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## **Ionic Compounds and Metals**

تُستخدم أوراق العمل للمساعدة على أداء الأنشطة داخل الصف،  
ولا تُغني عن الكتاب المدرسي

 **MOHAMED**  
Ahmed Abdelbari

### **Valence Electrons and Chemical Bonds**

Atoms can join together by forming a chemical bond, which is a very strong attraction between two atoms. Chemical bonds are formed when electrons in different atoms interact with each other to make an arrangement that is more stable than when the atoms are apart.

What causes atoms to make a chemical bond with other atoms, rather than remaining as individual atoms?

Chemists have concluded that atoms be stable if they have eight electrons in their outermost shell. This useful rule of thumb is called the octet rule, and it is a key to understanding why compounds form.

There are two ways for an atom that does not have an octet of valence electrons **to obtain an octet** in its outer shell.

- 1) One way is the transfer of electrons between two atoms until all atoms have octets.
- 2) The second way for an atom to obtain an octet of electrons is by sharing electrons with another atom.

## Valence Electrons

Recall that the valence electrons of an atom are the electrons located in the highest occupied principal energy level. Valence electrons are primarily responsible for the chemical properties of elements. The number of valence electrons can be easily determined from the electron configuration.

**Electron dot diagrams** are diagrams in which the valence electrons of an atom are shown as dots distributed around the element's symbol.

		1A(1)	2A(2)						
		$ns^1$	$ns^2$	3A(13)	4A(14)	5A(15)	6A(16)	7A(17)	8A(18)
				$ns^2np^1$	$ns^2np^2$	$ns^2np^3$	$ns^2np^4$	$ns^2np^5$	$ns^2np^6$
Period	2	• Li	• Be •	• B •	• C •	• N •	• O •	• F •	• Ne •
	3	• Na	• Mg •	• Al •	• Si •	• P •	• S •	• Cl •	• Ar •

- 1) Describe two different causes of force of attraction in a chemical bond.  
\_\_\_\_\_
- 2) Compare between group 18 and group 17 elements according to reactivity.  
\_\_\_\_\_

## Valence Electrons

3) What are valence electrons?

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4) The valence electrons largely determine the \_\_\_\_\_ of an element and are usually the only electrons used in \_\_\_\_\_

5) Is the following sentence true or false? The group number of a representative element in the periodic table is related to the number of valence electrons it has.

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6) What is an electron dot structure?

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7) What is the octet rule?

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8) Metallic atoms tend to \_\_\_\_\_ valence electrons to produce a positively charged ion. Most nonmetallic atoms achieve a complete octet by gaining or \_\_\_\_\_ electrons.

9) Draw the electron dot structure for each of the following atoms.

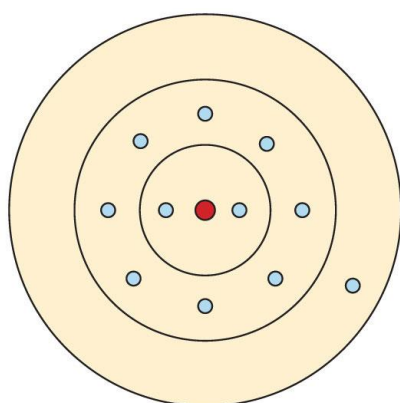
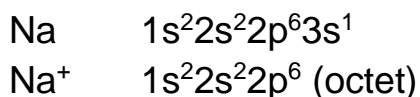
a) Argon

b) Calcium

c) Iodine

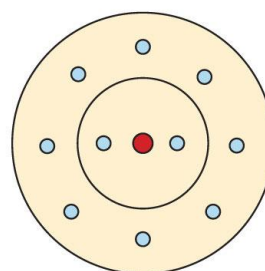
## Positive Ions (Cation) Formation

Cations are the positive ions formed by the loss of one or more electrons. The most commonly formed cations of the representative elements are those that involve the loss of all of the valence electrons. Consider the alkali metal sodium (Na). It has one valence electron in the third principal energy level. Upon losing that electron, the sodium ion now has an octet of electrons from the second principal energy level.



11 protons  
 11 electrons  
 = zero overall  
 charge

Na



11 protons  
 10 electrons  
 = 1+ overall  
 charge

Na<sup>+</sup>

The electron configuration of the sodium ion is now the same as that of the noble gas neon. It is important to understand that although sodium now has the electron configuration of neon it is not neon.

## Metal Ions

10) What are the most reactive metals?

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11) Why do those metals are reactive?

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Group	Configuration	# valence e <sup>-</sup>	# lost e <sup>-</sup>	Ion formed
1				
2				
13				

## Transition Metal ions

12) What is the general Electron configuration for transition metals?

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13) How many valence Electrons do Transition elements have?

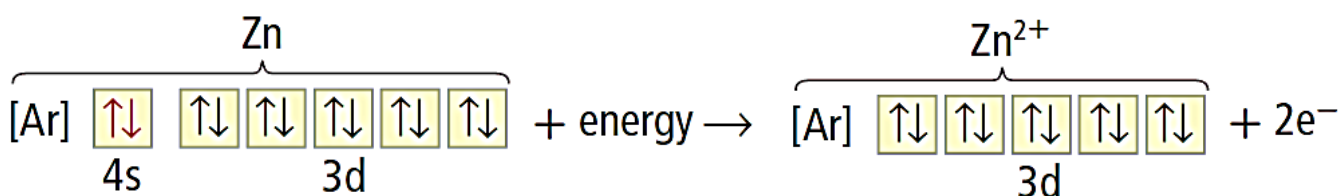
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How many Electrons do a Transition element will lose to form an Ion?

Transition elements also lose Electrons from d sublevel and commonly form 3+ ions, and sometimes lose more electrons from d and form ions of 3+ or greater.

## Pseudo-noble gas configuration

Not all stable ions result in the noble gas configuration; there are a few exceptions mainly in the transition metals. **Zn**  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$  loses the two valence electrons to become **Zn<sup>2+</sup>**  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$  that is stable but does not have the configuration of a noble gas. It does have a complete valence shell. Other ions like Cu<sup>+</sup>, Ag<sup>+</sup>, Au<sup>+</sup> and Cd<sup>2+</sup> have pseudo noble gas configurations.



14) Write the electron configurations for these metals, and circle the electrons lost when each metal forms a cation.

a. Mg \_\_\_\_\_

b. Al \_\_\_\_\_

c. K \_\_\_\_\_

15) Match the noble gas with its electron configuration.

- |            |  |
|------------|--|
| 1. Argon   | $1s^2$                                       |
| 2. helium  | $1s^2 2s^2 2p^6$                             |
| 3. neon    | $1s^2 2s^2 2p^6 3s^2 3p^6$                   |
| 4. krypton | $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ |

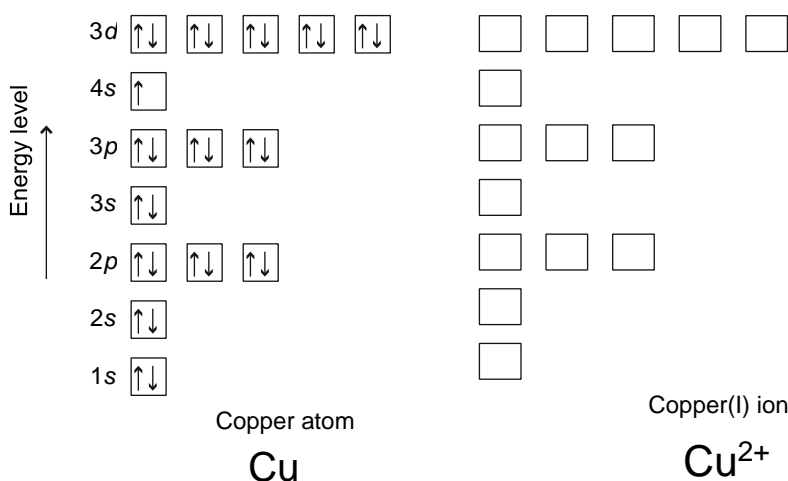
16) What is the electron configuration called that has 18 electrons in the outer energy level and all of the orbitals filled?

\_\_\_\_\_

17) Write the electron configuration for zinc

\_\_\_\_\_

18) Fill in the electron configuration diagram for the copper(I) ion.



## Negative ion (Anions) formation

**Anions** are the negative ions formed from the gain of one or more electrons. When nonmetal atoms gain electrons, they often do so until their outermost principal energy level achieves an octet.

19)

Group	Configuration	# valence e <sup>-</sup>	# gained e <sup>-</sup>	Ion formed
15				
16				
17				

20) Write the Electron configuration for,

Neon atom:	
Nitrogen atom:	Nitrogen ion:
Oxygen atom:	Oxygen ion:
Fluorine atom:	Fluorine ion:

21) Compare between the electro configuration for ions and the for the Neon atom.

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22) Under typical conditions, \_\_\_\_\_ electrons are the maximum number, that will be gained in the formation of anions.

The anion name is formed from the name of the element, but “ide” replaces the normal ending in the elements name

23) Name the next ions.

Atom	Ion name	Atom	Ion name
Oxygen		Nitrogen	
Fluorine		Chlorine	
Bromine		Sulfur	

Some nonmetals can lose or gain electrons as well, like Phosphorus,

24) How many electrons could phosphorus **gain**? Why?

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25) How many electrons could phosphorus **lose**? Why?

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26) Atoms of most nonmetallic elements achieve noble-gas electron configurations by gaining electrons to become \_\_\_\_\_ or negatively charged ions.

27) What property of nonmetallic elements makes them more likely to gain electrons than lose electrons?  
\_\_\_\_\_

28) Is the following sentence true or false? Elements of the halogen family lose one electron to become halide ions. \_\_\_\_\_

29) How many electrons will each element gain in forming an ion?

a. nitrogen \_\_\_\_\_

b. oxygen \_\_\_\_\_

c. sulfur \_\_\_\_\_

d. bromine \_\_\_\_\_

30) Write the symbol and electron configuration for each ion from Question 19, and name the noble gas with the same configuration.

e. Nitride \_\_\_\_\_

f. oxide \_\_\_\_\_

g. sulfide \_\_\_\_\_

h. bromide \_\_\_\_\_



Answer the following questions:

- 31) Will metals lose or gain electrons? Answer \_\_\_\_\_
- 32) Considering your answer for #1, what type of ion will metals form, positive or negative? Answer \_\_\_\_\_
- 33) What is the name of a positive ion? Answer \_\_\_\_\_
- 34) What is the name of a negative ion? Answer \_\_\_\_\_
- 35) How many electrons are contained in a completed outer shell for period 1? Answer \_\_\_\_\_
- 36) How many electrons are contained in completed outer shells for all periods above period 1? Answer \_\_\_\_\_
- 37) What is the charge on ions that is common to all elements of the "d" block, transition metals? Answer \_\_\_\_\_
- 38) What is the charge on ions that is common to all elements of the "f" block, inner transition metals? Answer \_\_\_\_\_
- 39) What types of electrons, "s," "p," "d," or "f," are considered those involved in the make-up of the outer shells of atoms? Answer \_\_\_\_\_
- 40) What is the term used for a completed outer shell of eight electrons? Answer \_\_\_\_\_
- 41) What is the only charge common to group 1 elements? Answer \_\_\_\_\_
- 42) What is the only charge common to group 2 elements? Answer \_\_\_\_\_
- 43) What type of electrons, "s," "p," "d," or "f," are involved in ion formation of group 1 and group 2 elements? Answer \_\_\_\_\_
- 44) What does carbon, C #6, group 14, form either +4 or -4 ions? Answer \_\_\_\_\_
- 45) Why do elements in group 18, noble gases, have zero, 0, as the charge that their ions will form? Answer \_\_\_\_\_

I. Answer the following by placing the letter of the answer that best completes the statement or answers the question.

46) What is the most likely combination of types of electrons that are involved in forming complete outer shells?

- "s" and "p"       "s" and "d"       "p" and "d"       "p" and "f"

47) The ion charge that is common to all transition elements is

- +1       +2       -1       -2.

48) Metals form which type of ions?

- negative       anions       cations       neutral.

49) What is the most probable charge of the ions of elements located in group 12?

- +1       +2       +3       +4.

50) What is the charge of an atom that has lost four electrons?

- positive       +4       negative       -4.

II. Answer the following placing your answers on the spaces provided at right:

51) What is the charge on an atom that has gained one electron? \_\_\_\_

52) What is the charge of an atom that has lost three electrons? \_\_\_\_

53) What is the charge of elements in group 16? \_\_\_\_

54) What is the charge of elements in group 1? \_\_\_\_

55) What is the most probable charge of an ion of fluorine, #9, group 17? \_\_\_\_

56) What is the most probable charge of an ion of magnesium, #12, group 2? \_\_\_\_

57) What is the most probable charge of an ion of sulfur, #16, group 16? \_\_\_\_

58) What are the two charges possible for elements in group 5? \_\_\_\_

59) What is the charge common to all inner-transition elements, the "f" block? \_\_\_\_

60) Which electrons, "s," "p," "d," or "f," are involved in the ion formation of  $Al^{3+}$ ? \_\_\_\_

## Formation of an ionic Bond

Oppositely charged particles attract each other. This attractive force is often referred to as an **electrostatic force**

An **ionic bond** is the electrostatic force that holds ions together in an ionic compound

When the ionic compound formed from Oxygen and a metal it is called OXIDE, most other ionic compounds called salts.

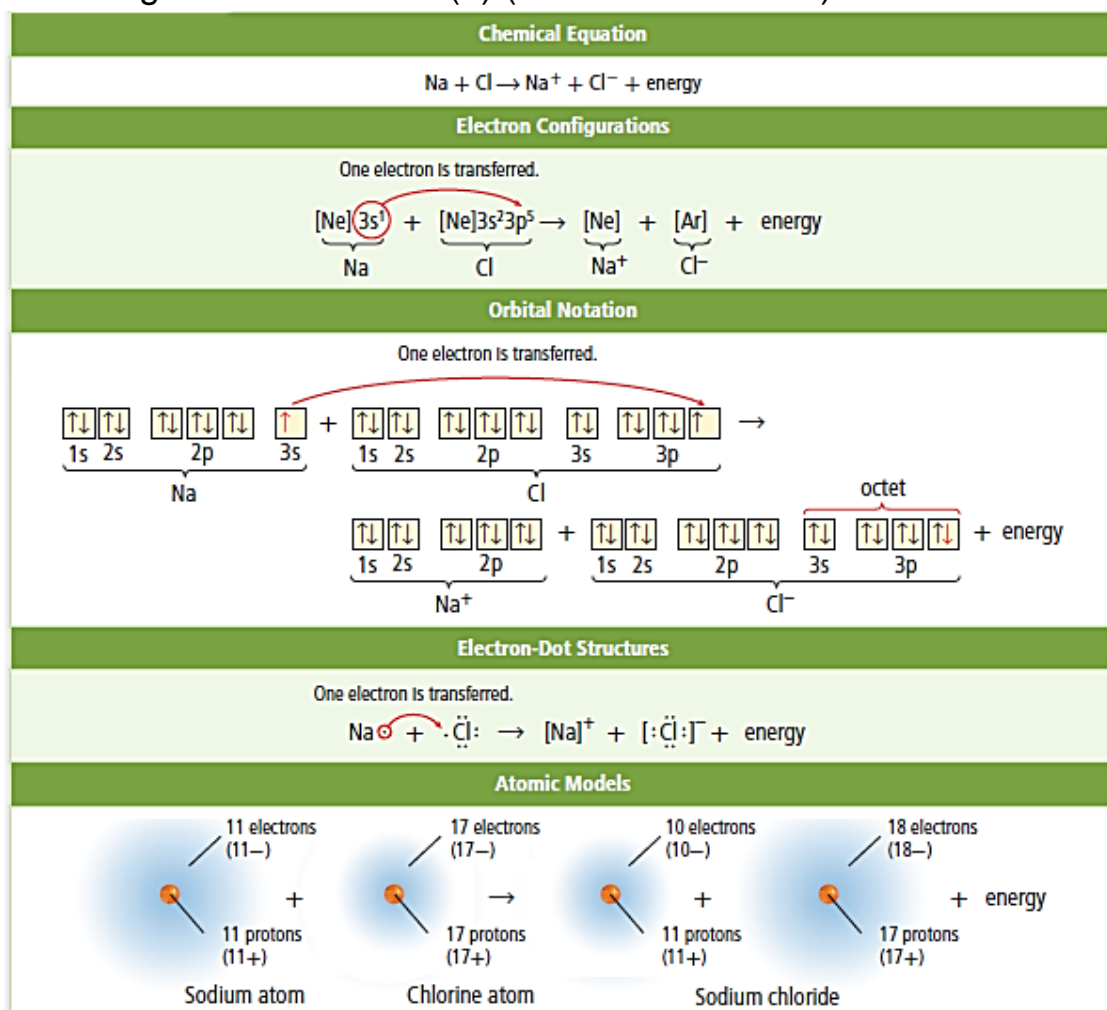
A binary ionic compound is composed of ions of two different elements - one of which is a metal, and the other a nonmetal.

For example, sodium chloride (NaCl) and Magnesium Oxide (MgO)

## Compound formation and charge

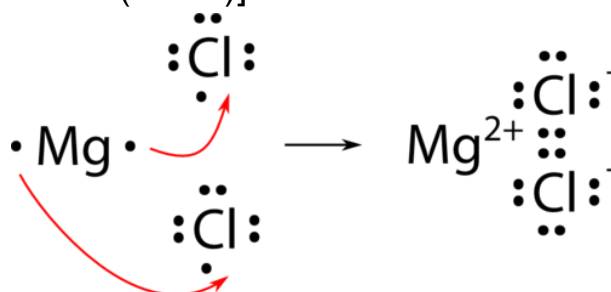
### In sodium chloride

- ✓ Sodium is a metal and loses its one valence electron to become a cation.
- ✓ Chlorine is a nonmetal and gains one electron in becoming an anion.
- ✓ Both achieve a noble-gas electron configuration.
- ✓ The ionic bond is the attraction of the Na<sup>+</sup> ion for the Cl<sup>-</sup> ion.
- ✓ Total charge should be zero (0) (+1 ion + -1 ion = 0)



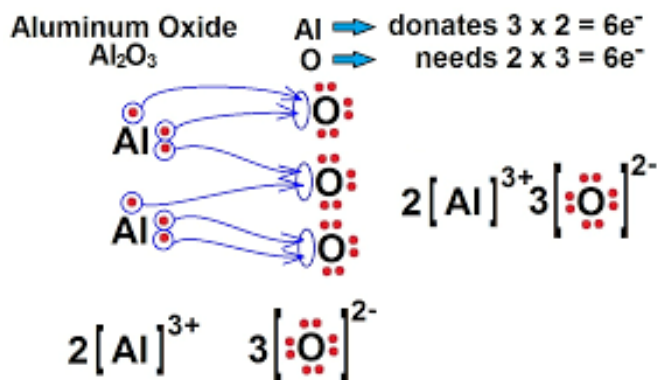
### For magnesium chloride

- ✓ Magnesium has two valence electrons, it needs to lose both to achieve the noble-gas configuration.
- ✓ Chlorine is a nonmetal and gains one electron in becoming an anion.
- ✓ Therefore, two chlorine atoms will be needed
- ✓ Total charge [ $+2$  ion  $+ 2 \times (-1$  ion)] = zero



### For Aluminum oxide

- ✓ Aluminum has three valence electrons, it needs to lose three electrons to achieve the noble-gas configuration.
- ✓ Oxygen is a nonmetal and gains two electrons in becoming an anion.
- ✓ Therefore, two Aluminum atoms will be needed with three oxygen atoms.
- ✓ Total charge [ $2 \times (-3$  ion)  $+ 3 \times (-2$  ion)] = zero



Explain how an ionic compound forms from these elements.

61) Sodium and Nitrogen

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62) Lithium and Oxygen

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63) Aluminum and Sulphur

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64) Which cation ( $\text{Na}^+$  or  $\text{Ca}^{2+}$ ) would form a stronger ionic bond with  $\text{Cl}^-$ ?

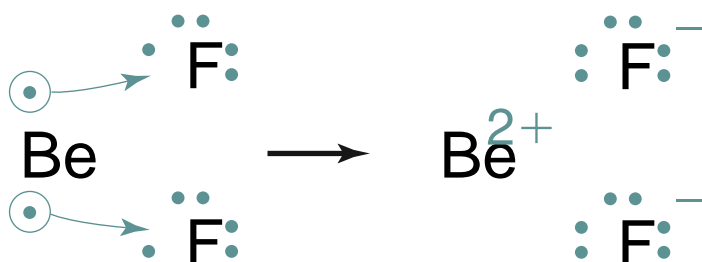
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65) What is an ionic bond?

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66) In an ionic compound, the charges of the \_\_\_\_\_ and \_\_\_\_\_ must balance to produce an electrically \_\_\_\_\_ substance

67) Complete the electron dot structures below to show how beryllium fluoride ( $\text{BeF}_2$ ) is formed. Use the diagram on page 203 as a model.



68) Why do beryllium and fluorine combine in a 1:2 ratio?

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69) A chemical formula shows the types and \_\_\_\_\_ of atoms in the smallest representative unit of a substance

70) List the numbers and types of atoms represented by these chemical formulas.

a.  $\text{Fe}_2\text{O}_3$  \_\_\_\_\_

b.  $\text{KMnO}_4$  \_\_\_\_\_

c.  $\text{CH}_3$  \_\_\_\_\_

d.  $\text{NH}_4\text{NO}_3$  \_\_\_\_\_

71) What is a formula unit?

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72) Explain why the ratio of magnesium ions to chloride ions in  $\text{MgCl}_2$  is 1:2.

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73) Describe the structure of ionic compounds.

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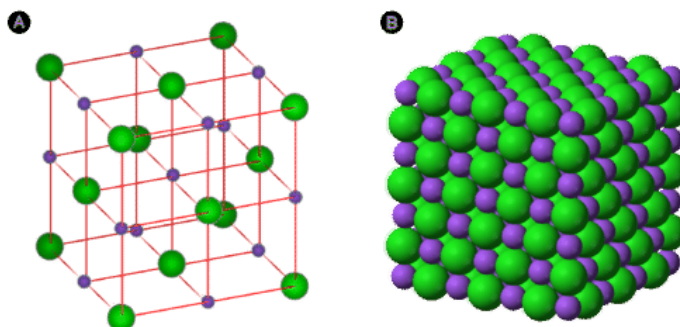
## Properties of ionic compounds

The physical structure of the ionic compound contributes to its physical properties.

### Physical structure

Ionic compounds do not exist as discrete molecules. In order to minimize the potential energy of the system, ionic compounds take on the form of an extended three-dimensional array of alternating cations and anions. This maximizes the attractive forces between the oppositely charged ions, and reduce the repulsion between the identical ions.

Two models of a sodium chloride crystal are shown. The purple spheres represent the  $\text{Na}^+$  ions, while the green spheres represent the  $\text{Cl}^-$  ions.



Naturally occurring sodium chloride (halite) does not look at first glance like the neat diagrams shown above. It is only when we use modern techniques to analyze the crystal structure at the atomic level that we can see the true regularity of the organized ions.

In sodium chloride crystal every sodium ion is surrounded by \_\_\_\_\_ chloride ions, and each chloride ion is surrounded by \_\_\_\_\_ sodium ions.

74) What is the shape of the small salt crystal?

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75) What determine the ratio of positive to negative ions in an ionic crystal?

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76) Do ionic compounds exist as discrete molecules?

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The atoms in a crystal are in a regular repeating pattern called the crystalline lattice. The crystalline lattice can be reproduced by repeating the unit cell in three dimensions.

77) Define crystal lattice

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Scientists use several classification schemes to classify minerals (ionic compounds) such as color, hardness, chemical properties, magnetic and electric properties. They also use types of anions as a classification scheme,

Formula	Anions	Mineral	
$\text{SiO}_3^{2-}$	Silicon , Oxygen	<b>Silicates</b>	
$\text{BO}_3^{3-}$	Boron , Oxygen	<b>Borates</b>	
$\text{CO}_3^{2-}$	Carbon , Oxygen	<b>Carbonates</b>	
$\text{FO}_3^{1-}$	Fluorine , Oxygen	<b>Fluorates</b>	<b>Halides</b>
$\text{ClO}_3^{1-}$	Chlorine , Oxygen	<b>Chlorates</b>	
$\text{BrO}_3^{1-}$	Bromine , Oxygen	<b>Bromates</b>	
$\text{IO}_3^{1-}$	Iodine , Oxygen	<b>Iodates</b>	



## Physical properties

### Melting and boiling points

Ionic compounds are characterized by high melting and boiling points due to the strength of the ionic bond, which is related to the attraction between the positive and negative ions of the crystal and is characterized by different bright colors due to the presence of transition metals within the crystalline network.

### Electric conductivity

The Electric conductivity depends on the availability of free-moving charges, and because the charges are coherent in the case of solid ionic materials, they do not conduct electricity. On the contrary, in the case of molten or solution, they conduct the current due to the presence of charged particles free movement.

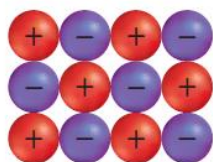
**Electrolyte:** An ionic compound that conduct the electric current.

### Hardness

Ion compounds are characterized by hardness and rigidity, due to the apparent coherence between the various charged ionic compound components.

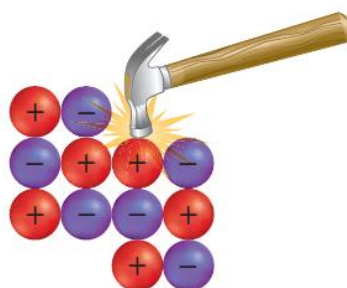
### The brittleness

In the ionic crystal, when we apply force, the charged particles move along the crystal, causing their rearrangements to meet similar charges. The repulsion between them affects the cohesion of the crystal, making it crack and crumbly.



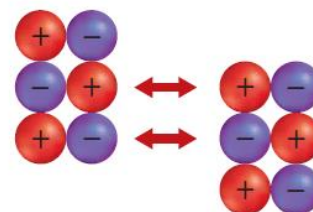
Undisturbed ionic crystal

Before the force is applied, the crystal has a uniform pattern of ions.



Applied force realigns particles.

If the applied force is strong enough, it pushes the ions out of alignment.



Forces of repulsion break crystal apart.

A repulsive force created by nearby like-charged ions breaks apart the crystal.

### Energy and the ionic bonds

**Exothermic reaction:** The reaction that releases energy as it occurs.

**Endothermic interaction:** The reaction that absorbs energy as it occurs.

The reactions in which the ionic compounds formed are described as Exothermic reactions. Ion energy in the case of the Compound is less than the energy in case of single atoms. Therefore, when combined and stabilized, the difference in energy release. When crystal acquires the same amount of energy that it releases as it forms, it disintegrates into its basic components.

## Lattice Energy

**Lattice energy:** The energy required to separate ions of 1 mole ionic material, in this case the energy is absorbed, and increases as the attraction between the components of the compound increase

It is also the same amount of energy released during the formation of the same 1 mol, in this case energy is release

Lattice energy is related to

Ions size

- ✓ The Lattice energy is reduced by increasing the volume of the component ions.
- ✓ The greater the volume of ions, the greater the distances between them, which reduces the forces of attraction and thus reduces the Lattice energy.
- ✓ The compounds made by the lithium are stronger than those made of potassium because lithium is smaller than potassium.

The amount of the Charge

- ✓ The Lattice energy increases as the component ions charge increase.
- ✓ MgO compound has a Lattice energy 4 times greater than the NaF compound
- ✓ Mg ion charge is 2+ and O ion charge is 2-
- ✓ Na ion charge is 1+ and F ion charge is 1-

78) Most ionic compounds are \_\_\_\_\_ at room temperatur

79) Is the following sentence true or false? Ionic compounds generally have low melting points. \_\_\_\_\_

80) Circle the letter of each statement that is true about ionic compounds.

- a. When dissolved in water, ionic compounds can conduct electricity.
- b. When melted, ionic compounds do not conduct electricity.
- c. Ionic compounds have very unstable structures.
- d. Ionic compounds are electrically neutral.

## Formulas for ionic compounds

**Chemical formula unit:** Chemical formula of ionic compound

Since the ionic compound consists of a large number of positive and negative ions, the smallest value to be extracted from the positive and negative ion ratios is what is written when writing the formula unit.  $\text{CaCl}_2$  is the smallest percentage present in the calcium chloride compound. Finally, the total charge on the compound is zero.

## Monoatomic ions

**Monoatomic ion:** An ion consisting of only one atom, either positive resulting from a metal or negative result from a nonmetal.

**The binary ion compounds** are composed of two monoatomic ions, positive one and the other is negative. The ions are monoatomic ions regardless of its charge or the value of the charge. Fluoride ( $\text{F}^{-1}$ ), magnesium ( $\text{Mg}^{2+}$ ) and aluminum ( $\text{Al}^{3+}$ ) are monoatomic ions.

Group	Element	Ion charge
1	H, Li, Na, K, Rb, Cs	1+
2	Be, Mg, Ca, Sr, Ba	2+
13	Al	3+
15	N, P, As	3-
16	O, S, Se, Te	2-
17	F, Cl, Br, I	1-

## Oxidation numbers

**Oxidation number:** The charge carried by monoatomic ion.

The Oxidation number indicates the number of electrons lost or gained during ion formation. The Oxidation number of sodium in sodium chloride is +1 and the chlorine oxidation is -1. The possible oxidation numbers for the transition elements falling within groups 3 to 12 differ in the periodic table as well as some elements of groups 13 and 14 as in the following table

Group	Common Ions
3	$\text{Sc}^{3+}$ , $\text{Y}^{3+}$ , $\text{La}^{3+}$
4	$\text{Ti}^{2+}$ , $\text{Ti}^{3+}$
5	$\text{V}^{2+}$ , $\text{V}^{3+}$
6	$\text{Cr}^{2+}$ , $\text{Cr}^{3+}$
7	$\text{Mn}^{2+}$ , $\text{Mn}^{3+}$ , $\text{Tc}^{2+}$
8	$\text{Fe}^{2+}$ , $\text{Fe}^{3+}$
9	$\text{Co}^{2+}$ , $\text{Co}^{3+}$
10	$\text{Ni}^{2+}$ , $\text{Pd}^{2+}$ , $\text{Pt}^{2+}$ , $\text{Pt}^{4+}$
11	$\text{Cu}^{+}$ , $\text{Cu}^{2+}$ , $\text{Ag}^{+}$ , $\text{Au}^{+}$ , $\text{Au}^{3+}$
12	$\text{Zn}^{2+}$ , $\text{Cd}^{2+}$ , $\text{Hg}_2^{2+}$ , $\text{Hg}^{2+}$
13	$\text{Al}^{3+}$ , $\text{Ga}^{2+}$ , $\text{Ga}^{3+}$ , $\text{In}^{+}$ , $\text{In}^{2+}$ , $\text{In}^{3+}$ , $\text{Tl}^{+}$ , $\text{Tl}^{3+}$
14	$\text{Sn}^{2+}$ , $\text{Sn}^{4+}$ , $\text{Pb}^{2+}$ , $\text{Pb}^{4+}$

## Formulas for binary ionic compounds

The basics of writing the formula

- 1) The total charge of any compound is always zero.
- 2) The positive ion symbol is written first followed by the negative ion symbol.
- 3) Subscripts which are small numbers shall be placed to the lower right of the symbol of the element indicating its number in the compound
- 4) If a number is not written below the symbol, it indicates that the ratio is equal to one (1)

Example

### Sodium fluoride

- ✓ Elements: sodium Na and fluorine F
- ✓ Fluoride ion charge is -1 while sodium ion charge is + 1
- ✓ Number of electrons lost by the metal equals the number of electrons gained by the nonmetal.
- ✓ The formula is  $\text{N}^{1+} \text{F}^{1-}$
- ✓ Total charge:  $+1-1 = 0$



Example 2

### Potassium oxide

- ✓ Elements: oxygen O and potassium K
- ✓ Oxygen ion Charge is -2 while potassium ion + 1
- ✓ Number of electrons acquired by the nonmetal is twice electrons lost by the metal.
- ✓ The formula would be  $\text{K}^{1+} \text{O}^{2-}$
- ✓ Total charge:  $(+1 \times 2) -2 = 0$



81) Determine the formula for the compound formed from aluminum ions and sulfide ions.

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82) Determine the formula for the compound formed from Magnesium ions and Chloride ions.

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## Polyatomic ionic compounds

Polyatomic ions: ions made up of more than one atom.

Basics of writing the formula

Are the same as the principles of binary ionic formulations because the polyatomic ion behaves as monoatomic ions. Since its charge is constant, the number of ions involved varies according to the number of corresponding charges.

Oxygen ions: A polyatomic ion consists of a nonmetal attached to one or more oxygen atoms.

The nonmetal sometimes has different oxygen ions according to the number of oxygen atoms.

Ion	Name	Ion	Name
$\text{NH}_4^+$	ammonium	$\text{IO}_4^-$	periodate
$\text{NO}_2^-$	nitrite	$\text{C}_2\text{H}_3\text{O}_2^-$	acetate
$\text{NO}_3^-$	nitrate	$\text{H}_2\text{PO}_4^-$	dihydrogen phosphate
$\text{OH}^-$	hydroxide	$\text{CO}_3^{2-}$	carbonate
$\text{CN}^-$	cyanide	$\text{SO}_3^{2-}$	sulfite
$\text{MnO}_4^-$	permanganate	$\text{SO}_4^{2-}$	sulfate
$\text{HCO}_3^-$	hydrogen carbonate	$\text{S}_2\text{O}_3^{2-}$	thiosulfate
$\text{ClO}^-$	hypochlorite	$\text{O}_2^{2-}$	peroxide
$\text{ClO}_2^-$	chlorite	$\text{CrO}_4^{2-}$	chromate
$\text{ClO}_3^-$	chlorate	$\text{Cr}_2\text{O}_7^{2-}$	dichromate
$\text{ClO}_4^-$	perchlorate	$\text{HPO}_4^{2-}$	hydrogen phosphate
$\text{BrO}_3^-$	bromate	$\text{PO}_4^{3-}$	phosphate
$\text{IO}_3^-$	iodate	$\text{AsO}_4^{3-}$	arsenate

Example

### Ammonium oxide

- ✓ Elements: oxide  $\text{O}^{2-}$ , ammonium  $\text{NH}_4^+$
- ✓ The formula would be  $\text{NH}_4^{1+} \text{O}^{2-}$
- ✓ total charge:  $(+1 \times 2) - 2 = 0$



## Names of ions and ionic compounds

### nomenclature of negative oxygen ions

Because of the difference in the number of possible oxygen atoms in the ion, the name is different. For example, molecules with more oxygen end up with (ate) while those with less oxygen atoms end up with (ete)

#### Nitrogen ions

$\text{NO}_3^-$	$\text{NO}_2^-$
Nitrate	Nitrite

#### Sulphur ions

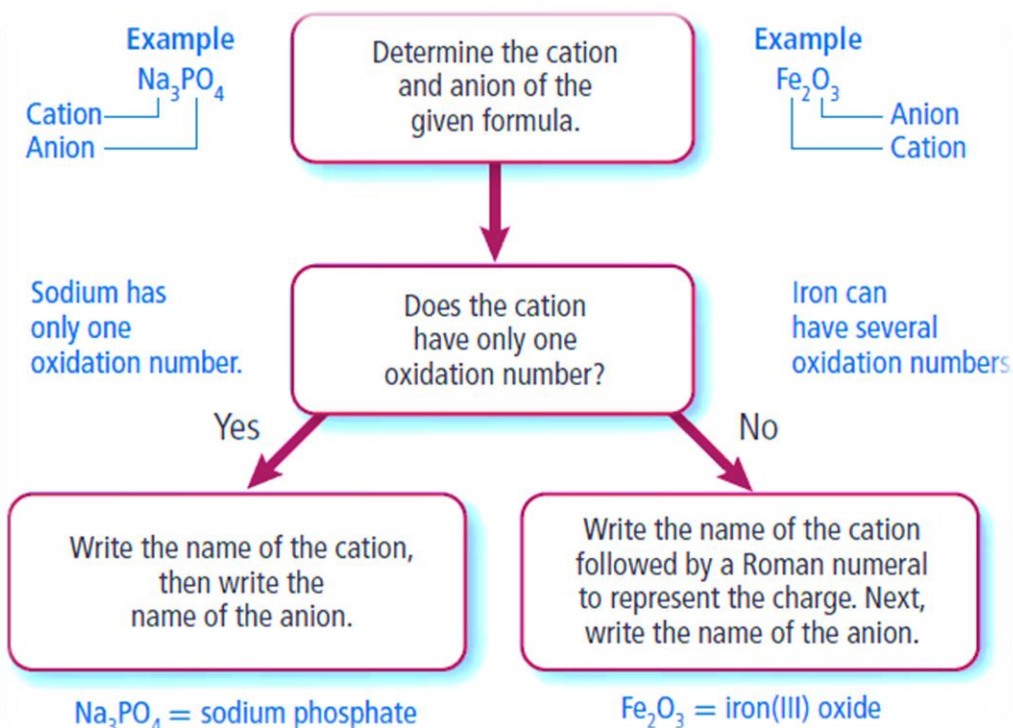
$\text{SO}_4^{2-}$	$\text{SO}_3^{2-}$
Sulphate	Sulphete

If the ion have four different forms of oxygen ions, the name is as follows,

$\text{ClO}^-$	$\text{ClO}_2^-$	$\text{ClO}_3^-$	$\text{ClO}_4^-$
Hypochlorete	Chlorete	Chlorate	Perchlorate

### Naming ionic compounds

- 1) Negative ion name is written first followed by the positive ion.
- 2) The name of the element is used in a case that is positive in a monoatomic ion.
- 3) Add the suffix (ide) to the name of the element in the case of formation of monoatomic negative ion.
- 4) Oxidation number for the positive ion is written in case it has more than one oxidation number.



83) Write the chemical formula for the following binary ionic compounds.

sodium fluoride \_\_\_\_\_

potassium chloride \_\_\_\_\_

calcium oxide \_\_\_\_\_

lithium bromide \_\_\_\_\_

beryllium chloride \_\_\_\_\_

f. potassium sulphide \_\_\_\_\_

g. magnesium nitride \_\_\_\_\_

h. calcium phosphide \_\_\_\_\_

i. magnesium oxide \_\_\_\_\_

j. aluminum chloride \_\_\_\_\_

k. sodium iodide \_\_\_\_\_

l. potassium nitride \_\_\_\_\_

m. lithium sulfide \_\_\_\_\_

n. barium phosphide \_\_\_\_\_

#### 84) Write the name for the following binary ionic compounds

LiCl \_\_\_\_\_

h. N<sub>2</sub>O \_\_\_\_\_

MgS \_\_\_\_\_

i. KBr \_\_\_\_\_

NaCl \_\_\_\_\_

j. BeO \_\_\_\_\_

Al<sub>2</sub>O<sub>3</sub> \_\_\_\_\_k. CaF<sub>2</sub> \_\_\_\_\_

CaS \_\_\_\_\_

l. BaBr<sub>2</sub> \_\_\_\_\_f. Zn<sub>3</sub>P<sub>2</sub> \_\_\_\_\_m. Na<sub>3</sub>N \_\_\_\_\_g. Be<sub>3</sub>P<sub>2</sub> \_\_\_\_\_n. Al<sub>2</sub>S<sub>3</sub> \_\_\_\_\_



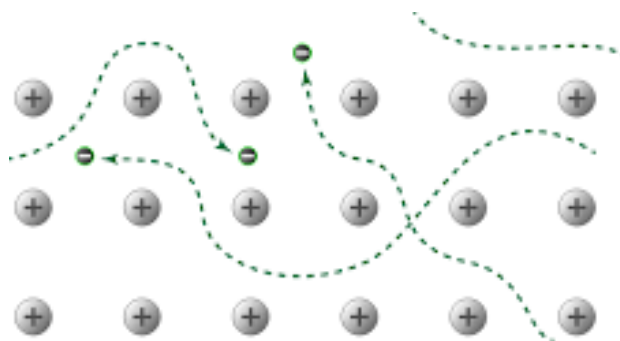
## Metallic bonds

What are the similarities between the bonds in metals and bonds in ionic compounds?

- 1) The bonds depend on the attraction between the different charges.
- 2) Metals form crystalline networks like those formed by ionic compounds.

## A sea of Electrons

Instead of sharing or losing valence electrons, the outer energy levels of the metal overlap. The sea of electrons surrounds the positive ions, forming the metal grid together. The electrons are not bound to a specific atom but are transported freely from one atom to another.



**Electrons sea Model:** Interference between the external energy levels of metal ions and the surrounding electrons.

**Delocalized electrons:** Electrons that move freely between the positive ions that form the metal grid.

**Metallic bond:** the attraction force between positive ions and the delocalized electrons in the metal grid.

## Properties of metals

### Melting and boiling points

Metals have high melting and boiling points because of the strength of the metal bond, but the melting point is less than expected because positive ions and negative electrons do not need much energy to slide over each other, but they need great energy to separate completely, which is reflected on high boiling points.

The boiling point of metals varies. Mercury is found as a liquid at room temperatures, which is used in thermometers. In contrast, Tungsten melting point is 3422°C, so it is used in manufacturing of lamps and spacecraft.

## Malleability, ductility, and durability



**Malleability:** Ability of a substance to be deformed or molded into a different shape

**Ductility:** The material's ability to be stretched into a wire

Metals are durable, because particles move by pushing or pulling, emphasizing that bonding is very strong between positive ions and the sea of electrons, making the majority of metals durable

### Thermal and electric conductivity

Because of the free movement of electrons, metals are good conductors of heat and electricity, and not only that, but it is also the main reason of some metals' luster.

### Hardness and strength

The greater the number of positive and negative charges in a metal grid, the stronger the metal. Transition metals not only participate in the grid with (s) sub-level electrons but also some of (d) sub-level electrons, which makes them stronger and harder.

### Why do iron and nickel stronger and harder than lithium and sodium?

Lithium and sodium soft metals as well as all alkaline metals (Group I metals) because they participate in the metal grid with a single electron. In contrast, iron and nickel elements participate with (d) sub-level electrons and (s) sub-level electrons as well, which makes them stronger and harder.

### Metal alloys

**Alloy:** A mixture of elements with unique metallic properties. Such as steel and bronze

### Alloys properties

Alloys properties differ from constituents, although they are a mixture rather than a compound. Steel, for example, is made of iron mixed with elements such as carbon but much harder.

Write the meaning of each vocabulary term below. Then invent a method that will help you remember the meaning of the terms. One has been done for you.

Vocabulary	Meaning	How I'm going to remember the meaning
85) formula unit	shows what anions and cations are in an ionic compound and the simplest ratio of these ions	formula unit - "for" showing ions and ratio simply, g., NaCl
86) ionic bond	the force of attraction between an anion and a cation	
87) ionic compound	what forms when anions and cations are joined by ionic bonds	
88) metallic bond	the attraction between a metal cation and the electrons that surround it	
89) valence electron	an electron located in the outer energy level of an electron cloud	
90) chemical formula	a combination of element symbols and subscripts that shows the composition of a representative unit of a compound	
91) electron dot formula	uses an element's symbol and dots to represent valence electrons and model an atom	
92) halide ion	an anion formed when a halogen atom gains an electron	
93) coordination number	the number of oppositely charged ions that surround an ion in an ionic crystal	
94) alloy	a mixture of a metal and at least one other element	
95) octet rule	explains how elements in a compound try to achieve the configuration of a noble gas	

## REVISION

96) Which one of the following statements about positive ions is incorrect?

- they are also known as cations
- they are formed when electrons are removed from atoms
- they are larger than the atom from which they were formed
- they are smaller than the atom from which they were formed

97) Which one of the following statements about negative ions is incorrect?

- they are also known as anions
- they are formed when atoms gain electrons
- they are larger than the atom from which they were formed
- they are smaller than the atom from which they were formed

98) Which of the following equations represents the 1st Ionization Energy of sodium?

- |  |  |
|--|--|
| <input type="checkbox"/> $\text{Na}_{(s)} \rightarrow \text{Na}^+_{(g)} + e^-$ | <input type="checkbox"/> $\text{Na}_{(g)} \rightarrow \text{Na}^+_{(g)} + e^-$ |
| <input type="checkbox"/> $\text{Na}_{(s)} \rightarrow \text{Na}^+_{(s)} + e^-$ | <input type="checkbox"/> $\text{Na}_{(s)} + e^- \rightarrow \text{Na}^+_{(g)}$ |

99) Which of the following equations represents the 2nd Ionization Energy of sodium?

- |   |   |
|---|---|
| <input type="checkbox"/> $\text{Na}_{(g)} \rightarrow \text{Na}^{2+}_{(g)} + 2e^-$  | <input type="checkbox"/> $\text{Na}_{(s)} \rightarrow \text{Na}^{2+}_{(g)} + 2e^-$  |
| <input type="checkbox"/> $\text{Na}^+_{(s)} \rightarrow \text{Na}^{2+}_{(g)} + e^-$ | <input type="checkbox"/> $\text{Na}^+_{(g)} \rightarrow \text{Na}^{2+}_{(g)} + e^-$ |

100) Which one of the following pairs atoms is most likely to form an ionic bond?

- |                                   |                                  |                                  |                                  |
|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| <input type="checkbox"/> Na and F | <input type="checkbox"/> C and F | <input type="checkbox"/> N and F | <input type="checkbox"/> O and F |
|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|

101) Aluminum is in Group 13. Its oxide will have the formula..

- |                              |   |   |   |
|------------------------------|---|---|---|
| <input type="checkbox"/> AlO | <input type="checkbox"/> AlO <sub>2</sub> | <input type="checkbox"/> Al <sub>2</sub> O <sub>3</sub> | <input type="checkbox"/> Al <sub>3</sub> O <sub>2</sub> |
|------------------------------|---|---|---|

102) Which of the following statements about sodium chloride is incorrect?

- it has a high melting point
- it conducts electricity at room temperature
- it is soluble in water
- it is brittle

103) The structure normally associated with ionic bonding is...

- a giant lattice
- a simple molecule
- a giant molecule
- a regular arrangement of ions surrounded by a sea, or cloud, of electrons

104) Which one of the following correctly describes the trend in electronegativity?

- increases across a period and decreases down a group
- decreases across a period and decreases down a group
- increases across a period and increases down a group
- decreases across a period and increases down a group

105) Which one of the following is not true of metallic bonding?

- it gives rise to excellent electrical conductivity
- electrons are free to move throughout the structure
- the strength of metallic bonds increases down a group
- the strength of metallic bonding affects the boiling point of metals

106) Which one of the following statements about the melting point of metals is true?

- sodium has a lower melting point than potassium
- sodium has a higher melting point than magnesium
- potassium has a higher melting point than rubidium
- lithium has a lower melting point than sodium

107) Which one of the following statements about the three states of matter is incorrect?

- in solids the particles vibrate about fixed positions
- energy is released when a gas turns back to a liquid
- particles in gases move in a random manner
- the closer particles are together, the smaller the force of attraction between them

108) Which of the following molecules has an ionic bond?

- O<sub>2</sub>       H<sub>2</sub>O       NaCl       SO<sub>2</sub>       Cl<sub>2</sub>

109) Which factor is used to determine if a bond is considered ionic?

- Electronegativity                       Charge                       Size  
 Number of atoms bound                       Mass

110) Which of the following molecules has an ionic bond?

- N<sub>2</sub>                       H<sub>2</sub>O                       CH<sub>3</sub>OH                       CH<sub>4</sub>                       KCl

111) KCl is considered what kind of solid?

- Molecular  
 Network  
 Ionic  
 Metallic  
 Macromolecular

112) Electrons involved in bonding between atoms are

- valence electrons                       inside the nucleus  
 closest to the nucleus                       positively charged

113) Each family in the periodic table has its own characteristic properties based on the number of

- neutrons                       valence electrons                       protons                       ions

114) What is the greatest number of valence electrons an atom can have? With the exception of helium.

- 2                       3                       8                       12

115) If atoms of a halogen nonmetal (Group 17) gains one electron, the atoms then have

- no valence electrons                       7 valence electrons  
 8 valence electrons                       17 valence electrons

116) When an atom loses an electron, it becomes a

- positive ion                       negative ion                       neutral ion                       neutral atom

117) An ionic bond is the attraction between

- similarly charged ions                       oppositely charged ions  
 neutral ions                       neutral atoms

118) The element boron is directly above aluminum on the periodic table Which statement about boron is true?

- Boron is in the same period as aluminum
- Boron is in the same group as aluminum and has 5 valence electrons
- Boron has 5 valence electrons and is in the same period as aluminum
- Boron is in the same group as aluminum and has 3 valence electrons

119) Magnesium bromide is an ionic compound with the chemical formula  $MgBr_2$ .

What does the "2" tell you?

- Bromide has a 2- charge
- There are two magnesium ions to every bromide ion.
- There are two bromide ions for every magnesium ion.
- Bromide has a 2+ charge

120) What is the chemical name for the compound with the formula  $N_2S$ ?

- sodium fluoride
- magnesium sulfide
- lithium oxide
- sodium sulfide

121) In the chemical formula for an ionic compound, which item is written first?

- positive ion
- negative ion
- subscript
- charge

122) Which of the following is a characteristic property of ionic compounds?

- They have low melting points.
- They have low boiling points.
- They form hard, brittle crystals with characteristic shapes.
- They contain no charged particles.

123) In what form can an ionic compound conduct electricity?

- as a solid
- as a crystal
- when dissolved in water
- when warmed slightly

124) A chemical bond formed when two atoms share electrons is called a(n)

- ionic bond
- covalent bond
- polyatomic bond
- crystal bond

125) If you found a carbon-13 atom, you would know that

- it has 13 protons
- it has 13 electrons
- it has 13 neutrons
- it has 7 neutrons

126) The attraction between a positive metal ion and the electrons surrounding it is a(n)

- chemical bond     covalent bond     ionic bond     metallic bond

127) Which of the following terms means that metals can be hammered or pounded into thin sheets, as in aluminum foil, or beaten into complex shapes?

- polar     alloy     ductile     malleable

128) Which of the following terms means that metals can be pulled into thin strands or wires?

- polar     alloy     ductile     malleable

**True/False: Indicate whether the statement is true (A) or false (B).**

129) ( ) The valence electrons are those electrons closest to the nucleus.

130) ( ) Each family in the periodic table has its own characteristic properties based upon its number of valence electrons.

131) ( ) When an atom gains an electron, it becomes a positive ion.

132) ( ) The attraction between a positive ion and a negative ion results in a covalent bond

133) ( ) Orderly crystal shapes, high melting points, and electrical conductivity when dissolved in water are properties of ionic compounds.

134) ( ) When electrons are transferred between two atoms, a covalent bond is formed.

**Complete each statement by matching the word with the statement.**

valence    positive    equal    most    negative

135) Elements in Group 17 (the halogens) are the \_\_\_\_\_ reactive nonmetals.

136) Elements in Group 1 lose one electron to form ions with a(n) \_\_\_\_\_ charge

137) An element is stable when it has a full \_\_\_\_\_ shell.

138) When an ionic compound forms, the total number of positive charges and the total number of negative charges must be \_\_\_\_\_.

Use the diagram to answer the next set of questions.

**Five Groups of Elements From the Periodic Table**

1	2	13	17	18
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.012	5 <b>B</b> Boron 10.811	9 <b>F</b> Fluorine 18.998	2 <b>He</b> Helium 4.0026
11 <b>Na</b> Sodium 22.990	12 <b>Mg</b> Magnesium 24.305	13 <b>Al</b> Aluminum 26.982	17 <b>Cl</b> Chlorine 35.453	10 <b>Ne</b> Neon 20.179
19 <b>K</b> Potassium 39.098	20 <b>Ca</b> Calcium 40.08	31 <b>Ga</b> Gallium 69.723	35 <b>Br</b> Bromine 79.904	18 <b>Ar</b> Argon 39.948
37 <b>Rb</b> Rubidium 85.468	38 <b>Sr</b> Strontium 87.62	49 <b>In</b> Indium 114.82	53 <b>I</b> Iodine 126.90	36 <b>Kr</b> Krypton 83.80
55 <b>Cs</b> Cesium 132.91	56 <b>Ba</b> Barium 137.33	81 <b>Tl</b> Thallium 204.37	85 <b>At</b> Astatine (210)	54 <b>Xe</b> Xenon 131.30
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)			86 <b>Rn</b> Radon (222)

139) The group containing the most reactive nonmetals

- 1       2       13       17       18

140) In each period, how does the number of electrons in each kind of atom change from left to right between Groups 1 and 2?

- remains the same     increases by 1       increases by 2  
 decreases by 1       decrease by 2

141) In an electron dot diagram of aluminum (Al), how many dots should be drawn around the element's symbol?

- 1       2       3       4       5

142) Which group of elements loses electrons most easily?

- 1       2       13       17       18

143) Which group contains elements with two valence electrons?

- 1       2       13       17       18

144) How many atoms of a Group 17 element would be needed to react with one atom of a Group 2 element?

- 1       2       3       4       5



Use the table below to answer the following questions.

### Ions and Their Charges

Name	Charge	Symbol or Formula
Lithium	?	Li <sup>+</sup>
?	1+	Na <sup>+</sup>
Calcium	2+	?
Chloride	1-	?
?	1-	NO <sub>3</sub> <sup>-</sup>
Carbonate	2-	?

145) What is the charge for a lithium ion?

- 3<sup>+</sup>  1<sup>-</sup>  2<sup>+</sup>  1<sup>+</sup>

146) What is the symbol for a calcium ion?

- Ca<sup>2+</sup>  Ca<sup>1+</sup>  Ca<sup>2-</sup>  Ca<sup>3+</sup>

147) What is the chemical formula of the compound that forms when sodium and chloride combine?

- SCl  SC  NaCl  NaCl

148) Which periodic table group has 2 electrons in their outer most energy level?

- group 1 (alkaline metals)  group 17 (halogens)  
 group 16 (oxygen family)  group 2 (alkaline earth metals)

149) An element's properties can be predicted from its

- number of isotopes  location on the periodic table  
 number of neutrons  atomic mass

150) The atomic mass of an atom is the total number of \_\_\_\_ in the nucleus

- protons and neutrons  protons  
 protons and electrons  neutrons

151) The zigzag line on the periodic table divides

- alkali metals and transition metals  semimetals and transition metals  
 metals and nonmetals  inert gases and halogens

152) An atom of gold with 79 protons, 79 electrons, and 118 neutrons would have a mass number of

- 39  158  197  276

What type of ions have names ending in -ide?

- only cations
- only anions
- only metal ions
- only gaseous ions

153) When Group 2 elements form ions, they \_\_\_\_\_.

- lose two protons
- gain two protons
- lose two electrons
- gain two electrons

154) What is the correct name for the  $N^{3-}$  ion?

- nitrate ion
- nitrogen ion
- nitride ion
- nitrite ion

155) When naming a transition metal ion that can have more than one common ionic charge, the numerical value of the charge is indicated by a \_\_\_\_\_.

- prefix
- suffix
- Roman numeral following the name
- superscript after the name

156) Aluminum is a group 13 metal. Which ion does Al typically form?

- $Al^{3-}$
- $Al^{5-}$
- $Al^{5+}$
- $Al^{3+}$

157) Which of the following correctly provides the name of the element, the symbol for the ion, and the name of the ion?

- fluorine,  $F^+$ , fluoride ion
- zinc,  $Zn^{2+}$ , zincate ion
- copper,  $Cu^+$ , cuprous ion
- sulfur,  $S^{2-}$ , sulfurous ion

158) The nonmetals in Groups 16 and 17 \_\_\_\_\_.

- lose electrons when they form ions
- have a numerical charge that is found by subtracting 8 from the group number
- all have ions with a  $-1$  charge
- end in -ate

159) Which of the following is NOT a cation?

- iron(III) ion                        $\text{Ca}^{2+}$                        sulfate                       mercurous ion

160) In which of the following are the symbol and name for the ion given correctly?

- $\text{NH}_4^+$ : ammonia;  $\text{H}^+$ : hydride                        $\text{OH}^-$ : hydroxide;  $\text{O}^{2-}$ : oxide  
  $\text{C}_2\text{H}_3\text{O}_2^-$ : acetate;  $\text{C}_2\text{O}_4^-$ : oxalite                        $\text{PO}_3^{3-}$ : phosphate;  $\text{PO}_4^{3-}$ : phosphite

161) Which of the following correctly provides the names and formulas of polyatomic ions?

- carbonate:  $\text{HCO}_3^-$ ; bicarbonate:  $\text{CO}_3^{2-}$   
 nitrite:  $\text{NO}^-$ ; nitrate:  $\text{NO}_2^-$   
 sulfite:  $\text{S}^{2-}$ ; sulfate:  $\text{SO}_3^-$   
 chromate:  $\text{CrO}_4^{2-}$ ; dichromate:  $\text{Cr}_2\text{O}_7^{2-}$

162) An -ate or -ite at the end of a compound name usually indicates that the compound contains \_\_\_\_\_.

- fewer electrons than protons                       only two elements  
 neutral molecules                       a polyatomic anion

163) Which of the following compounds contains the  $\text{Mn}^{3+}$  ion?

- $\text{MnS}$                         $\text{Mn}_2\text{O}_3$                         $\text{MnBr}_2$                         $\text{MnO}$

164) How are chemical formulas of binary ionic compounds generally written?

- cation on left, anion on right  
 anion on left, cation on right  
 Roman numeral first, then anion, then cation  
 subscripts first, then ions

165) Which of the following formulas represents an ionic compound?

- $\text{CS}_2$                         $\text{N}_2\text{O}_4$                         $\text{BaI}_2$                         $\text{PCl}_3$

166) Which element, when combined with fluorine, would most likely form an ionic compound?

- lithium                       phosphorus                       carbon                       chlorine

167) Which of the following shows correctly an ion pair and the ionic compound the two ions form?

- $\text{Sn}^{4+}$ ,  $\text{N}^{3-}$ ;  $\text{Sn}_4\text{N}_3$ 
  $\text{Cr}^{3+}$ ,  $\text{I}^-$ ;  $\text{CrI}$   
  $\text{Cu}^{2+}$ ,  $\text{O}^{2-}$ ;  $\text{Cu}_2\text{O}_2$ 
  $\text{Fe}^{3+}$ ,  $\text{O}^{2-}$ ;  $\text{Fe}_2\text{O}_3$

168) Which of the following correctly represents an ion pair and the ionic compound the ions form?

- $\text{Ca}^{2-}$ ,  $\text{F}^-$ ;  $\text{CaF}_2$ 
  $\text{Ba}^{2+}$ ,  $\text{O}^{2-}$ ;  $\text{Ba}_2\text{O}_2$   
  $\text{Na}^+$ ,  $\text{Cl}^-$ ;  $\text{NaCl}_2$ 
  $\text{Pb}^{4+}$ ,  $\text{O}^{2-}$ ;  $\text{Pb}_2\text{O}_4$

169) Which of the following compounds contains the lead(II) ion?

- $\text{PbO}$ 
  $\text{Pb}_2\text{O}$ 
  $\text{PbCl}_4$ 
  $\text{Pb}_2\text{S}$

170) Which set of chemical name and chemical formula for the same compound is correct?

- iron(II) oxide,  $\text{Fe}_2\text{O}_3$ 
 tin(IV) bromide,  $\text{SnBr}_4$   
 aluminum fluoride,  $\text{AlF}_3$ 
 potassium chloride,  $\text{K}_2\text{Cl}_2$

171) What is the correct formula for potassium sulfite?

- $\text{KHSO}_3$ 
  $\text{K}_2\text{SO}_3$ 
  $\text{KHSO}_4$ 
  $\text{K}_2\text{SO}_4$

172) Which set of chemical name and chemical formula for the same compound is correct?

- ammonium sulfite,  $(\text{NH}_4)_2\text{S}$ 
 lithium carbonate,  $\text{LiCO}_3$   
 iron(III) phosphate,  $\text{FePO}_4$ 
 magnesium dichromate,  $\text{MgCrO}_4$

173) What type of compound is  $\text{CuSO}_4$ ?

- monatomic ionic
  polyatomic ionic  
 polyatomic covalent
  binary molecular

174) Which polyatomic ion forms a neutral compound when combined with a group 1A monatomic ion in a 1:1 ratio?

- ammonium
  nitrate
  carbonate
  phosphate

175) Sulfur hexafluoride is an example of a \_\_\_\_\_.

- monatomic ion
  binary compound  
 polyatomic ion
  polyatomic compound

176) Metals tend to \_\_\_\_\_ electrons and nonmetals tend to \_\_\_\_\_ electrons.

- gain, gain
- lose, lose
- lose, gain
- gain, gain
- neither, they keep their electrons

177) Anions tend to have a \_\_\_\_\_ charge and cations tend to have a \_\_\_\_\_ charge

- positive, positive
- negative, negative
- positive, negative
- negative, positive
- neither, they are both neutral

178) Anions tend to be \_\_\_\_\_ and cations tend to be \_\_\_\_\_.

- metals, metals
- nonmetals, nonmetals
- metals, nonmetals
- nonmetals, metals
- metalloids, metalloids

179) When a metal and a nonmetal react, the \_\_\_\_\_ tends to lose electrons and the \_\_\_\_\_ tends to gain electrons.

- metal, metal
- nonmetal, nonmetal
- metal, nonmetal
- nonmetal, metal
- None of the above, these elements share electrons.

180) \_\_\_\_\_ typically form ions with a 2+ charge

- Alkaline earth metals
- Halogens
- Chalcogens
- Alkali metals
- Transition metals

181) Which species below is the nitride ion?

- $\text{Na}^+$         $\text{NO}_3^-$         $\text{NO}_2^-$         $\text{NH}_4^+$         $\text{N}^{3-}$

182) Sodium forms an ion with a charge of \_\_\_\_\_.

- 1+       1-       2+       2-       0

183) Aluminum forms an ion with a charge of \_\_\_\_\_.

- 2+       1-       3+       2-       0

184) Calcium forms an ion with a charge of \_\_\_\_\_.

- 1-       2-       1+       2+       0

185) Barium forms an ion with a charge of \_\_\_\_\_.

- 1+       2-       3+       3-       2+

186) Bromine forms an ion with a charge of \_\_\_\_\_.

- 2+       3-       1+       3+       1-

187) Fluorine forms an ion with a charge of \_\_\_\_\_.

- 1-       1+       2+       3+       3-

188) Iodine forms an ion with a charge of \_\_\_\_\_.

- 7-       1+       2-       2+       1-

189) Oxygen forms an ion with a charge of \_\_\_\_\_.

- 2-       2+       3-       3+       6+

190) Sulfur forms an ion with a charge of \_\_\_\_\_.

- 2+       2-       3+       6-       6+

191) How many electrons does the  $\text{Al}^{3+}$  ion possess?

- 16       10       6       0       13

192) Predict the charge of the most stable ion of P

- 2+       3-       3+       1-       2-

193) Predict the charge of the most stable ion of S

- 3+       1-       6+       2+       2-

194) Which of the following compounds would you expect to be ionic?

- $\text{SF}_6$         $\text{H}_2\text{O}$         $\text{CO}_2\text{NH}_3$         $\text{CaO}$

195) Which of the following compounds would you expect to be ionic?

- H<sub>2</sub>O                       CO<sub>2</sub>                       SrCl<sub>2</sub>SO<sub>2</sub>                       H<sub>2</sub>S

196) Which pair of elements is most likely to form an ionic bond?

- barium, Chlorine  
 calcium, sodium  
 oxygen, fluorine  
 sulfur, carbon  
 nitrogen, hydrogen

197) Of the choices below, which one is not an ionic compound?

- PCl<sub>5</sub>                       CrCl<sub>6</sub>                       RbCl                       PbCl<sub>2</sub>                       NaCl

198) What is the formula of the compound formed between strontium ions and nitrogen ions?

- SrN                       Sr<sub>3</sub>N<sub>2</sub>                       Sr<sub>2</sub>N<sub>3</sub>                       SrN<sub>2</sub>                       SrN<sub>3</sub>

199) Magnesium reacts with a certain element to form a compound with the general formula MgX. What would the most likely formula be for the compound formed between Lithium and element X?

- Li<sub>2</sub>X                       LiX<sub>2</sub>                       Li<sub>2</sub>X<sub>3</sub>                       Li<sub>2</sub>X<sub>2</sub>                       LiX

200) Aluminum reacts with a certain nonmetallic element to form a compound with the general formula AlX. Element X is a diatomic gas at room temperature. Element X must be \_\_\_\_.

- sulfur                       fluorine                       Bromine                       nitrogen                       oxygen

201) Predict the formula of the ionic compound that forms from Calcium and Fluorine

- CaF<sub>2</sub>                       C<sub>2</sub>F                       C<sub>2</sub>F<sub>2</sub>                       C<sub>2</sub>F<sub>3</sub>                       Ca<sub>3</sub>F<sub>2</sub>

202) Predict the formula of the ionic compound that forms from magnesium and fluorine

- Mg<sub>2</sub>F<sub>3</sub>                       MgF                       Mg<sub>2</sub>F                       Mg<sub>3</sub>F<sub>2</sub>                       MgF<sub>2</sub>

203) Predict the formula of the ionic compound that forms from magnesium and oxygen.

- Mg<sub>2</sub>O                       MgO                       MgO<sub>2</sub>                       Mg<sub>2</sub>O<sub>2</sub>                       Mg<sub>3</sub>O<sub>2</sub>

204) What is the ionic compound that forms from aluminum and oxygen?

- AlO       Al<sub>3</sub>O<sub>2</sub>       Al<sub>2</sub>O<sub>3</sub>       AlO<sub>2</sub>       Al<sub>2</sub>O

205) The correct name for SrO is \_\_\_\_\_.

- strontium oxide  
 strontium hydroxide  
 strontium peroxide  
 strontium monoxide  
 strontium dioxide

206) The correct name for K<sub>2</sub>S is \_\_\_\_\_.

- potassium sulfate  
 potassium disulfide  
 potassium bisulfide  
 potassium sulfide  
 dipotassium sulfate

207) The correct name for Al<sub>2</sub>O<sub>3</sub> is \_\_\_\_\_.

- aluminum oxide  
 dialuminum oxide  
 dialuminum trioxide  
 aluminum hydroxide  
 aluminum trioxide

208) The correct name for CaH<sub>2</sub> is \_\_\_\_\_.

- hydrocalcium  
 calcium dihydride  
 calcium hydroxide  
 calcium dihydroxide  
 calcium hydride

209) The correct name of the compound Na<sub>3</sub>N is \_\_\_\_\_.

- sodium nitride  
 sodium azide  
 sodium trinitride  
 sodium(III) nitride  
 trisodium nitride



210) Element M reacts with fluorine to form an ionic compound with the formula  $MF_3$ . The M-ion has 18 electrons. Element M is \_\_\_\_\_.

- P       Sc       Ar       Ca       Cr

211) When calcium reacts with sulfur the compound formed is \_\_\_\_\_.

- $C_2S_2$         $Ca_3S_2$        CaS        $CaS_2$         $C_2S_3$

212) Aluminum reacts with a certain nonmetallic element to form a compound with the general formula  $Al_2X_3$ . Element X must be from Group \_\_\_\_\_ of the Periodic Table of Elements.

- 13       14       15       16       17

213) The charge on the manganese in the salt  $MnCl_3$  is \_\_\_\_\_.

- 1+       1-       2+       2-       3+

214) Chromium and chlorine form an ionic compound whose formula is  $CrCl_3$ . The name of this compound is \_\_\_\_\_.

- chromium chlorine  
 chromium(III) chloride  
 monochromium trichloride  
 chromium(III) trichloride  
 chromic trichloride

215) The correct formula of iron(III) bromide is \_\_\_\_\_.

- $FeBr_2$         $FeBr_3$        FeBr        $Fe_3Br_3$         $Fe_3Br$

216) Which one of the following compounds is chromium(III) oxide?

- $Cr_2O_3$         $CrO_3$         $Cr_3O_2$         $Cr_3O$         $Cr_2O_4$

217) Which one of the following compounds is copper(I) chloride?

- CuCl        $CuCl_2$         $Cu_2Cl$         $Cu_2Cl_3$         $Cu_3Cl_2$

218) The correct name for  $MgF_2$  is \_\_\_\_\_.

- manganese difluoride  
 magnesium difluoride  
 monomagnesium difluoride  
 manganese bifluoride  
 magnesium fluoride

219) Which metal is capable of forming more than one cation?

- Li       Ba       Sr       Al       Sn

220) The charge on the iron ion in the salt  $\text{Fe}_2\text{O}_3$  is \_\_\_\_\_.

- +1       +2       +3       -5       -6

221) Which metal is not required to have its charge specified in the names of ionic compounds it forms?

- Mn       Fe       Cu       Ca       Pb

222) The ions  $\text{Ca}^{2+}$  and  $\text{PO}_4^{3-}$  form a salt with the formula \_\_\_\_\_.

- $\text{CaPO}_4$   
  $\text{C}_2(\text{PO}_4)_3$   
  $\text{C}_2\text{PO}_4$   
  $\text{Ca}(\text{PO}_4)_2$   
  $\text{Ca}_3(\text{PO}_4)_2$

223) The formula of ammonium carbonate is \_\_\_\_\_.

- $(\text{NH}_4)_2\text{CO}_3$        $\text{NH}_4\text{CO}_2$        $(\text{NH}_3)_2\text{CO}_4$        $(\text{NH}_3)_2\text{CO}_3$        $\text{N}_2(\text{CO}_3)_3$

224) The correct name for  $\text{Mg}(\text{ClO}_3)_2$  is \_\_\_\_\_.

- magnesium chlorate  
 manganese chlorate  
 magnesium chloroxide  
 magnesium perchlorate  
 manganese perchlorate

225) What is the correct formula for ammonium sulfide?

- $\text{NH}_4\text{SO}_3$        $(\text{NH}_4)_2\text{SO}_4$        $(\text{NH}_4)_2\text{S}$        $\text{NH}_3\text{S}$        $\text{N}_2\text{S}_3$

226) Which formula/name pair is incorrect?

- $\text{Mn}(\text{NO}_2)_2$       manganese(II) nitrite  
  $\text{Mg}(\text{NO}_3)_2$       magnesium nitrate  
  $\text{Mn}(\text{NO}_3)_2$       manganese(II) nitrate  
  $\text{Mg}_3\text{N}_2$       magnesium nitrite  
  $\text{Mg}(\text{MnO}_4)_2$       magnesium permanganate

227) The formula for a salt is XBr. The X-ion in this salt has 46 electrons. The metal X is \_\_\_\_.

- Ag       Pd       Cd       Cu       Cs

228) Which formula/name pair is incorrect?

- FeSO<sub>4</sub>      iron(II) sulfate  
 Fe<sub>2</sub>(SO<sub>3</sub>)<sub>3</sub>      iron(III) sulfite  
 FeS      iron(II) sulfide  
 FeSO<sub>3</sub>      iron(II) sulfite  
 Fe<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>      iron(III) sulfide

229) The formula for aluminum hydroxide is \_\_\_\_\_.

- AlOH       Al<sub>3</sub>OH       Al<sub>2</sub>(OH)<sub>3</sub>       Al(OH)<sub>3</sub>       Al<sub>2</sub>O<sub>3</sub>

230) The name of the ionic compound (NH<sub>4</sub>)<sub>3</sub>PO<sub>4</sub> is \_\_\_\_\_.

- ammonium phosphate  
 tetrammonium phosphate  
 nitrogen hydrogen phosphate  
 ammonia phosphide  
 triammonium phosphate

231) The correct name for Cu(CN)<sub>2</sub> is \_\_\_\_\_.

- Copper (I) cyanide  
 Carbon cyanide  
 Carbon carbonate  
 Copper (II) cyanide  
 Copper (I) nitride

232) The correct name for N<sub>2</sub>O<sub>2</sub> is \_\_\_\_\_.

- Sodium oxide  
 Sodium dioxide  
 Disodium oxide  
 Sodium peroxide  
 Disodium dioxide

233) Barium reacts with a polyatomic ion to form a compound with the general formula  $Ba_3(X)_2$ . What would be the most likely formula for the compound formed between sodium and the polyatomic ion X?

- NaX        $N_2X$         $N_2X_2$         $Na_3X$         $Na_3X_2$

234) Chemical bonding in metals is

- the same as ionic bonding.  
 the same as covalent bonding.  
 a combination of ionic and covalent bonding.  
 different from ionic or covalent bonding.

235) The valence electrons in a metallic bond

- move freely throughout the network of metal atoms.  
 are held tightly by the most positively charged atom.  
 are shared equally between two metal atoms.  
 continuously move from one energy level to another.

236) Which of the following properties is not explained by metallic bonding?

- electrical conductivity       thermal conductivity  
 brittleness       ductility

237) Metals are malleable because when struck, one plane of metal atoms

- can slide past another plane without breaking bonds.  
 cannot easily move out of the way.  
 moves in a way that maximizes the repulsive forces within the metal.  
 bonds to the plane directly beneath it.

238) In general, as you move from right to left across any row of the periodic table, the strength of a metallic bond

- increases.       decreases.       stays the same       shows no trend.

239) Which of these is responsible for the good electrical conductivity of metals?

- the arrangement of metal atoms in separate layers  
 the high density of metals atoms in the crystal lattice  
 the ability of electrons to move freely about the crystal structure  
 the fact that metal atoms contain many orbitals separated by very small energy

240) The arrangement of valence electrons in a metallic bond is best described as

- fixed positions in a lattice
- a sea of free-moving electrons.
- concentrated electron density around specific atoms.
- electron pairs existing in multiple bonds.

241) The number of electrons in the outer shell

- Isotope
- ion
- atomic mass
- valence

242) These elements don't bond with other elements because their outer shell is filled.

- Metals
- Inert gases
- noble solids
- none of the answers are correct

243) Most atoms adopt one of three simple strategies to achieve a filled shell. Which of the following is NOT one of these strategies?

- they keep their own electrons
- they share electrons
- they accept electrons
- they give away electrons

244) Which of the following is NOT a type of chemical bond?

- Metallic
- Valence
- Covalent
- Ionic

245) In ionic bonding

- Electrons are given away
- Two answers are correct
- Electrons are accepted
- electrons are shared

246) In ionic bonding electrical forces between same charged ions holds the atoms together.

- True
- False

247) In metallic bonding...

- One atom takes the outer shell electrons from another atom.
- Bonding takes place between positively charged areas of one atom with a negatively charged area of another atom.
- A couple of atoms share their electrons with each other.
- Some electrons are shared by all the atoms in the material.

248) Which of the following is NOT a characteristic of metals?

- |  |   |
|--|---|
| <input type="checkbox"/> Shiny luster            | <input type="checkbox"/> conducts electricity |
| <input type="checkbox"/> Brittle/Shatters easily | <input type="checkbox"/> Malleable            |

249) When two or more metal elements are combined they form an...

- |                                |                                 |  |                                |
|--------------------------------|---------------------------------|--|--------------------------------|
| <input type="checkbox"/> Alloy | <input type="checkbox"/> bronze | <input type="checkbox"/> covalent bond | <input type="checkbox"/> brass |
|--------------------------------|---------------------------------|--|--------------------------------|

250) In metals, the \_\_\_\_\_ electrons form a shared sea of electrons.

- |                                   |                                |                                |                                |
|-----------------------------------|--------------------------------|--------------------------------|--------------------------------|
| <input type="checkbox"/> Metallic | <input type="checkbox"/> Inner | <input type="checkbox"/> Outer | <input type="checkbox"/> Ionic |
|-----------------------------------|--------------------------------|--------------------------------|--------------------------------|

251) In general, what can be said of the melting points of metals?

- |   |   |
|---|---|
| <input type="checkbox"/> They are low.                  | <input type="checkbox"/> They are high.                   |
| <input type="checkbox"/> They are lower than nonmetals. | <input type="checkbox"/> They do not have melting points. |

252) I can hit a metal with a hammer without the metal shattering because of its

- |                                    |                                       |                                       |                                       |
|------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| <input type="checkbox"/> Ductility | <input type="checkbox"/> Malleability | <input type="checkbox"/> Conductivity | <input type="checkbox"/> Lustrousness |
|------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|

253) Metals like to \_\_\_\_\_ electrons.

- |                               |                               |                                     |                                 |
|-------------------------------|-------------------------------|-------------------------------------|---------------------------------|
| <input type="checkbox"/> Gain | <input type="checkbox"/> Lose | <input type="checkbox"/> Annihilate | <input type="checkbox"/> Juggle |
|-------------------------------|-------------------------------|-------------------------------------|---------------------------------|

254) There are more metals than nonmetals in the periodic table

- |                               |                                |
|-------------------------------|--------------------------------|
| <input type="checkbox"/> True | <input type="checkbox"/> False |
|-------------------------------|--------------------------------|

255) What do metals conduct?

- |                               |                                      |                               |                                  |
|-------------------------------|--------------------------------------|-------------------------------|----------------------------------|
| <input type="checkbox"/> Heat | <input type="checkbox"/> electricity | <input type="checkbox"/> both | <input type="checkbox"/> neither |
|-------------------------------|--------------------------------------|-------------------------------|----------------------------------|

256) Why are alloys generally used to make everyday objects?

- Alloys are often stronger and less active than pure metals.
- Alloys have higher melting point than pure metals.
- Alloys are less expensive to produce than pure metals.
- Alloys have ionic bonds instead of metallic bonds.

257) Metallic bonding is...

- a type of covalent bond.
- a type of ionic bond.
- an attraction between positive and negative ions.
- an attraction between positive ions and electrons.

258) What does malleable mean?

- able to be shaped
- will break easily
- can be used for wire
- is shiny

259) At room temperature, most metals are

- Liquid
- solid
- gas
- an alloy

260) Why do metals conduct electricity?

- They are shiny
- The electrons are held tightly within the lattice
- The electrons are delocalized and able to move
- The electrons are shared between two metal ions

261) Why do metals have high melting points?

- They don't
- The negatively charged electrons act as a glue to hold the positively charged ions together.
- All the electrons become delocalized

262) A mixture of two or more metals is called:

- Mixture
- solution
- compound
- alloy

263) Which of the following is an alloy?

- sterling silver
- chromium
- nickel
- lead