

I. Bonding

A. Atoms

- 1. Have energy due to their composition and structure.
- 2. Have the ability and desire to combine with other atoms.
- 3. Chemical bonds are _____

- 4. Atoms can _____, _____, or _____ electrons

B. Energy Changes and Bonding

B. A. R. F.

- 1. Chemical energy is _____ energy. [stored]
- 2. Energy is _____ when bonds form.
 - a. _____ process
 - b. when bonds are formed electrons move to a _____ energy state
- 3. Energy is _____ when bonds break.
 - a. _____ process
 - b. when bonds are broken electrons move to a _____ energy state

4.	<u>Strong bonds</u>	vs	<u>Weak bonds</u>
Stability	_____		_____
Energy stored	_____		_____
Energy released	_____		_____
in forming	_____		_____
Energy to break	_____		_____

C. Bonds between Atoms

- 1. Electronegativity [EN] is the _____

 - a. Metals have a _____ electronegativity and a _____ attraction for electrons.
 - b. Nonmetals have a _____ electronegativity and a _____ attraction for electrons.

2. There are 3 types of bonds between atoms- _____, _____, and _____

3. **Ionic Bonds** [Between _____ and _____]

- a. Electrons are _____
- b. A metal with _____ EN gives up one or more electrons and has a _____ charge
- c. The atom with a _____ EN, the _____, gains one or more electrons and becomes _____ charged
- d. EN difference is ≥ 1.7

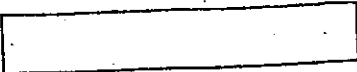
4. **Covalent Bonds** [Between 2 _____]

- a. Electrons are _____
- b. Single covalent bond = share _____ ex. _____
Double covalent bond = " _____ ex _____
_____ covalent bond = " _____ ex _____
- c. Coordinate covalent bond = _____ ex _____
- d. Polar covalent bond is _____
_____ ex _____
- e. Non-polar covalent bond is _____
_____ ex _____

E.N. diff. of 0

5. **Metallic Bonds** [metal to metal]

- a. Metal atoms have few _____ electrons, _____ EN, and _____ ionization energy
- c. Can't _____ or _____ electrons to become stable
- d. Positive _____ arranged in crystal structure with electrons moving around forming an electron cloud = _____ electrons, often called a "sea of _____"



ELECTRON DOT DIAGRAMS are used to show bonding reactions. An electron dot diagram uses the **SYMBOL** of the element to represent the **KERNEL** of the atom (the nucleus and inner electrons). The **DOTS** represent the **VALENCE ELECTRONS** (electrons in the outermost principle energy level).

Complete the **ELECTRON DOT** diagrams for the **REPRESENTATIVE ELEMENTS**

2		13	14	15	16	17	18
							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

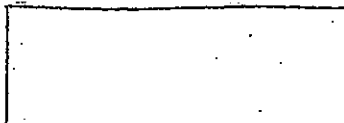
2. Which classification of elements is not included in the REPRESENTATIVE elements?

3. What is important about the VALENCE electrons? _____

4. What is the relationship between the valence electrons and the group number of the representative elements? _____

4. Which element is the EXCEPTION to the generalization you have made above? _____

EXAMPLE:



Dot Diagram: Li.
Oxidation number +1
Which Noble Gas? He

Electron Configuration 2-1
Bonding Electron Configuration 2

Dot Diagram: B
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

5. Dot Diagram: P
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

Dot Diagram: Cl
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

6. Dot Diagram: C
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

Dot Diagram: O
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

7. Dot Diagram: Na
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

Dot Diagram: Mg
Electron Configuration _____
Oxidation number _____
Bonding Electron Configuration _____
Which Noble Gas? _____

8. Dot Diagram N
Electron Configuration _____
Oxidation number: _____
Bonding Electron Configuration _____
Which Noble Gas _____



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Molecular Geometry –

The shape of a molecule is determined by the location and number of _____ around the _____ atom. _____ and _____ pairs of _____ will always position themselves to be as _____ from each other as possible because of _____.

A. Linear:

Bond angle

a.

b.

c.

Ex.

B.

_____ - named as such because

Bond angle

a.

Ex.

C.

Tetrahedral –

Bond angle

a.

Ex.

D.

Bond angle

a.

Ex.

E. Bent a.k.a. Angular
Bond angle

a.

Ex.

7. Intramolecular forces

A.A. Coordinate covalent – both of the _____ shared in the _____ come from

Ex.

B. Molecular substances – a molecule is the smallest piece of any _____ bound substance.

C. Network solid – substances that have a

D. Metallic Bonds

1. Generally occur in metals with
2. Frequently possess vacant orbitals in the
3. Electrons belong to
4. Often referred to as

E. Polar Covalent bond – a difference in

1. Electrons spend

Ex.

F. Non-polar covalent bond -

Ex.

8. Intermolecular forces - forces of attraction between two

A. Dipole-dipole - attraction between

Ex.

B. Hydrogen bonding - special case of the _____. Hydrogen is bonded to a very

Ex.

***H-bonding is the _____ type of intermolecular forces

C. van der Waals - a.k.a. _____. These are the _____ of the intermolecular forces.

1. Increase as

Ex.

D. Molecule-ion attractions - usually occurs in _____

Ex.



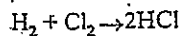
1. What occurs when an atom of chlorine and an atom of hydrogen become a molecule of hydrogen chloride?

- (1) A chemical bond is broken and energy is released.
- (2) A chemical bond is broken and energy is absorbed.
- (3) A chemical bond is formed and energy is released.
- (4) A chemical bond is formed and energy is absorbed.

2. Which particles may be gained, lost, or shared by an atom when it forms a chemical bond?

- (1) protons
- (2) electrons
- (3) neutrons
- (4) nucleons

3. Given the reaction:



Which statement best describes the energy change as bonds are formed and broken in this reaction?

- (1) The breaking of the Cl-Cl bond releases energy.
- (2) The breaking of the H-H bond releases energy.
- (3) The forming of the H-Cl bond absorbs energy.
- (4) The forming of the H-Cl bond releases energy.

4. What happens when two oxygen atoms combine to form a molecule of oxygen?

- (1) Chemical bonds are broken and energy is absorbed.
- (2) Chemical bonds are broken and energy is released.
- (3) Chemical bonds are formed and energy is absorbed.
- (4) Chemical bonds are formed and energy is released.

5. As energy is released during the formation of a bond, the stability of the chemical system generally will

- (1) decrease
- (2) increase
- (3) remain the same

6. Which kind of energy is stored in a chemical bond?

- (1) potential energy
- (2) kinetic energy
- (3) activation energy
- (4) ionization energy

7. As a chemical bond forms between two hydrogen atoms the potential energy of the atoms

- (1) decreases
- (2) increases
- (3) remains the same

8. When a chemical bond is broken, energy is

- (1) absorbed, only
- (2) released, only
- (3) both absorbed and released
- (4) neither absorbed nor released

9. A chemical bond results when two nuclei have a simultaneous attraction for

- (1) nucleons
- (2) protons
- (3) neutrons
- (4) electrons

10. Which compound contains a bond with the least ionic character?

- (1) CO
- (2) CaO
- (3) K_2O
- (4) Li_2O

11. Which compound has the least ionic character?

- (1) KCl
- (2) CaCl_2
- (3) AlCl_3
- (4) CCl_4

12. Which formula represents an ionic compound?

- (1) NaCl
- (2) N_2O
- (3) HCl
- (4) H_2O

13. A neutral atom with the electron configuration 2-6 would most likely form a bond with an atom having the configuration

- (1) 2
- (2) 2-2
- (3) 2-8
- (4) 2-8-8

14. Which pair of elements forms a bond with the least ionic character?

- (1) P-Cl
- (2) Br-Cl
- (3) H-Cl
- (4) O-Cl

15. Two atoms with an electronegativity difference of 0.4 form a bond that is

- (1) ionic, because electrons are shared
- (2) ionic, because electrons are transferred
- (3) covalent, because electrons are shared
- (4) covalent, because electrons are transferred

16. Which type of bonds are formed when calcium atoms react with oxygen atoms?

- (1) polar covalent
- (2) coordinate covalent
- (3) ionic
- (4) hydrogen

17. When a metal atom combines with a nonmetal atom, the nonmetal atom will

- (1) lose electrons and decrease in size
- (2) lose electrons and increase in size
- (3) gain electrons and decrease in size
- (4) gain electrons and increase in size

18. When an atom of chlorine forms an ionic bond with an atom of sodium, the atom of chlorine

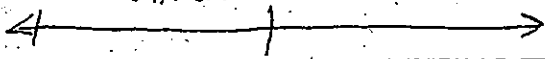
- (1) loses an electron
- (2) loses a proton
- (3) becomes an ion with a smaller radius than the atom of chlorine
- (4) becomes an ion with a larger radius than the atom of chlorine

19. Which compound contains only ionic bonds?

- (1) HNO_3
- (2) NH_4Cl
- (3) H_2O
- (4) Na_2O

REMINDER: ELECTRONEGATIVITY Δ

NONPOLAR COVALENT POLAR COVALENT IONIC



NONPOLAR COVALENT

1.7

8

TYPES OF CHEMICAL BONDS

Name _____

Classify the following compounds as ionic (metal + nonmetal), covalent (nonmetal + nonmetal) or both (compound containing a polyatomic ion).

1. CaCl_2 _____

11. MgO _____

2. CO_2 _____

12. NH_4Cl _____

3. H_2O _____

13. HCl _____

4. BaSO_4 _____

14. KI _____

5. K_2O _____

15. NaOH _____

6. NaF _____

16. NO_2 _____

7. Na_2CO_3 _____

17. AlPO_4 _____

8. CH_4 _____

18. FeCl_3 _____

9. SO_3 _____

19. P_2O_5 _____

10. LiBr _____

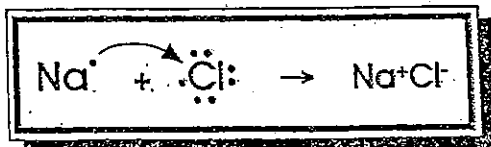
20. N_2O_3 _____

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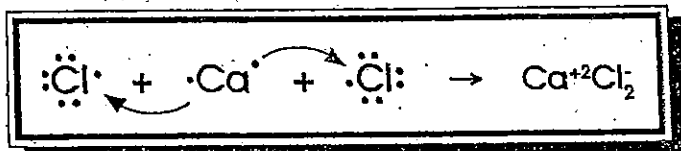
IONIC BONDING

Name HI

Ionic bonding occurs when a metal transfers one or more electrons to a nonmetal in an effort to attain a stable octet of electrons. For example, the transfer of an electron from sodium to chlorine can be depicted by a Lewis dot diagram.

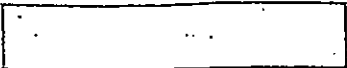


Calcium would need two chlorine atoms to get rid of its two valence electrons.

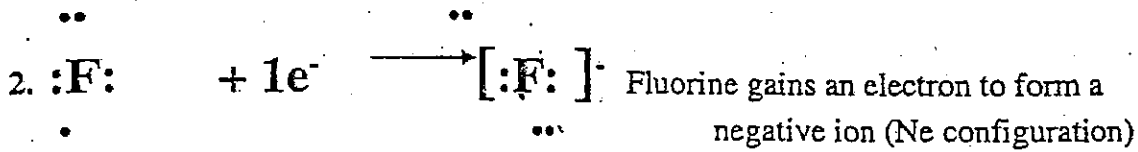
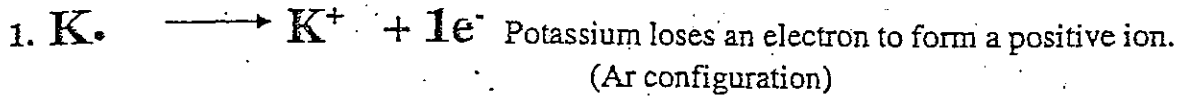


Show the transfer of electrons in the following combinations.

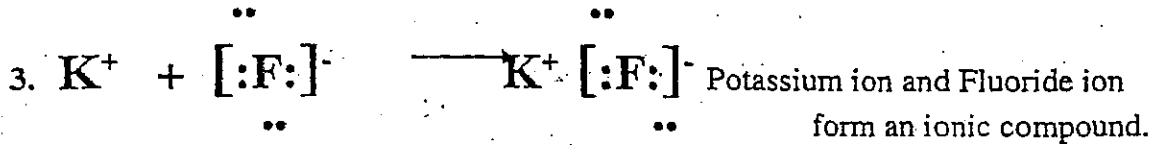




DOT DIAGRAMS may be used to represent ionic bonding reactions between atoms as shown in the steps below:



BONDING REACTION



Write equations for the BONDING REACTIONS of the elements below, which form ionic compounds. Follow the model of equation #3

PAIRS CHECK

Sodium and Chlorine

Calcium and Oxygen

Barium and Sulfur

Lithium and Bromine

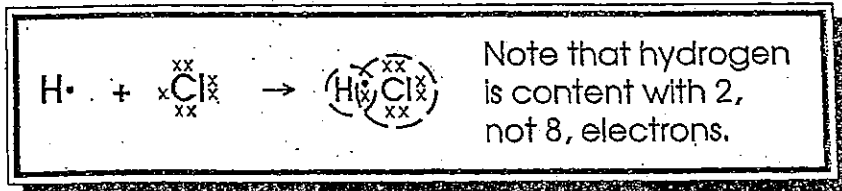
Lithium and Sulfur

Magnesium and Nitrogen

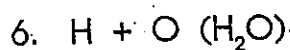
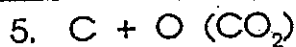
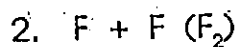
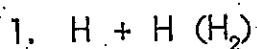
COVALENT BONDING

Name _____

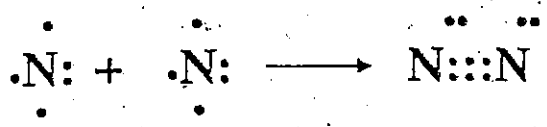
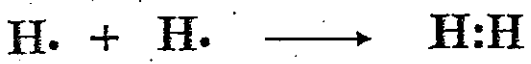
Covalent bonding occurs when two or more nonmetals share electrons, attempting to form a stable octet of electrons at least part of the time. For example:



Show how covalent bonding occurs in each of the following pairs of atoms. Atoms may share one, two or three pairs of electrons.



DOT DIAGRAMS are also used to represent molecules having covalent bonds (shared electrons). A pair of shared electrons is represented by a pair of dots (·); two pairs of electrons by two pairs of dots (::). Bonding reactions between two hydrogen atoms and two nitrogen atoms are shown below:



Write equations for the BONDING REACTIONS of the atoms below, which form covalent compounds. Follow the model of equations 1 & 2. Remember: In covalent bonding every element forms a stable octet of 8 valence electrons, except hydrogen which uses 2.

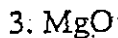
PAIRS CHECK

2 Hydrogen and Oxygen → Water (H ₂ O)	Carbon and 2 Oxygen → Carbon Dioxide (CO ₂)
Carbon and 2 Sulfur → Carbon Disulfide (CS ₂)	2 Oxygen atoms → Oxygen molecule (O ₂)
Nitrogen and 3 Hydrogen → Ammonia (NH ₃)	Carbon and 4 Hydrogen → Methane (CH ₄)

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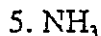
Under each substance below, write the electronegativity difference, and identify the bond type as non-polar covalent, polar covalent, or ionic.



e.d.

bond type

dot diagram



e.d.

bond type

dot diagram

Questions 7-10

Examine your answers to 1-6. Use the Periodic Table, as necessary, to identify the elements as metals or non-metals, then answer the questions. Use non-polar covalent, polar covalent & ionic as your answers.

7. When two different non-metals bond, the bond type will be: _____

8. When a metal and a non-metal bond, the bond will be: _____

9. When two of the same non-metals bond, the bond will be: _____

10. All diatomic elements must have which type of bond? _____

11. If no electronegativity values were available, explain how the Periodic Table might be used to determine bond type:

TYPES OF BONDS/COMPOUNDS

IONIC BONDING

ex: _____
1) _____
2) _____
3) _____

COVALENT BONDING

POLAR COV.
ex: _____
1) _____
2) _____

NONPOLAR COV.
ex: _____
1) _____
2) _____

TYPES OF COMPOUNDS

IONIC SOLID

ex: _____
1) _____
2) _____
3) _____

MOLECULAR SOLID

ex: _____
1) _____
2) _____
3) _____

NETWORK SOLID

ex: _____
1) _____
2) _____
3) _____
4) _____

METALLIC SOLID

ex: _____
1) _____
2) _____

- A crystalline solid has a high melting point and is a good conductor of electricity in the liquid state. This solid could be
 - CO_2
 - Hg
 - $\text{C}_6\text{H}_{12}\text{O}_6$
 - KCl
- Which substance is a conductor of electricity in the liquid phase but *not* in the solid phase?
 - Br_2
 - HBr
 - Na
 - NaCl
- A characteristic of ionic solids is that they
 - have high melting points
 - have low boiling points
 - conduct electricity
 - are non-crystalline
- A solid substance is soft, has a low melting point, and is a poor conductor of electricity. The substance is most likely
 - an ionic solid
 - a network solid
 - a metallic solid
 - a molecular solid
- Which type of substance is soft, has a low melting point, and is a poor conductor of heat and electricity?
 - network solid
 - molecular solid
 - metallic solid
 - ionic solid
- The bonds in all network solids are
 - covalent
 - ionic
 - metallic
 - nonpolar
- A diamond is an example of
 - a supercooled liquid
 - an ionic compound
 - a metallic substance
 - a network solid
- Which substance will conduct electricity in both the solid phase and the liquid phase?
 - AgCl
 - Ag
 - H_2
 - HCl
- Which substance is a good conductor of electricity in both the solid and liquid phases?
 - a metallic substance
 - an ionic substance
 - a network substance
 - a molecular substance
- Which element consists of positive ions immersed in a "sea" of mobile electrons?
 - sulfur
 - nitrogen
 - calcium
 - chlorine
- A certain substance is a poor conductor of electricity and has a high melting point. This substance is most likely
 - CO_2
 - SiO_2
 - Cl_2
 - $\text{C}_6\text{H}_{12}\text{O}_6$

12. The table shows some properties of three solids, X, Y and Z.

Properties	X	Y	Z
Melting Point ($^{\circ}\text{C}$)	800	80	1200
Soluble in water	yes	no	no
Solid state conducts electricity	no	no	yes
Molten state conducts electricity	yes	no	yes

What is the correct classification for each solid.

solid X _____
 solid Y _____
 solid Z _____

13. An unknown solid was tested and showed the properties listed below:

Properties
 high melting point
 soluble in water
 conductor of electricity when dissolved in water
 non-conductor of electricity as a solid
 hard surface.

- State the type of bonding you would expect of this substance.
- Explain why this substance conducts electricity when dissolved in water.
- Explain why it is hard.

(SNAP)

POLARITY OF MOLECULES

POLAR MOLECULES

NONPOLAR MOLECULES

1) ex:

2) ex:

TYPES OF INTERMOLECULAR FORCES OF ATTRACTION

POLAR

DIPOLE-DIPOLE

ex:

IRREG

HYDROGEN BONDING

ex:

N.P.

VAN DERWAALS (LONDON DISPERSION)

ex:

IONIC (aq)

MOLECULE ION ATTRACT

ex:

Q. No.:

1. NH_3

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

2. Br_2

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

3. H_2O

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

4. HBr

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

5. I_2

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

6. CO_2

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

7. CH_4

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

8. CCl_4

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

9. CHCl_3

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

10. N_2

- a) BONDS BETWEEN ATOMS \Rightarrow _____
- b) POLARITY OF MOLECULE \Rightarrow _____

SHAPES OF MOLECULES

Name _____

Using VSEPR Theory, name and sketch the shape of the following molecules.

1. N_2	7. HF
2. H_2O	8. CH_3OH
3. CO_2	9. H_2S
4. NH_3	10. I_2
5. CH_4	11. $CHCl_3$
6. SO_3	12. O_2