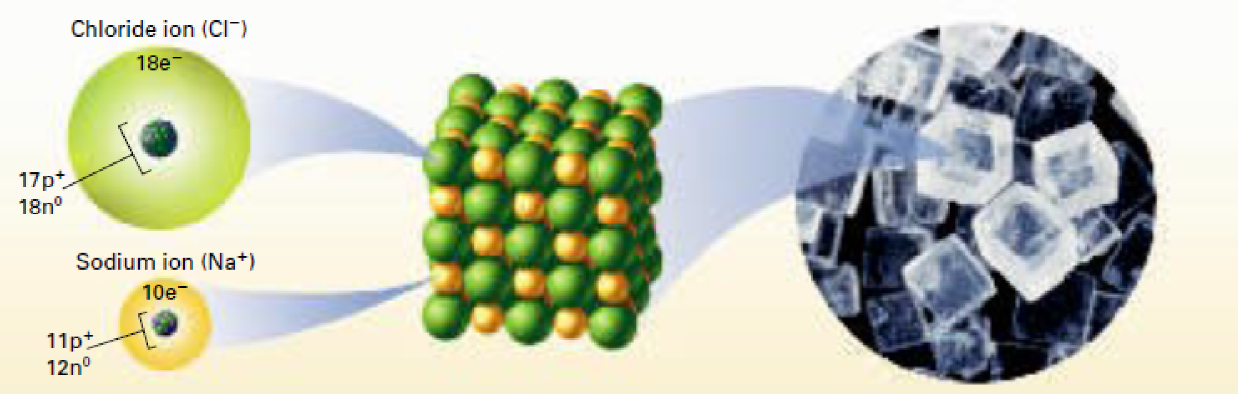
Ionic bonds and Ionic Compounds

Ionic compounds are composed of IONS but are electrically neutral.



properties of ionic compounds

- crystalline at room temperature
- generally high melting points
- conduct an electric current when melted or dissolved in water

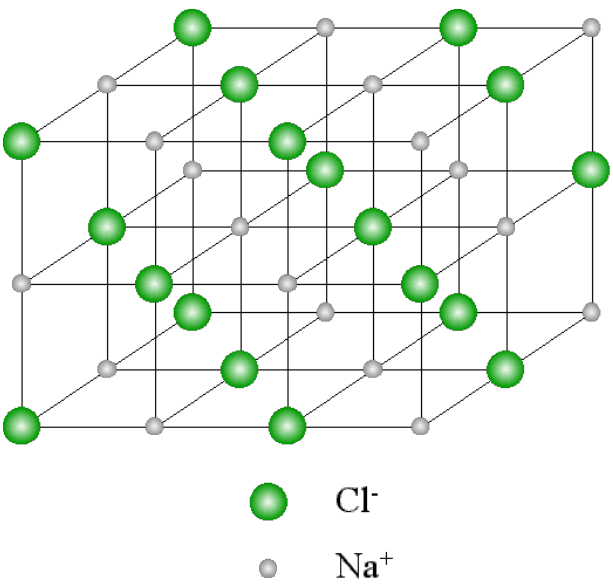


Structures of sodium ion and chloride ion

Arrangement of Na^+ ions and Cl^- ions in a crystal of sodium chloride

Crystals of sodium chloride

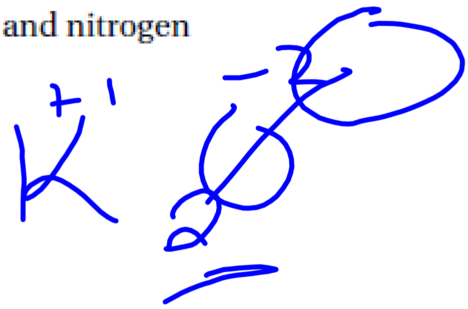
Crystal Structure of Ionic Solids



Predicting Formulas of Ionic Compounds

The ionic compound formed from potassium and oxygen is used in ceramic glazes. Use electron dot structures to predict the formulas of the ionic compounds formed from the following elements.

a. potassium and oxygen **b.** magnesium and nitrogen



2 Solve ***Apply concepts to this situation.***

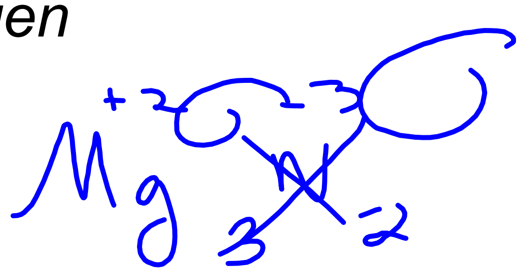
a. Start with the atoms.

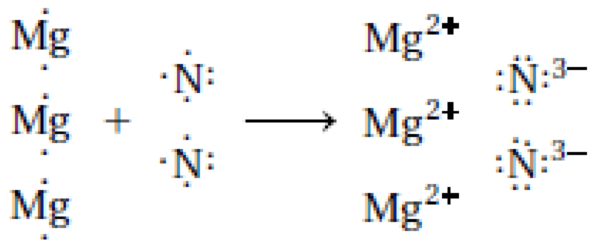
K· and ·Ö:

In order to have a completely filled valence shell, oxygen must gain two electrons. These electrons come from two potassium atoms, each of which loses one electron.

$$\begin{matrix} K\cdot \\ K\cdot \end{matrix} + \cdot\ddot{O}: \longrightarrow \begin{matrix} K^{+} \\ K^{+} \end{matrix} \; :\ddot{\underset{..}{O}}:^{2-}$$

magnesium and nitrogen





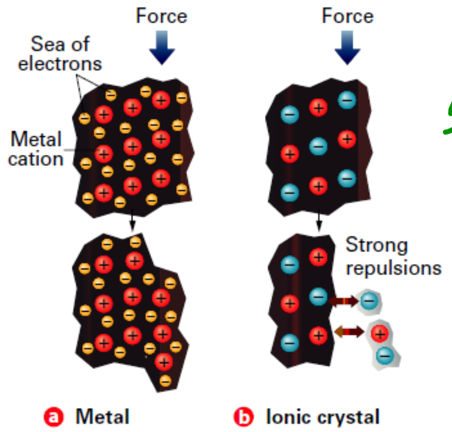
The formula of the compound formed (magnesium nitride) is Mg_3N_2.

Behaviour of metallic structures | Chemistry for All | The Fuse School
https://www.youtube.com/watch?v=JPH5-fCxX-Q

Metallic Bonds

Metals are made of closely packed **cations** rather than neutral atoms.

In metals, the valence electrons drift freely from one part of the metal to another. (like sea of electrons)



Metallic bonds consist of the free-floating valence electrons for the positively charged metal ions.

Ductility and Malleability

Metals - cations insulated by 'sea' of electrons

Ionic compounds - positive ions pushed together and repel, causing crystal to shatter.

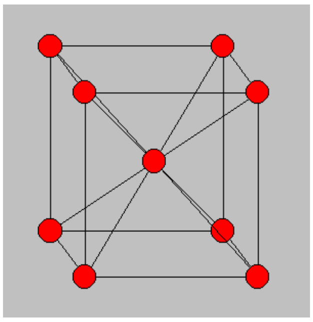
`

Crystalline Structure of Metals

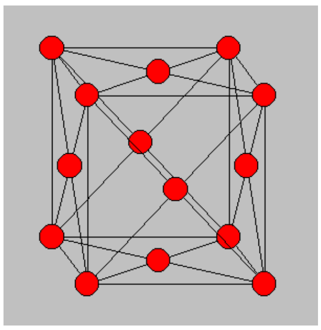
Metals are arranged in very compact and orderly patterns.

Closely-Packed Arrangements:

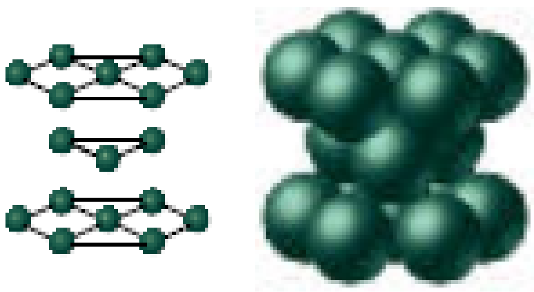
- **Body-Centered Cubic**- every atom(except surface atoms) have 8 neighbors. Na, K, Fe



Face-Centered Cubie every atom has 12 neighbors, ex Cu, Ag, Au, Al



- Hexagonal Close-Packed - every atom has 12 neighbors, but the pattern is different ex. Mg, Zn, Cd



Hexagonal close-packed

Alloys

Alloys
Mixtures of two or more elements, at least one of which is a metal.

Alloys are important because their properties are often SUPERIOR to those of their component elements.
Table 7.3

Table 7.3
Composition of Some Common Alloys

Name	Composition (by mass)
Sterling silver	Ag 92.5% Cu 7.5%
Cast iron	Fe 96% C 4%
Stainless steel	Fe 80.6% Cr 18.0% C 0.4% Ni 1.0%
Spring steel	Fe 98.6% Cr 1.0% C 0.4%
Surgical steel	Fe 67% Cr 18% Ni 12% Mo 3%

Form in one of two ways:
1) Substitutional Alloys
If atoms of the alloy are about the same size, they can replace each other in the crystal.

2) Interstitial Alloys
If atomic sizes are quite different, smaller atoms can fit into the spaces between the larger atoms.

Alloy and their Properties | Chemistry for All | The Fuse School
https://www.youtube.com/watch?v=KgUmNQD6m5Q

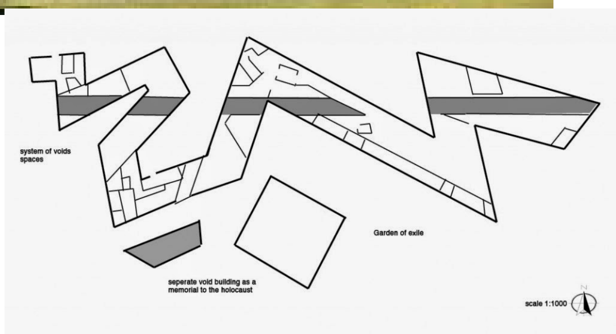
Building with Alloys

The Atomium, Brussels, Belgium

Made with aluminium alloy

Shiny, corrosion resistant & malleable

Jewish Museum ,Berlin



zinc-titanium alloy

corrosion resistant & light

Chrysler Building, New York City

Steel - shiny, malleable, corrosion-resistance

Homework

Guided reading sheets
section 7.1 & 7.2
p. 193 #3-11
p 196 #12 & 13
p. 203 #23-29

P 193

Section 7.1 Assessment

3. look up the group number of that element
4. Atoms of nonmetallic elements tend to gain electrons; atoms of metallic elements tend to lose electrons.
5. when an atom loses valence electrons
6. when an atom gains valence electrons
7. **a.** 1 **b.** 4 **c.** 2 **d.** 6
8. **a.** K· **b.** ·Ċ· **c.** ·Mg· **d.** :Ö:
9. **a.** lose 2 **b.** gain 1 **c.** lose 3 **d.** gain 2
10. **a.** potassium cation, K^+
    b. zinc cation, Zn^{2+}
    c. fluoride anion, F^-
11. Cd^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$

a) K· c) Mg (2 dots)

b) C (4 dots) d) O (6 dots)

K^{1+}

Zn^{2+} F^{1-}

CONCEPTUAL PROBLEM 7.2

Answers

12. **a.** KI

b. Al_2O_3

13. $CaCl_2$

p . 196

$K + I \rightarrow K^{1+} \quad I^{1-}$

$Al \quad O \qquad\qquad Al^{3+} \quad O^{2-}$

$O \qquad\qquad O^{2-}$

$+ \rightarrow$

$Al \quad O \qquad\qquad Al^{3+} \quad O^{2-}$

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Section 7.3 Assessment

23. metal cations surrounded by a sea of mobile valence electrons
24. Atoms in metals are arranged in a compact and orderly manner.
25. The properties of alloys are often superior to their component elements.
26. ductile: can be drawn into wires; malleable: can be hammered into different shapes
27. Under pressure, the cations in a metal slide past each other. The ions in ionic crystals are forced into each other by the rigid structure.
28. body-centered cubic; face-centered cubic; hexagonal close-packed
29. Sterling silver used in jewelry is 92.5% silver and 7.5% copper; bronze used in casting is 7 parts copper and 1 part tin.

5. a) Ar

b) Ca

c) I

8. a) [Ne] $3s^2$

b) [Ne] $3s^2 3p^1$

c) [Ar] $4s^1$

13 pseudo noble gas config.

15. 4s [ ] } leave blank

16 anions

Homework

8 a) K· b) ·Ċ· c) ·Mg· d) ·Ö:

p. 193 #3-11

p. 203 #23-29

10. a) K^+ potassium ion
b) Zn^{2+} zinc ion
c) F^- fluoride ion

11. Cd^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$ ($5s^2$ removed)

24. a) $\cdot\underset{\cdot}{\dot{Si}}\cdot$

b) $\cdot Rb$

c) $\cdot Ba \cdot$

Electronegativity

<u>Electronegativity</u>
The ability of an atom in a compound to attract electrons

<u>Trends</u>

- Within a group, electronegativity decreases from top to bottom
- Within a period, electronegativity increases from left to right

Ex. F

Table 6.2

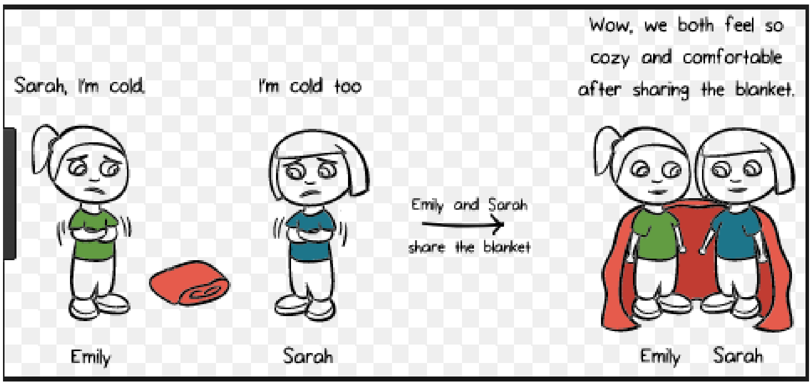
Electronegativity Values for Selected Elements

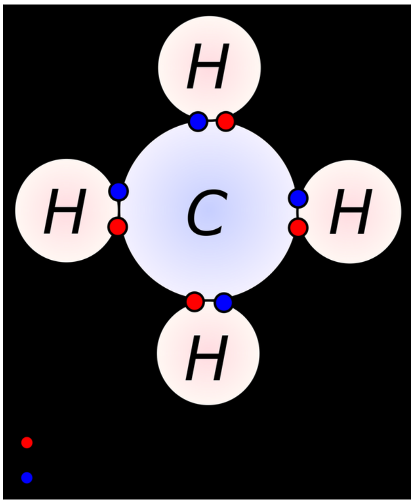
INCREASES →

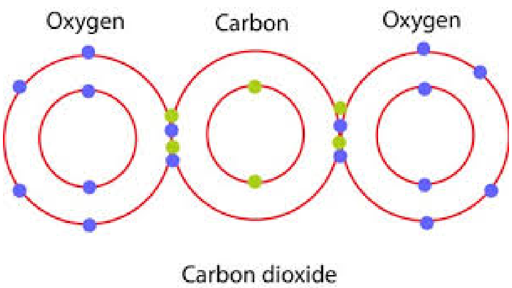
H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	Tl 1.8	Pb 1.9	Bi 1.9		

DECREASES ↓

Chapter 8- Covalent Bonds







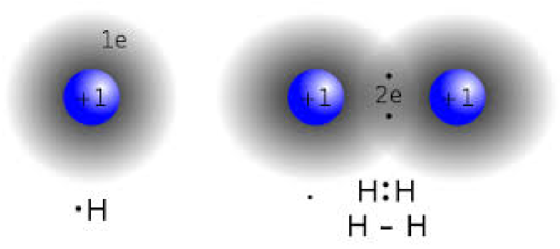
nm-nm

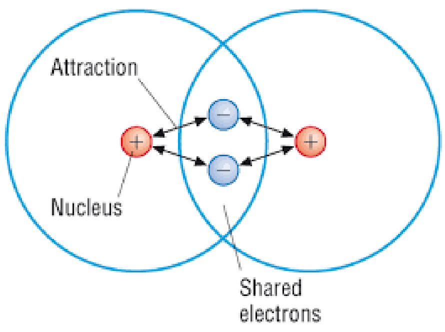
Covalent Bond

MOLECULAR COMPOUNDS

Recall that a **covalent bond** is a shared pair of electrons between two nonmetal atoms.

- Each atom wants to reach the electron configuration of a noble gas (ns^2np^6 - Octet Rule)





Diatomic Molecules

Which elements are diatomic?

H_2 N_2 O_2 F_2 Cl_2 Br_2 I_2

H_2 N_2 O_2 F_2 Cl_2 Br_2 I_2

8.2 - The Nature of Covalent Bonding

Single covalent Bonds- sharing a pair of electrons

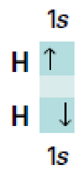
ex H_2

Electron Dot Structure

H : H

Structural Formula

H — H



Covalent Bonding Tutorial — Covalent vs. Ionic bonds, explained | Crash Chemistry Academy

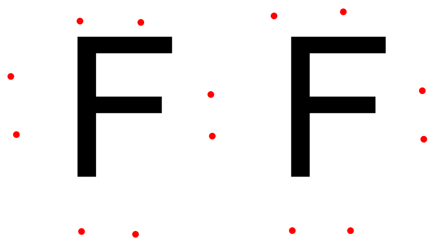
https://www.youtube.com/watch?v=MlgKp4FUV6I

Molecular Formula (symbols)

F_2

Electron Dot Structure (valence $\bar{e}$)

F F

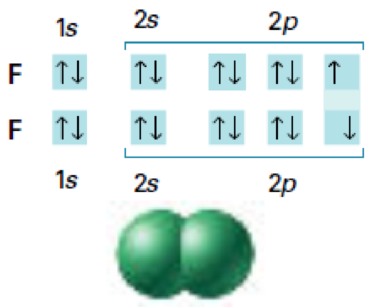


Structural Formula (bonds)

F—F

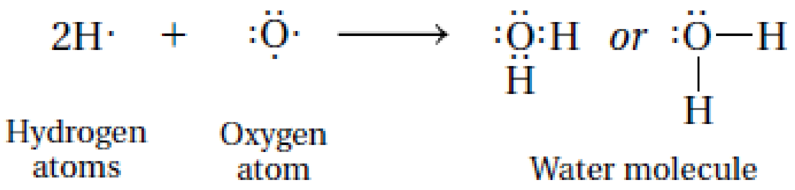
Lone pair (unshared pair)

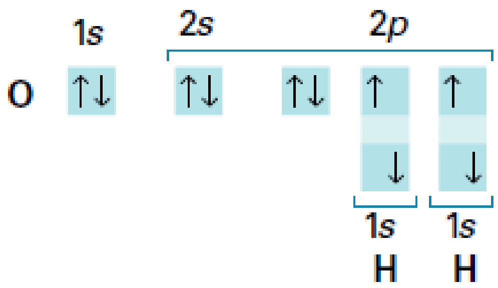
A pair of valence electrons not shared between atoms



Fluorine molecule

Two shared and two unshared pairs of electrons

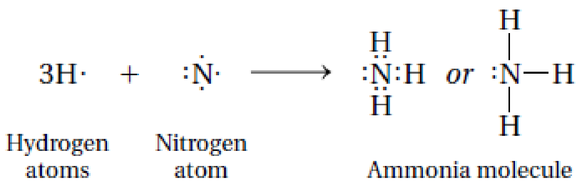


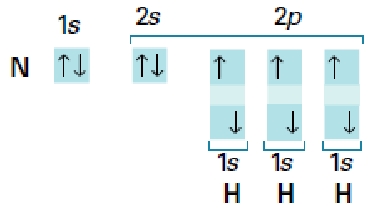



Water molecule

one unshared pair of electrons

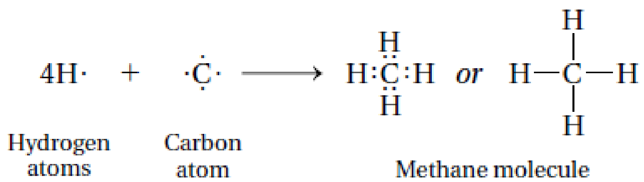
3 shared pairs of electrons

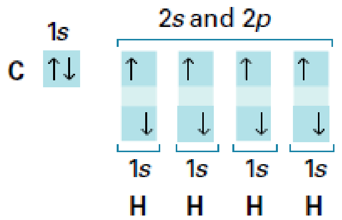




Ammonia molecule

No unshared pairs of electrons





Methane molecule

Page 220 # 7 & 8

81 + 82

Guided Reading

write down

Practice Problems

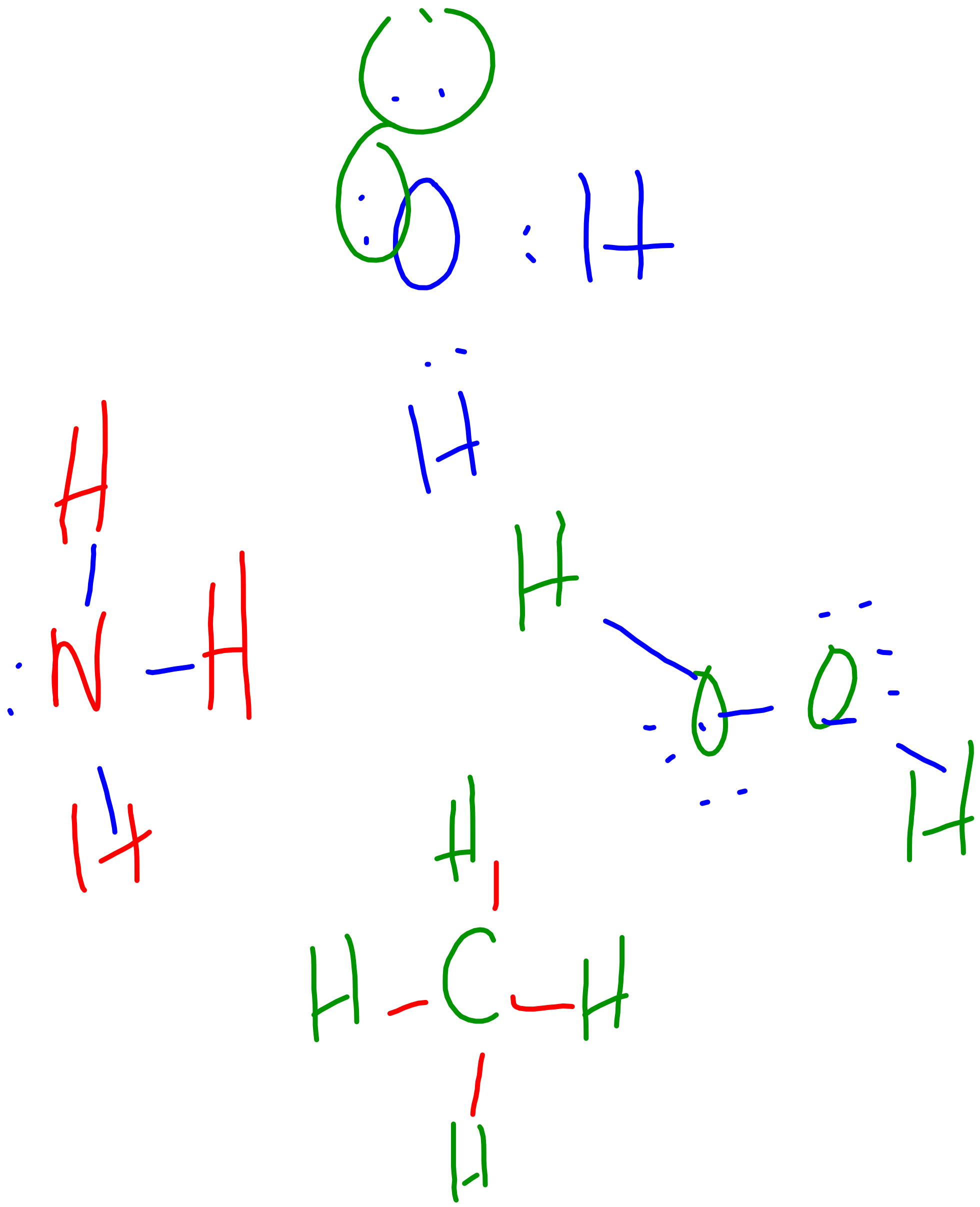
7. Draw electron dot structures for each molecule.
   a. chlorine b. bromine c. iodine
8. The following molecules have single covalent bonds. Draw an electron dot structure for each.
   a. H_2O_2 b. PCl_3

Practice Problems Plus L2

The following covalent molecules have only single covalent bonds. Draw an electron dot structure for each.

a. NF_3

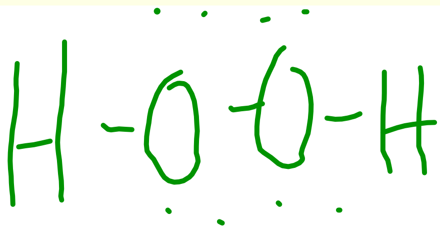
b. SBr_2

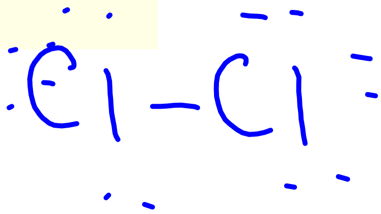

O
H
H
N
H
H
H
O
O
H
H
H
C
H
H
H

Answers

7. a. :Cl:Cl: **b.** :Br:Br: **c.** :I:I:

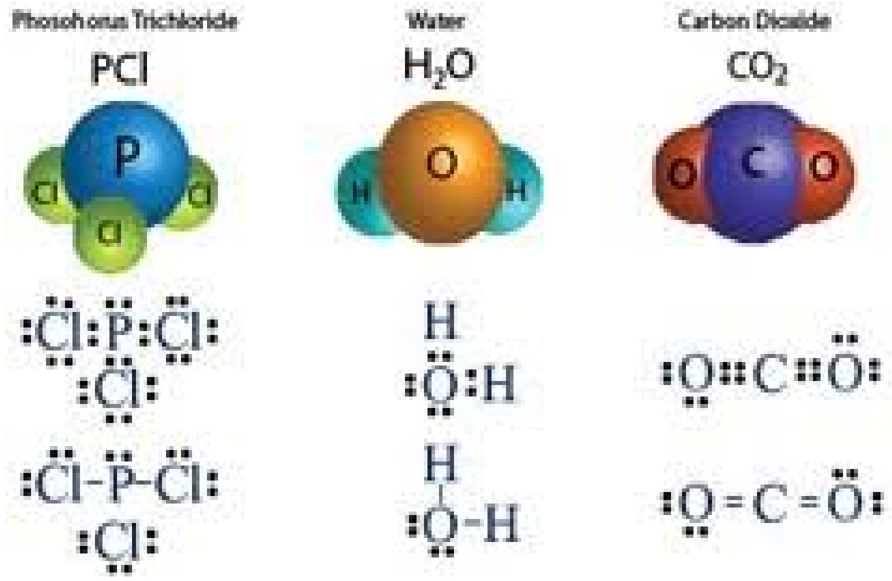
8. a. H:O:O:H **b.** :Cl:P:Cl:
:Cl:





a. NF_3 :F:N:F:
:F:

b. SBr_2 :Br:S:Br:


Phosohorus Trichloride
PCl
Water
H_2O
Carbon Dioxide
CO_2

Molecular formula

H_2O

Lewis dot
electron dot

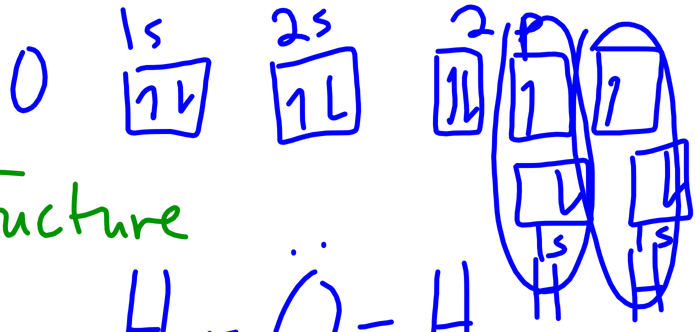
Structural diagram

CH_4

- one of carbon's *2s* electrons is promoted to the *2p* orbital:

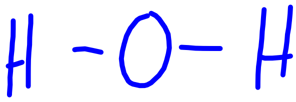
Molecular formula

H_2O



Lewis dot structure
electron dot

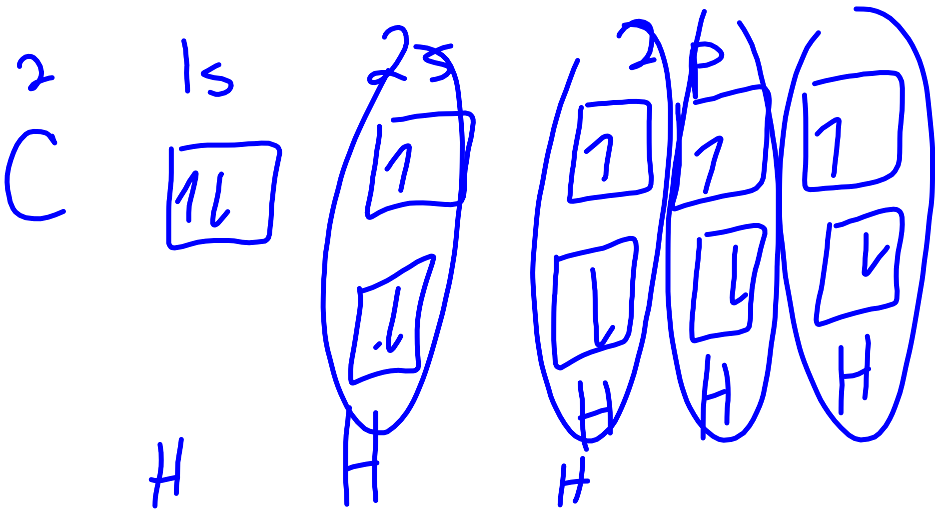
Structural diagram

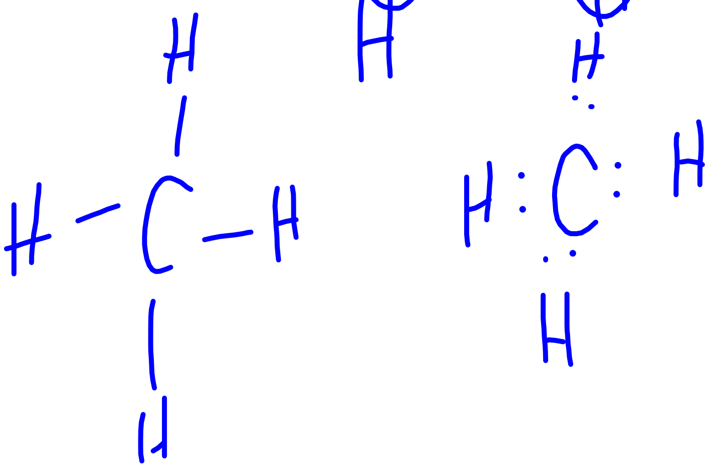


CH_4

- one of carbon's *2s* electrons is promoted to the *2p* orbital:

CH_2

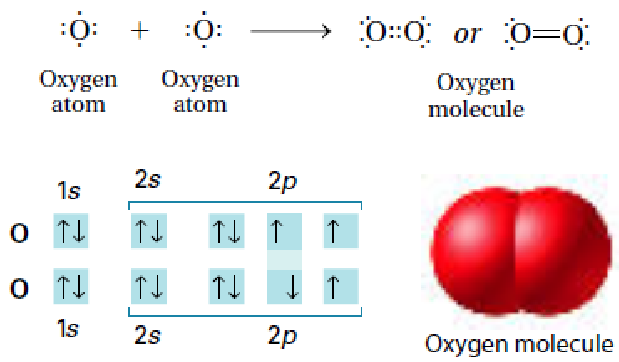




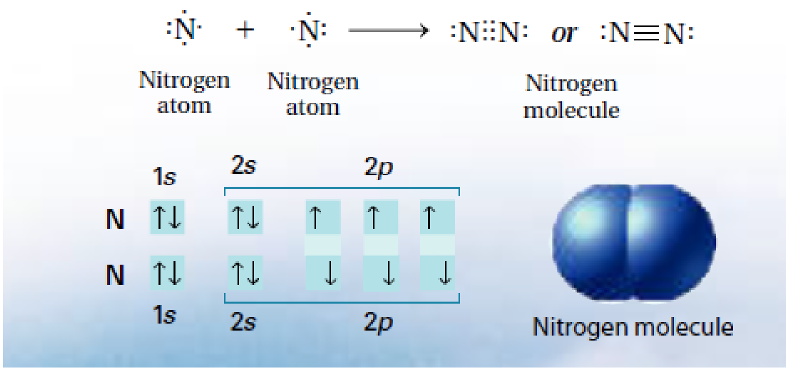
Double and Triple Covalent Bonds

Atoms form double or triple covalent bonds if they attain a noble gas structure by sharing two or three pairs of electrons.

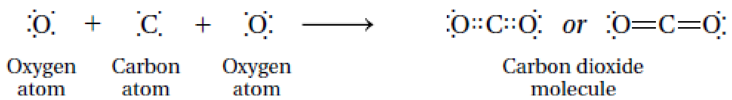
Double covalent bond - two shared pairs

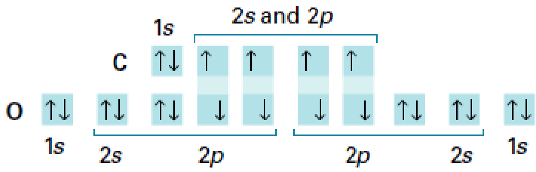


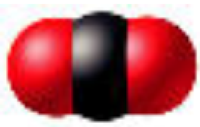
Triple covalent bond - three shared pairs



The carbon dioxide molecule contains two oxygens, each of which shares two electrons with carbon to form a total of two carbon–oxygen double bonds.







Carbon dioxide molecule

The two double bonds in the carbon dioxide molecule are identical to each other. Carbon dioxide is an example of a triatomic molecule, which is a molecule consisting of three atoms.

Figure 8.8 Carbon dioxide gas is soluble in water and is used to carbonate many beverages. A carbon dioxide molecule has two carbon–oxygen double bonds.

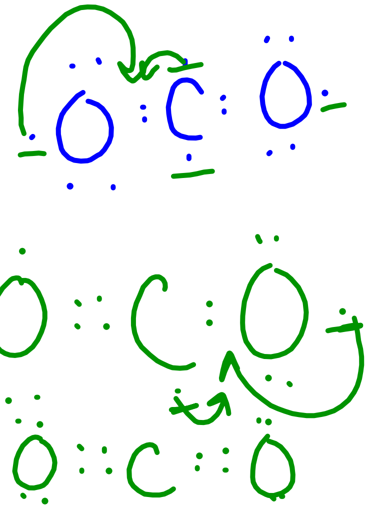
Molecular Formula

CO_2

Electron dot structure

O=C=O

Structural diagram



Double covalent bond

Two shared pairs of electrons

Molecular structure / electron dot structure / structural diagram

N_2

Triple covalent bond

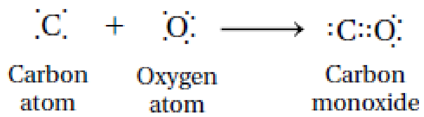
Three shared pairs of electrons

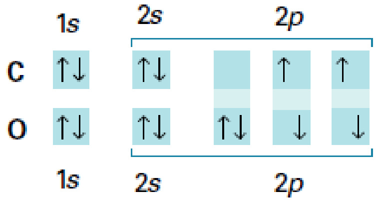
Coordinate Covalent Bonds

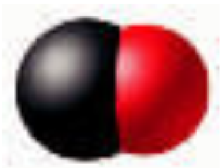
<u>**Coordinate Covalent Bond**</u>

A covalent bond in which one atom contributes a shared pair of electrons.

CO

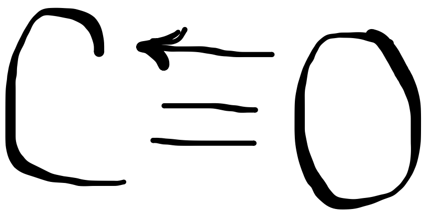






Carbon monoxide molecule

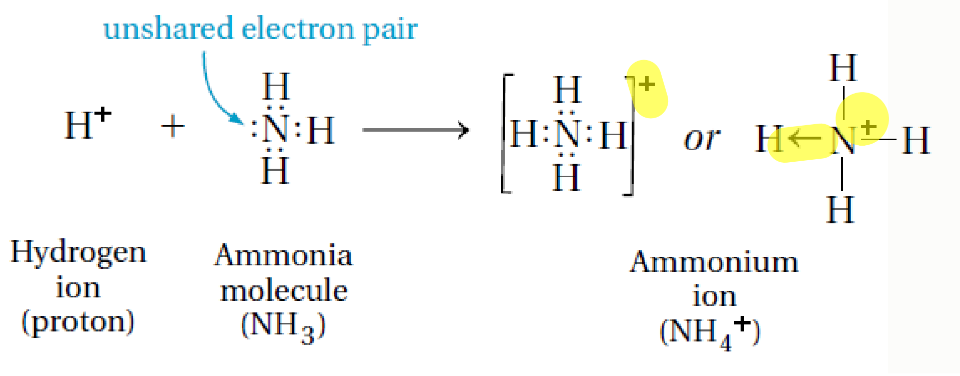
Carbon monoxide molecule



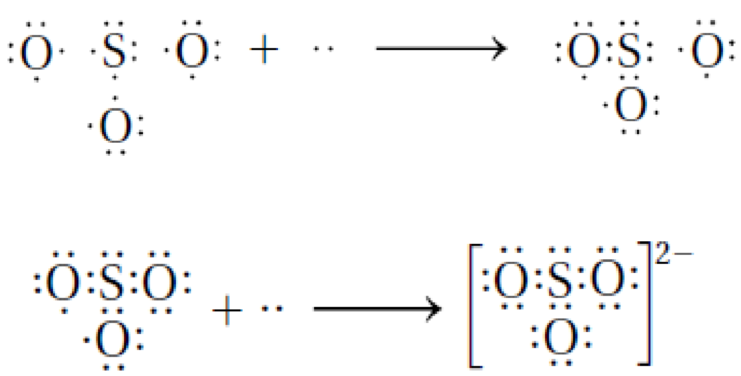
Coordinate Covalent Bonds

Coordinate covalent bonding is common in ***polyatomic ions.***

NH_4^+



SO_3^{2-}



Each of the atoms of the completed structure has eight valence electrons, satisfying the octet rule. Without the two extra electrons, two of the oxygens would be electron-deficient.

with covalent bonds.

Table 8.2

Some Common Molecular Compounds

Name	Chemical formula	Structure	Properties and uses
Hydrogen peroxide	H_2O_2	H—:Ö—Ö:—H	Colorless, unstable liquid when pure. It is used as rocket fuel. A 3% solution is used as a bleach and antiseptic.
Sulfur dioxide	SO_2	:Ö=S̈→:Ö:	Oxides of sulfur are produced in combustion of petroleum products and coal. They are major air pollutants in industrial areas. Oxides of sulfur can lead to respiratory problems.
Sulfur trioxide	SO_3	:Ö=S(→:Ö:)→:Ö:	
Nitric oxide	NO	:Ö=N̈·	Oxides of nitrogen are major air pollutants produced by the combustion of fossil fuels in automobile engines. They irritate the eyes, throat, and lungs.
Nitrogen dioxide	NO_2	:Ö=Ṅ→:Ö:	
Nitrous oxide	N_2O	:Ö←N≡N:	Colorless, sweet-smelling gas. It is used as an anesthetic commonly called laughing gas.
Hydrogen cyanide	HCN	H—C≡N:	Colorless, toxic gas with the smell of almonds.
Hydrogen fluoride	HF	H—F̈:	Two hydrogen halides, all extremely soluble in water. Hydrogen chloride, a colorless gas with pungent odor, readily dissolves in water to give a solution called hydrochloric acid.
Hydrogen chloride	HCl	H—C̈l:	

Homework

Pg. 225

CONCEPTUAL PROBLEM 8.2

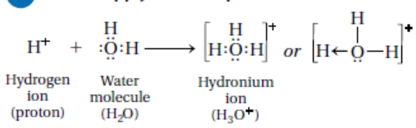
Drawing the Electron Dot Structure of a Polyatomic Ion

The polyatomic hydronium ion (H_3O^+), which is found in acidic mixtures such as lemon juice, contains a coordinate covalent bond. The H_3O^+ ion forms when a hydrogen ion is attracted to an unshared electron pair in a water molecule. Draw the electron dot structure of the hydronium ion.

1 Analyze ***Identify the relevant concepts.***

H_3O^+ forms by the addition of a hydrogen ion to a water molecule. Draw the electron dot structure of the water molecule. Then, add the hydrogen ion. Oxygen must share a pair of electrons with the added hydrogen ion to form a coordinate covalent bond.

2 Solve ***Apply the concepts to this situation.***

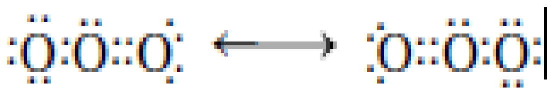


The oxygen in the hydronium ion has eight valence electrons, and each hydrogen shares two valence electrons. This satisfies the needs of both hydrogen and oxygen for valence electrons. The water molecule is electrically neutral, and the hydrogen ion has a positive charge. The combination of these two species must have a charge of 1+, as is found in the hydronium ion.

Resonance

Ozone O_3

The ozone molecule has two possible electron dot structures.

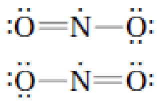


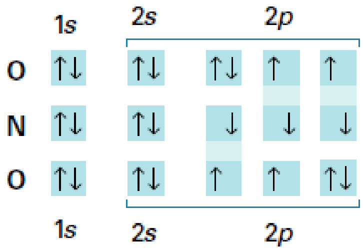
A resonance structure is a structure that occurs when it is possible to draw 2 or more valid electron dot structures that have the same number of electron pairs for a molecule or ion.

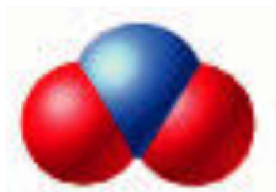
The actual bonding of oxygen atoms in ozone is a hybrid, or mixture, of the extremes represented by the resonance forms.

Exceptions to the Octet Rule

The octet rule cannot be satisfied in molecules whose total number of valence electrons is an odd number. There are also molecules in which an atom has fewer or more, than a complete octet of valence electrons







Nitrogen dioxide molecule

NO_2 has 17 valence electrons, an odd number.