

Warm-Up

Types of Chemical Bonds

Lesson Objectives

By the end of this lesson, you should be able to:

- Compare and contrast **ionic**, metallic, and covalent bonds.
- Relate electronegativity and ionization energy to **bond** formation.

Science Practice: Create a chart to compare and contrast ionic, metallic, and covalent bonds.

W
2K

Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

- | | |
|----------------------------|--|
| <u> C </u> chemical bond | A. a bond resulting from the attraction between oppositely charged ions |
| <u> A </u> ionic bond | B. a bond resulting from a sharing of electrons between two atoms |
| <u> B </u> covalent bond | C. a strong connection between atoms |
| <u> E </u> metallic bond | D. a collection of atoms connected by covalent bonds; the smallest unit of a covalent compound |
| <u> F </u> formula unit | E. a bond resulting from the sharing of valence electrons among many atoms |
| <u> D </u> molecule | F. an electrically neutral group of ions joined by ionic bonds; the smallest unit of an ionic compound |

Instruction

Types of Chemical Bonds

Slide

1

Lesson Question

What are the three main ways that elements can come together to form bonds?

3

Types of Bonds

Chemical bond: a strong connection between atoms

- Three types of bonds:
 - Ionic
 - Covalent
 - Metallic
- Type of bond affects properties of a compound:
 - Melting point, conductivity, malleability

Type of Bond	Typical Properties
Ionic	Brittle, high melting point, conducts electricity when molten or dissolved in water
Covalent	Brittle, low melting point, does not conduct electricity in any form
Metallic	Malleable and ductile, relatively high melting point, conducts electricity in solid and molten forms

Instruction

Types of Chemical Bonds

Slide

6

Bonds Represent Low Energy States

Low energy = more **stable**

As opposite charges approach:

- potential **energy** decreases.
- electrostatic force **pulls**.

As like charges approach:

- potential energy increases.
- electrostatic **force** pushes.

8

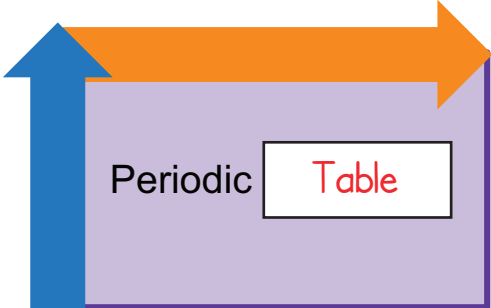
Reactivity and Bond Formation

Electronegativity:

- Attraction of an atom for an **electron**
- Higher values = more reactive
- Difference in electronegativity affects type of **bond** that forms

Ionization **energy**:

- Ease of **removal** of an electron
- Lower values = more **reactive**



Periodic **Table**

Slide

11

Ionic Bonds

Ionic bond: bond resulting from the attraction between oppositely charged ions

- Bond primarily between **metals** and nonmetals
- Smallest unit: **formula unit**
 - An electrically neutral group of **ions** joined by ionic bonds; the smallest unit of an ionic compound

Periodic Table of Elements

Click an element's box for more info.

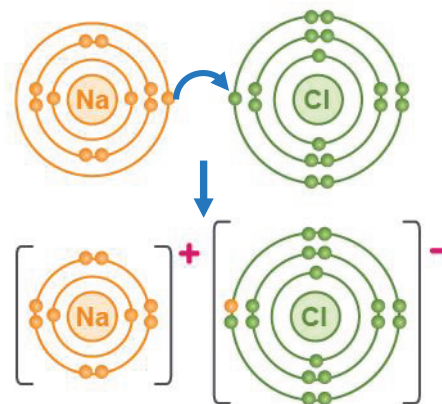
1A		2A		3A-10A										11A		12A																							
1	H	2	He	3	Li	4	Be	5	B	6	C	7	N	8	O	9	F	10	Ne	11	Na	12	Mg	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar				
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr				
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe				
55	Cs	56	Ba	57-71	Lanthanide Series					72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
87	Fr	88	Ra	89-103	Actinide Series					104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Cn	113	Uut	114	Fl	115	Uup	116	Lv	117	Uus	118	Uuo
89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr										

- Valence electron “attracted” by more electronegative **atom**

- Electron “given up” by atom with lower ionization **energy**

- Resulting positive and (ions) strongly attract **negative** atoms

- Electronegativity difference **>** 1.5



Slide

14

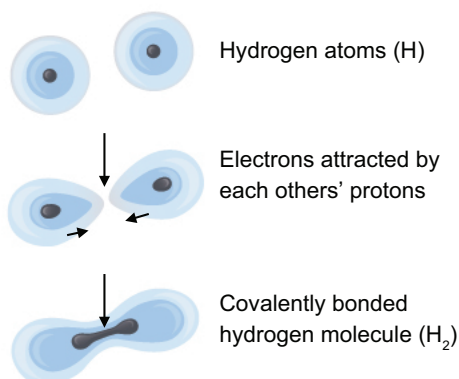
Covalent Bonds

Covalent bond: bond resulting from a sharing of electrons between two atoms

- **Atoms** have similar electronegativities

Water; H ₂ O	Methane; CH ₄
H: 2.1	H: 2.1
O: 3.44	C: 2.55
- Neither can extract **electron** from the other
- Electronegativity difference < 1.5
- Between **nonmetals** (typically)

- Technically, all bonds both covalent and ionic
- Bonds between atoms of **same** element are, by definition, 100% covalent
- Smallest unit: **molecule**
 - A collection of atoms connected by covalent bonds; the smallest unit of a **covalent** compound



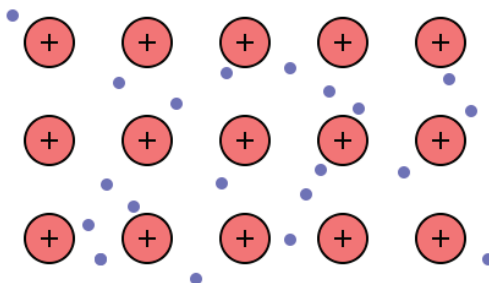
Slide

18

Metallic Bonds

Metallic bond: bond resulting from the sharing of **valence** electrons among many atoms

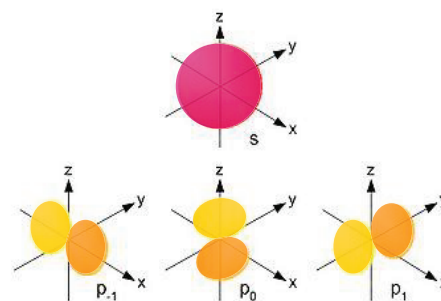
- “Electron sea” model of **metals**
- Valence electrons shared among all metal nuclei
- Bonds not **directional** (malleable)
- Electrons move freely (conductive)



Orbital Shape and Bond Types

Electron **orbitals** must overlap to share electrons.

- s-Orbitals
 - Spherical
 - **Overlap** in all directions
- p-Orbitals
 - **Dumbbell**-shaped on an axis
 - Overlap in one direction



Slide

18

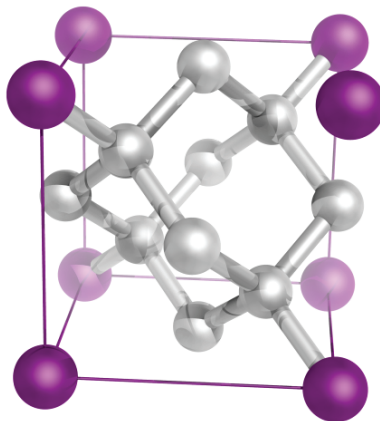
Valence Electrons: Nonmetals vs. Metals

Valence electrons in nonmetals occupy directional **p**-orbitals.

- Hardest substances known
- Brittle, given enough **force**

Metal valence electrons spread out into **spherical** s-orbitals.

- Bonds do not “shatter”
- Easily deformed (**malleable**)



20

Ionic Bonds and Physical Properties

- Crystal lattice
- Melt at high **temperature**
- Brittle
- Dissolve in water to form **ions**
- Conduct electricity in liquid or **solution** form

Slide

20

Covalent Bonds and Physical Properties

- Smaller molecules
- **Low** melting points
- Nonconductive

Metallic Bonds and Physical Properties

- **Excellent** conductors
- Malleable

Summary

Types of Chemical Bonds

**Lesson Question**

What are the three main ways that elements can come together to form bonds?

**Answer**

(Sample answer) The three types of bonds that exist between elements are ionic, covalent, and metallic. Ionic bonds are formed due to large electronegativity difference between atoms. In a covalent bond, electrons are shared between atoms. Metallic bonds exist between atoms of metals.

Slide

2

Ionic Bonds

- Ionic bonds form between atoms with large differences in electronegativity.
 - Typically **metals** and nonmetals
 - Electronegativity difference > 1.5
- Ionic bonds form between two atoms when one atom loses an electron to an atom with a stronger electron affinity. This produces oppositely charged ions, which are attracted to each other to form an ionic bond.
- Ionic compounds tend to be **brittle**, have a high melting point, and conduct electricity when melted or dissolved in water.

Slide

2

Covalent Bonds

- Covalent bonds form between atoms with small differences in electronegativity.
 - Typically nonmetals
 - Electronegativity difference < 1.5
- Covalent bonds form between two atoms when the atoms share electrons. The sharing may be equal (as between two atoms of the same element) or unequal (as between atoms of **different** elements).
- Covalent substances tend to be brittle, have a low melting point, and are unable to **conduct** electricity.

Metallic Bonds

- Metallic bonds form between atoms of metals.
- Metallic bonds form when **electrons** move easily between atoms.
- Metallic substances tend to be malleable and **ductile**, have a relatively high melting point, and conduct electricity well as a solid or liquid.

Use this space to write any questions or thoughts about this lesson.