NAME: _____

UNIT #4A: IONIC COMPOUNDS

1. CHARACTERISTICS ON IONIC COMPOUNDS

   a) Formed between **metals and non-metals.** Neutral metal atoms lose valence electrons to become positively charged ions called **cations**; neutral non-metal atoms gain electrons to become negatively charged ions called **anions.** The electrostatic force that holds oppositely charged particles together in an ionic compound is referred to as an **ionic bond**.
   b) Ions are packed into a regular repeating pattern and form a **crystal lattice**, which is a three-dimensional geometric arrangement of particles. Ionic crystals vary in shape due to the sizes and numbers of ions bonded.
   c) Ionic crystals are **hard, rigid and brittle solids.**
   d) Ionic bonds are relatively strong, thus the crystals that result require a large amount of energy to be broken apart; thus, ionic compounds have **high melting and boiling points**.
   e) In the solid state, ionic compounds do not conduct electricity because of the fixed positions of the ions; however, in a liquid state or when dissolved in water, ionic compounds are electrical conductors because the charged ions dissociate and move freely to conduct an electric current. Thus, ionic compounds in solution are termed **electrolytes.**

2. FORMATION OF IONIC COMPOUNDS AND NAMING

   a) Ionic compounds consist of a metal ion strongly bound to a non-metal ion.
   b) The charges that atoms acquire in becoming ions is related to the number of valence electrons in their outermost energy levels. Metals lose their valence electrons to become cations and non-metals gain electrons to become anions. The number of protons (+ subatomic particles) in the nucleus of the atom does not change, so if an atom loses 1 electron, it acquires a charge of 1+; if it loses 2 electrons, it acquires a charge of 2+ and if it loses 3 electrons, it acquires a charge of 3+. Likewise, if an atom gains 1 electron, it acquires a charge of 1-; if it gains 2 electrons, it acquires a charge of 2- and if it gains 3 electrons, it acquires a charge of 3-. Neutral atoms lose or gain electrons in order to achieve a stable octet of electrons (8 electrons) in their outermost energy level.

MONOATOMIC CATIONS (Metals Except for Hydrogen):

Group 1 (1 valence e^-)		Group 2 (2 valence e^-)		Group 13 (3 valence e^-)	
H^+	hydrogen				
Li^+	lithium	Be^{2+}	beryllium	B^{3+}	boron
Na^+	sodium	Mg^{2+}	magnesium	Al^{3+}	aluminum
K^+	potassium	Ca^{2+}	calcium	Ga^{3+}	gallium
Rb^+	rubidium	Sr^{2+}	strontium	In^{3+}	indium
Cs^+	cesium	Ba^{2+}	barium	Tl^{3+}	thallium
Fr^+	francium	Ra^{2+}	radium		

NOTE: The transition metals in groups 3 through 12 can have a charge of 1+, 2+ or 3+. Charges of transition metals will either be given, or will be determined from the ionic formula.

MONOATOMIC ANIONS (Non-Metals):

Group 15 (5 valence e^-)		Group 16 (6 valence e^-)		Group 17 (7 valence e^-)	
N^{3-}	nitride	O^{2-}	oxide	F^-	fluoride
P^{3-}	phosphide	S^{2-}	sulfide	Cl^-	chloride
As^{3-}	arsenide	Se^{2-}	selenide	Br^-	bromide
		Te^{2-}	telluride	I^-	iodide
				At^-	astatide

c) There are groups of atoms that form polyatomic ions, that is, ions containing more than one type of atom. These groups stay together as a unit, but have a net charge. They have specific names. With the exception of ammonium, all polyatomic ions are anions. You will be required to memorize several of these.

MOST COMMON POLYATOMIC IONS:

1^+ Charge	1^- Charge	2^- Charge	3^- Charge
Ammonium NH_4^+	Nitrite NO_2^-	Sulfite SO_3^{2-}	Phosphite PO_3^{3-}
	Nitrate NO_3^-	Sulfate SO_4^{2-}	Phosphate PO_4^{3-}
	Acetate $C_2H_3O_2^-$	Carbonate CO_3^{2-}	Arsenate AsO_4^{3-}
	Chlorate ClO_3^-	Chromate CrO_4^{2-}	
	Cyanide CN^-		
	Hydroxide OH^-		
	Permanganate MnO_4^-		
	Peroxide O^-		

d) When ionic compounds form, the positive metal cations attract to the negative non-metal ions in a ratio that ensures a neutral compound. In other words, the positive charge of the cation(s) has to be equal to the negative charge of the anion(s). The ionic formula shows the simplest whole number ratio of the metal and non-metal ions.

e) **The criss-cross method can be used to determine the ionic formula. Using this method, write the cation with charge, then write the anion with charge next to it. Bring down the charge number of the anion and make it the subscript (lower number) of the cation. Then, bring down the charge number of the cation and make it the subscript (lower number) of the anion.** In chemistry, a subscript of 1 is eliminated. No subscript indicates that there is only one ion in the formula. Also, if there is an equal number of cations and anions in a formula, it reduces to a 1:1 ratio and the subscripts are eliminated. Finally, when there is more than one polyatomic ion in a formula, you must write the polyatomic ion in parenthesis and follow it with a subscript to indicate the number of units in the formula.

Examples:

Na^+ Cl^-	Formula NaCl	sodium chloride
Mg^{2+} Br^-	Formula $MgBr_2$	magnesium bromide
Sr^{2+} P^{3-}	Formula Sr_3P_2	strontium phosphide
Li^+ PO_4^{3-}	Formula Li_3PO_4	lithium phosphate
NH_4^+ CO_3^{2-}	Formula $(NH_4)_2CO_3$	ammonium carbonate
Ca^{2+} S^{2-}	Formula CaS	calcium sulfide
Al^{3+} NO_3^-	Formula $Al(NO_3)_3$	aluminum nitrate
Cu^{2+} $C_2H_3O_2^-$	Formula $Cu(C_2H_3O_2)_2$	copper II acetate
Cu^{3+} $C_2H_3O_2^-$	Formula $Cu(C_2H_3O_2)_3$	copper III acetate

f) Naming Ionic Compounds

1. Name consists of metal cation first, followed by non-metal anion.
2. Cation is always named "as is." It is simply the name of the metal as it appears on the periodic table or if NH_4^+, it's ammonium.
3. The anion name is as follows:
   a. If the anion is a monoatomic ion, the name consists of the root of the element's name followed by the suffix **ide.**
   b. If the anion is a polyatomic ion, the name is "as is." It is simply the name of the polyatomic ion.
4. If the metal in the compound is a transition metal (from Groups 3 thru 12), then the name of the metal must be followed by a roman numeral to indicate the charge number on the metal.

Unit 4, Activity # ___ Name: _____ Date: _____ Pd: ___

Atoms and Ions

Directions: Complete the chart below. You will need a periodic table. Recall that protons have a positive charge and electrons have a negative charge. Neutral atoms have the same number of protons and electrons. Ions are atoms that have either gained or lost electrons. An atom that gains an electron has a negative charge and is called an **anion** (usually a nonmetal.) An atom that loses electrons has a positive charge and is called a **cation** (usually a metal.)

ELEMENT	ATOMIC NUMBER	MASS NUMBER	PROTONS	ELECTRONS	NEUTRONS	CHARGE	ATOM OR ION	SYMBOL
Na	11	23	11	11	12	0	Atom	$^{23}_{11}Na$
Na^{+}	11	23	11	10	12	+1	Cation	$^{23}_{11}Na^{+}$
			7	7				
	16			18	16			
	12						Atom	
Co^{+2}								
			35			0		
				20			Atom	
	29			28			Cation	
			14			+4		
								$^{16}_{8}O$
								$^{16}_{8}O^{-2}$
		56		26			Atom	
	35	80				-1		

Unit 4, Activity # ____

Name _____ Date: _____ Pd: __

Valence electrons and Energy levels

Purpose: Determine the relationship between location on the periodic table, valence electrons and Valence energy level and Charge an atom gets when it becomes an ion.

Explain the above relationship after completing the exercise below.

Element	Bohr Model	# of Valence electrons	Energy level of Valence electrons	Group #	Period #	# of electrons lost or gained to full shell	Charge of ion
H							
Li							
Na							
K							
F							

Element	Bohr Model	# of Valence electrons	Energy level of Valence electrons	Group #	Period #	# of electrons lost or gained to full shell	Charge of ion
Cl							
Br							
B							
Ga							
Al							

WRITING FORMULAS (CRISS-CROSS METHOD)

Name _____

Write the formulas of the compounds produced from the listed ions.

	Cl^-	CO_3^{-2}	OH^-	SO_4^{-2}	PO_4^{-3}	NO_3^-
Na^+						
NH_4^+						
K^+						
Ca^{+2}						
Mg^{+2}						
Zn^{+2}						
Fe^{+3}						
Al^{+3}						
Co^{+3}						
Fe^{+2}						
H^+						

Unit ___, Activity # ___

Naming and Writing Formulas for Ionic Compounds

Part A: Writing formulas from names

	Name	Cation	Anion	Formula
Ex	Barium Hydroxide	Ba^{2+}	OH^-	$Ba(OH)_2$
1.	Ammonium Bromide			
2.	Nickel (III) Nitrate			
3.	Aluminum Phosphate			
4.	Potassium Sulfite			
5.	Sodium Carbonate			
6.	Magnesium Nitrite			
7.	Iron (II) Sulfide			
8.	Copper (I) Oxide			
9.	Manganese (II) Phosphite			
10.	Copper (II) Acetate			

Part B: Writing names from formulas

	Formula	Cation	Anion	Name
Ex	$CuCl_2$	Cu^{2+}	Cl^-	copper (II) chloride
1.	CuCl			
2.	$FeSO_4$			
3.	$Al(OH)_3$			
4.	$Mg(NO_3)_2$			
5.	Fe_2O_3			
6.	$NiBr_3$			
7.	$AuCl_3$			
8.	NH_4NO_2			
9.	$PbSO_3$			
10.	K_2S			

NAMING IONIC COMPOUNDS

Name _____

Name the following compounds using the Stock Naming System.

1. $CaCO_3$ _____
2. KCl _____
3. $FeSO_4$ _____
4. $LiBr$ _____
5. $MgCl_2$ _____
6. $FeCl_3$ _____
7. $Zn_3(PO_4)_2$ _____
8. NH_4NO_3 _____
9. $Al(OH)_3$ _____
10. $CuC_2H_3O_2$ _____
11. $PbSO_3$ _____
12. $NaClO_3$ _____
13. CaC_2O_4 _____
14. Fe_2O_3 _____
15. $(NH_4)_3PO_4$ _____
16. $NaHSO_4$ _____
17. Hg_2Cl_2 _____
18. $Mg(NO_2)_2$ _____
19. $CuSO_4$ _____
20. $NaHCO_3$ _____
21. $NiBr_3$ _____
22. $Be(NO_3)_2$ _____
23. $ZnSO_4$ _____
24. $AuCl_3$ _____
25. $KMnO_4$ _____

WRITING FORMULAS FROM NAMES

Name _____

Write the formulas of the following compounds.

1. ammonium phosphate _____
2. iron (II) oxide _____
3. iron (III) oxide _____
4. carbon monoxide _____
5. calcium chloride _____
6. potassium nitrate _____
7. magnesium hydroxide _____
8. aluminum sulfate _____
9. copper (II) sulfate _____
10. lead (IV) chromate _____
11. diphosphorus pentoxide _____
12. potassium permanganate _____
13. sodium hydrogen carbonate _____
14. zinc nitrate _____
15. aluminum sulfite _____

Part A: Fill in the formula for the cation

1. $CaCl_2$ (s) → _____ + $2Cl^{-1}$ (aq)
2. NaCl (s) → _____ + Cl^{-1} (aq)
3. $MgBr_2$ (s) → _____ + $2Br^{-1}$ (aq)
4. Cr_2O_3 (s) → _____ + $3O^{-2}$ (aq)
5. $(NH_4)PO_4$ (s) → _____ + PO_4^{-3} (aq)

Part B: Fill in the formula for the anion

6. NaI(s) → Na^{+1} (aq) + _____
7. LiOH (s) → Li^{+} (aq) + _____
8. $Mg(NO_3)_2$ (s) → Mg^{+2} (aq) + _____
9. MgO (s) → Mg^{+2} (aq) + _____
10. K_2SO_4 (s) → K^{+1} (aq) + _____

Part C: Fill in the formulas for both the cation and anion

11. $AlCl_3$ (s) → _____ + _____
12. CaO (s) → _____ + _____
13. $NiSO_4$ (s) → _____ + _____
14. $CoPO_4$ (s) → _____ + _____
15. NH_4Cl (s) → _____ + _____
16. Cr_2O_3 (s) → _____ + _____
17. $SrSO_3$ (s) → _____ + _____
18. $Mg(OH)_2$ (s) → _____ + _____
19. Na_2SO_4 (s) → _____ + _____
20. $(NH_4)_2CO_3$ (s) → _____ + _____

Unit 3, Activity # ___

Name: _____

Date: _____ Period: ___

Dissociation of Ionic Compounds ®

Part A: Fill in the formula for the cation

1. FeO (s) → _____ + O^{-2} (aq)
2. Na_2S (s) → _____ + S^{-2} (aq)
3. $CaCl_2$ (s) → _____ + $2Cl^{-}$ (aq)
4. $Al_2(SO_3)_3$ (s) → _____ + $3SO_3^{-2}$ (aq)
5. NH_4NO_3 (s) → _____ + NO_3^{-} (aq)

Part B: Fill in the formula for the anion

6. Fe_2O_3 (s) → $2Fe^{+3}$ (aq) + _____
7. KOH (s) → K^{+} (aq) + _____
8. $Mg(NO_3)_2$ (s) → Mg^{+2} (aq) + _____
9. $AlCl_3$ (s) → Al^{+3} (aq) + _____
10. $CuSO_4$ (s) → Cu^{+2} (aq) + _____

Part C: Fill in the formulas for both the cation and anion

11. CuCl (s) → _____ + _____
12. CuO (s) → _____ + _____
13. NiS (s) → _____ + _____
14. Ag_3PO_4 (s) → _____ + _____
15. $ZnBr_2$ (s) → _____ + _____
16. Cr_2O_3 (s) → _____ + _____
17. $SrSO_3$ (s) → _____ + _____
18. $Mg(OH)_2$ (s) → _____ + _____
19. Na_2SO_4 (s) → _____ + _____
20. $(NH_4)_2CO_3$ (s) → _____ + _____

Unit 4a Note Quiz Questions

Unit 4a.2 – Ions

1. Which element is a noble gas?

A Fluorine (F)
B Hydrogen (H)
C Nitrogen (N)
D Xenon (Xe)

2. Atoms of the noble gases are generally inert because —

F they are too large to react
G they are not charged
H they are neutral atoms
J their outer electron levels are filled

Electronegativity Values of Some Atoms

2.1 H						
1.0 Li	1.5 Be	2.0 B	2.5 C	3.0 N	3.5 O	4.0 F
0.9 Na	1.2 Mg	1.5 Al	1.8 Si	2.1 P	2.5 S	3.0 Cl
0.8 K	1.0 Ca				2.4 Se	2.8 Br

3. Three elements, X, Y, and Z, have consecutive increasing atomic numbers. If element X is a noble gas, what will be the symbol for the ion of element Z in its compounds?

F Z^{2-}
G Z^{-}
H Z^{+}
J Z^{2+}

4. Which of the following describes what takes place when iron (Fe°) is oxidized to Fe^{2+} ions?

A A gain of two electrons
B A loss of two electrons
C A gain of two protons
D A loss of two protons

5. Electronegativity differences are often helpful in determining the bond character between two atoms. A general rule states that if the electronegativity difference between two atoms is greater than 1.67, an ionic bond would most likely be formed. Using the chart above, which pair of atoms would probably form the strongest ionic bond?

A Al-P
B Na-Cl
C K-F
D Ca-O

	Protons	Neutrons	Electrons
1	11	12	10
2	1	0	2
3	15	16	15
4	20	20	18

6. Which of these is an ion with a charge of 1+?

A 1
B 2
C 3
D 4

7. **Cations are formed when neutral atoms lose —**

A electrons
B protons
C neutrons
D positrons

8. **A chloride ion (Cl^-) has the same number of electrons as a neutral atom of —**

A fluorine
B sulfur
C argon
D bromine

9. **The correct formula of an ionic compound containing Al^{3+} and CO_3^{2-} is —**

A $AlCO_3$
B $Al(CO_3)_3$
C $Al_2(CO_3)_3$
D $Al_3(CO_3)_2$

Some Selected Polyatomic Ions

Positive Ions		Negative Ions	
Names	Symbols	Names	Symbols
ammonium	NH_4^+	acetate	CH_3COO^-
mercury (II)	Hg^{2+}	cyanide	CN^-
		oxalate	$C_2O_4^{2-}$
		phosphate	PO_4^{3-}
		thiosulfate	$S_2O_3^{2-}$

10. **Using the table above, what is the correct formula for ammonium phosphate?**

F NH_4PO_4
G $(NH_4)_2(PO_4)_3$
H $(NH_4)_3PO_4$
J $NH_4(PO_4)_3$

Unit 4a.3 – Ionic Nomenclature

1. **The correct name for MgI_2 is —**

F magnesium iodide
G magnesium iodite
H magnesium (II) iodide
J magnesium diiodide

2. **What is the correct formula for aluminum chloride?**

A $AlCl_3$
B Al_3Cl
C Al_2Cl_3
D $AlCl$

3. **The formula for lithium nitride is —**

A LiN
B Li_3N
C Li_3N_3
D NLi_3

4. **When ionic compounds are named, the name of a monatomic anion will end in which of the following suffixes?**

A -ic
B -ite
C -ate
D -ide

5. **Which of the following is the correct name for the compound MnF_3?**

A Manganese fluoride(III)
B Manganese(III) fluoride
C Manganese(I) fluoride(III)
D Manganese(III) fluoride(III)

6. **What is the chemical formula for iron(II) phosphide?**

A Fe_2P
B Fe_2P_3
C FeP_2
D Fe_3P_2

7. **When naming a transition metal that has more than one oxidation number, the numeric value of the oxidation number is indicated by a —**

A Roman numeral
B Greek prefix
C subscript
D suffix

8. **The correct name for $Mg_3(PO_4)_2$ is —**

A magnesium phosphite
B trimagnesium phosphate
C magnesium(III) phosphate
D magnesium phosphate

9. What is the name of NH_4OH ?

A Ammonium hydroxide
B Nitrogen oxygen hydride
C Nitrogen hydroxide
D Ammonium oxygen hydride

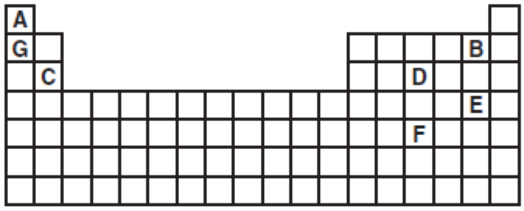
Selected Polyatomic Ions

Name	Formula
Hypochlorite	ClO^-
Chlorite	ClO_2^-
Chlorate	ClO_3^-
Perchlorate	ClO_4^-

10. Chlorine and bromine are in the same family in the periodic table. According to the information in the table above, what would be the correct formula for sodium bromate?

A $NaBrO$
B Na_2BrO
C Na_3BrO_3
D $NaBrO_3$

Unit 4a.4 – Ionic Bonds



1. An alien astronaut landed on Earth and created the periodic table shown. The astronaut was trying to determine what type of bond would be present in several compounds. The type of bond in a compound containing G and E would be —

A a metallic bond
B a nonmetallic bond
C a covalent bond
D an ionic bond

2. Which of these is *most* likely to form between elements transferring electrons to form oppositely charged particles?

A A metallic bond
B A hydrogen bond
C A covalent bond
D An ionic bond

3. Which of these compounds is *most* likely to contain an ionic bond?

F H_2
G SO_2
H CH_4
J $CaCl_2$

4. One example of an ionic compound is —

A F_2
B CO_2
C HBr
D $MgCl_2$

5. **Which compound contains both ionic and covalent bonds?**

F NH_4Cl
G $MgBr_2$
H CH_4
J NH_3

6. Which compounds are classified as electrolytes?

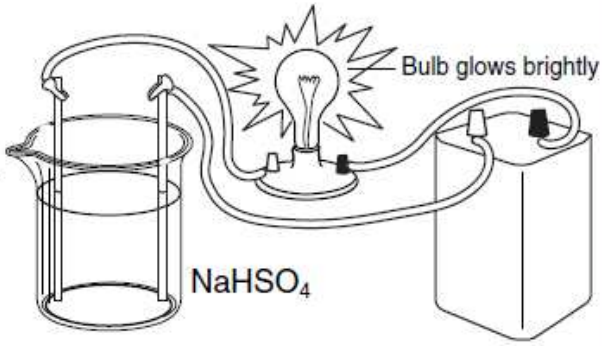
(1) KNO_3 and H_2SO_4
(2) KNO_3 and CH_3OH
(3) CH_3OCH_3 and H_2SO_4
(4) CH_3OCH_3 and CH_3OH

7. **The type of bond found in magnesium chloride is —**

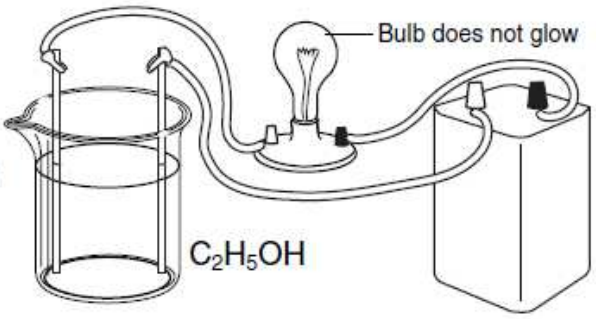
F covalent
G nonpolar
H ionic
J metallic

8. **Which of the following substances is a *weak* electrolyte?**

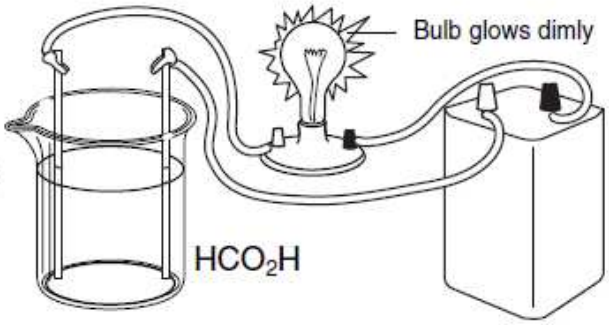
A



B



C



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