AP CHEMISTRY
SUMMER ASSIGNMENT

AP Chemistry is a rigorous science course which incorporates all the topics studied in your first year chemistry class, plus more advanced problems solving in extended areas. The summer assignment is to be a review of three topics you previously studied. It is hoped that you will come prepared with this knowledge so that we can move onto more challenging aspects of the AP course. The worksheets are to be done over the summer and handed in the first day of school. In addition, this material will be tested the first week of school.

The first topic is a general review of the Periodic Table with an emphasis on the names of the elements and their oxidation numbers, plus the names of the groups.

The second topic includes formula writing and naming of compounds. This also includes the memorization of the polyatomic ions and their charges.

The last topic involves reviewing the 5 basic chemical reactions and how to predict the products for these reactions. You will also begin memorizing solubility rules so that you can write net ionic equations.

Topic 1: Periodic Table

One of the most important tools a chemist has is the Periodic Table. Not only does the table display the elements in symbol form, but it has been crafted in such a way that key pieces of data for the elements can be found by knowing a few facts.

Facts:

1) **The Periodic Table is arranged by increasing atomic number and similar chemical and physical properties.**

2) **The atomic number (Z) is the large number on the Periodic Table and is equal to the number of protons in the element. The atomic number is unique for each element …no two elements have the same atomic number. In an atom of each element, the number of electrons will equal the number of protons.**

3) **The Periodic Table consists of 7 periods (the rows) and 18 groups or families (the columns).**

4) **Similarities in periods: The period corresponds to how many principal energy levels (PEL) the electrons occupy in the atom when in its ground state. Ex. Silicon (Si) and Magnesium (Mg) are in period 3 and have 3 energy levels in which their electrons are located.**

5) **Similarities in groups: Elements in the same group have similar chemical and physical properties because they have the same number of valence electrons.**
   Valence electrons – the electrons in the outermost energy level.
   Ex. Fluorine (F) and chlorine (Cl) both have 7 valence electrons.

6) **Names of the Groups and Number of Valence Electrons:**
   Group 1 - Alkali metals - 1 valence electron
   Group 2 - Alkaline earth metals - 2 valence electrons
   Group 13 - - 3 valence electrons
   Group 14 - - 4 valence electrons
   Group 15 - - 5 valence electrons
   Group 16 - Chalcogens - 6 valence electrons
   Group 17 - Halogens - 7 valence electrons
   Group 18 - Noble Gases - 8 valence electrons
   (8 valence electrons are the most stable arrangement of electrons)
   Group 3 – 11 are the Transition Elements; they often have multiple oxidation numbers and form colored compounds.

7) The <u>atomic mass</u> is the weighted average of the element's isotopes. The <u>mass number</u> is the sum of the protons and neutrons. It is written as a superscript or after the element: ^{14}C or Carbon-14

8) <u>Metals, Nonmetals and Metalloids:</u>

Metals – elements located to the left of the staircase; these elements tend to lose electrons. They are good conductors, shiny, malleable and ductile. They are solids except for liquid mercury.

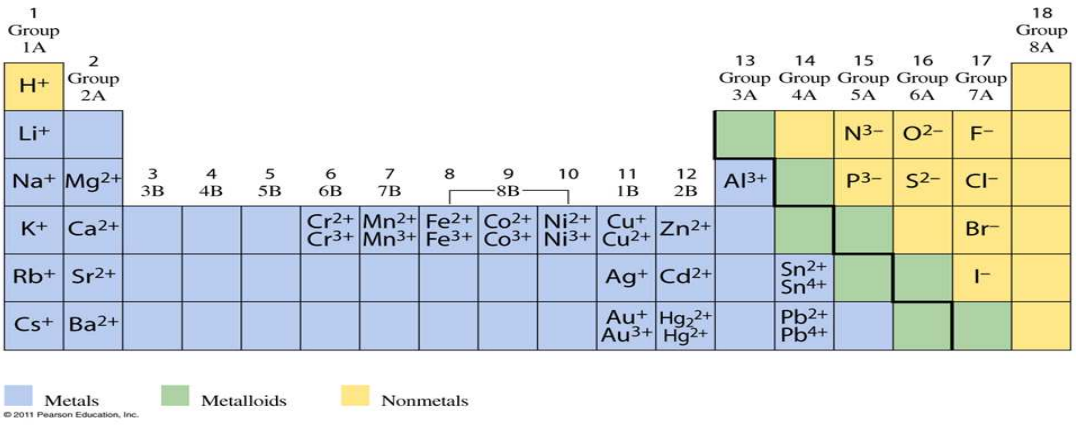
Nonmetals – elements located to the right of the staircase, plus Hydrogen; they share or gain electrons. Nonmetals can be solids, liquid (Br_2) or gases. They are brittle and are poor conductors of electricity.

Metalloids – elements located on the staircase that have properties of both metals and nonmetals. (B, Si, Ge, As, Sb, Te, Po, At)

9) <u>Oxidation numbers (oxidation states):</u> Oxidation numbers are values which indicate what the element does when it bonds in order to achieve its stable electron configuration.

If the oxidation number is 0 – no bonding occurs; if it is +, the element tends to lose its electrons when bonding; if it is -, the element will tend to gain or attract electrons when bonding.

Elements can have one oxidation number or multiple oxidation numbers…they bond in a variety of ways. You need to be able to figure out the oxidation number of the elements. In the table below notice Group 1 has +1, Group 2 is +2, Group 13 is +3, Group 15 is -3, Group 16 is -2, Group 17 is -1 and Group 18 is usually 0.



Periodic Table Questions

1. The elements in the Periodic Table are arranged according to _____.
2. What is the name of Group 17? _____
3. What is unique about the Noble Gases?
   _____
4. What is the typical oxidation number of oxygen? _____
5. How many valence electrons do the alkaline earth metals have? ___
6. Give 2 unique properties of Transition Elements:
   _____
   _____
7. An element is a gas at room temperature. It could be a Metal/ Nonmetal/ Metalloid.
8. What do elements in the same group have in common?
   _____
9. How many Energy levels do strontium and iodine have? _____
10. Which element is located in Period 4, group 2? _____
11. Name an element that has similar properties to sodium. _____
12. State a property of cobalt._____
13. Cobalt has a total of _____ protons.
14. What is the number of protons and neutrons in carbon-14? _____
15. How many valence electrons are in silicon? _____
16. An element with an oxidation number of -3 has _____valence electrons.
17. Which group has all three phases of matter at room temperature?
    _____

TOPIC 2: Formula Writing and Naming

1) A chemical formula indicates the elements and the amounts of each element that bond to form a compound.

Ex. $BaCl_2$ - 1barium ion combines with 2 chloride ions. The lower-case numbers are called SUBSCRIPTS and indicate the ratio between the elements.

2) An ionic compound's formula can be recognized since it consists of a metal and a nonmetal; or a polyatomic ion will be present. Ionic compounds are classified as salts. Ex: KBr , $Al_2(SO_4)_3$

Polyatomic Ions: a group of covalently bonded atoms that have an overall charge. You will have to memorize the polyatomic ions and their charges. These charges will act as the oxidation number when bonding. To help in memorizing, notice that ions made with the same elements tend to have the same charge. (NO_3 is -1, NO_2 is -1)

Selected Polyatomic Ions

NH_4+	ammonium	NO_2^-	nitrite
$C_2H_3O_2^-$	acetate	NO_3^-	nitrate
$CH_3COO–$}		O_2^{2-}	peroxide
CN^-	cyanide	OH^-	hydroxide
CO_3^{2-}	carbonate	PO_4^{3-}	phosphate
HCO_3^-	hydrogen carbonate	PO_3^{3-}	phosphite
$C_2O_4^{2-}$	oxalate	MnO_4^-	permanganate
ClO^-	hypochlorite	SCN^-	thiocyanate
ClO_2^-	chlorite	SO_3^{2-}	sulfite
ClO_3^-	chlorate	SO_4^{2-}	sulfate
ClO_4^-	perchlorate	HSO_4^-	hydrogen sulfate
CrO_4^{2-}	chromate	$S_2O_3^{2-}$	thiosulfate
$Cr_2O_7^{2-}$	dichromate		

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3) A covalent or molecular compound's formula consists or 2 or more nonmetals (no polyatomic ions are present). Covalent compounds are classified as molecules.

4) Compounds can be classified as binary compounds, made of 2 elements (H_2S) or those that contain more than 2 different elements (Ex. 3 elements would be called a ternary compound – HNO_3)

5) A compound does not have a charge and the sum of its oxidation numbers must add up to 0.

6) Important formula facts:
   a) Elements are represented by their symbol: copper = Cu
   b) Certain elements exist as a pair when they are not combined with another element. These are the BrINClHOF's. Bromine = Br_2 (bromine, iodine, nitrogen, chlorine, hydrogen, oxygen, fluorine)
   c) The + oxidation numbered element is written first in a formula, the – oxidation numbered element is second. One exception is NH_3.
   d) Sum of the oxidation numbers must equal zero in a compound.

TO WRITE THE FORMULA OF A COMPOUND

1. Write the + oxidation numbered element first (if a metal is present, this is it); then write the – oxidation numbered element (a nonmetal) or polyatomic ion.
2. Write the oxidation numbers above them.
3. Two methods to get final formula.

   a) Criss-cross the oxidation numbers so that they become the subscript of the other element. ***Make sure to use parentheses if a polyatomic ion gets a subscript larger than 1.
   Reduce subscripts to lowest terms.

   b) Adjust the number of elements so that the sum of the oxidation numbers add up to zero.
   Ca^{+2} Cl^{-1} You need 2 Cl^{-1} so that +2 + 2(-1) = 0 → $CaCl_2$
   Cr^{+3} SO_4^{-2} Least common multiple is 6, so 2(+3) + 3(-2) = 0
   ➔ $Cr_2(SO_4)_3$

TO NAME A COMPOUND using IUPAC

1. **Write the name of the first element.**
   Monatomic substances
   ***univalent (only one oxidation state): the ion is named the same as the element**
   Na = sodium; Na^{+1} = sodium
   Ba = barium; Ba^{+2} = barium
   ***polyvalent (multiple oxidation states): a roman numeral indicates the oxidation state**
   Fe^{+2} = iron II; Fe^{+3} = iron III
   Cu^{+1} = copper I; Cu^{+2} = copper II
   C^{+2} = carbon II; C^{+4} = carbon IV
   ***Polyatomic metal ions: Use the Table above.**
   NH_4^{+1} = ammonium

2. **Leave a space. (This space may get filled by a Roman numeral if the metal has more than one oxidation number.)**

3. **a) In binary compounds, change the ending of the name of the second element to –IDE.**
   Ex. K_3N potassium nitride
   The nonmetal always comes last in the name and in the formula
   *** Monatomic nonmetal ions - delete the last part of the elements name and add "IDE"**
   S = sulfur; S^{-2} = sulfIDE
   O = oxygen; O^{-2} = oxIDE
   I = iodine; I^{-1} = iodIDE
   ***Polyatomic nonmetal ions: Look on Table, write its name down without altering it.**
   SO_4^{-2} = sulfate
   OH^- = hydroxide
   Ex. $Ca(NO_3)_2$ calcium nitrate

4. **Check to see if the metal has more than one oxidation number.**
   a) If there is only ONE – you are DONE.
   b) If there is more than one oxidation number – you must use a Roman numeral which indicates the oxidation number used.
   Ex. $CuCl_2$ copper (II) oxide
   $Au(C_2H_3O_2)_3$ gold (III) acetate

5. **Alternative Method of Naming MOLECULAR compounds by the method of prefixes.**

**********BEWARE***********

THIS CAN ONLY BE DONE WITH MOLECULAR COMPOUNDS

1. **Name the first element**
2. **The second element's ending will be changed to –IDE**
3. **Prefixes will be used to indicate the number of each element in the formula, even when there is only one atom. The exception is when there is one atom of the first element.**
   - **CO - carbon monoxide**
   - **CO_2 - carbon dioxide**
   - **N_2O_5 - dinitrogen pentoxide (*NOTE:* the "a" in penta is dropped to avoid putting two vowels together)**
   - **SO_3 - sulfur trioxide**
   - **$SiCl_4$ - silicon tetrachloride**

Number of Atoms	Prefix
1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

NAMING ACIDS AND BASES

Acids are substances which produce H^+ or H_3O^+ in water. They are easily recognized by their formula – they will have a H^+ written first or if it is an organic acid, it will have the –COOH functional group. Ex. $HCl_{(aq)}$

You need to know the 7 strong acids. These are acids that ionize completely in water. They are HCl, HBr, HI, H_2SO_4, HNO_3, $HClO_4$ and $HClO_3$. (BrIClO-NO-SO-34)

Bases are substances which produce hydroxide ions (OH^-) in water. They can be recognized because they have the OH^- in their formula. Ex. KOH They can be remembered by the "b" they make on the Periodic Table using Group 1 and 2.

Naming:

Bases – name the same as any other ionic compound.

Acids –

a) **Binary acids: H^+ and one other element….ex. $H_2S_{(aq)}$**
   To name: use the prefix hydro change the –ide ending to ic and add the word acid.
   Ex. $H_2S_{(aq)}$ – hydrosulfuric acid $HBr_{(aq)}$ – hydrobromic acid
b) **Ternary Acids: Acids that contain a polyatomic ion….ex.$HNO_{3(aq)}$**
   To name: ATE-IC ITE-OUS Acid

If the polyatomic ion ends in ATE – change the ending to IC ACID
SO_4^{-2} sulfate so H_2SO_4 becomes sulfuric acid
If the polyatomic ion ends in ITE – change the ending to OUS ACID
ClO_2^{-1} chlorite so $HClO_2$ becomes chlorous acid

Naming Complexes

A complex ion is a charged species consisting of a metal ion (usually a transition metal ion) surrounded by ligands. A ligand is simply a Lewis base – a molecule or ion having a lone electron pair that can be donated to an empty orbital on the metal ion to form a covalent bond. The number of ligands attached to a metal ion is called the coordination number.

The most common ligands and their names are:

H_2O	- aqua	OH^-	- hydroxo
NH_3	- ammine	Cl^-	- chloro
CN^-	- cyano	Br^-	- bromo

How do you get the coordination number? It is usually twice the cation charge. (The coordination number is not higher than 6)

To name a complex ion:

1. **The ligands are named before the metal ion.**
2. **The prefixes mono-, di-, tri-, tetra-, penta-, amd hexa- are used to denote the number of simple ligands.**
3. **The oxidation state of the central metal ion is designated by a Roman numeral in parentheses.**
4. **When there is more than one ligand, they are named alphabetically.**
5. **If the complex ion has a negative charge, the suffix -ate is added to the name of the metal.**

Example: $[Fe(NH_3)_5Cl]^{+2}$ pentamminechloroiron (III) ion
$Co(CN)_6^{-3}$ hexacyanocobaltate(III) ion

Naming Ionic Compounds

Give the name of the following ionic compounds:

Name

1) Na_2CO_3 _____

2) NaOH _____

3) $MgBr_2$ _____

4) KCl _____

5) $FeCl_2$ _____

6) $FeCl_3$ _____

7) $Zn(OH)_2$ _____

8) $BeSO_4$ _____

9) CrF_2 _____

10) Al_2S_3 _____

11) PbO _____

12) Li_3PO_4 _____

13) TiI_4 _____

14) Co_3N_2 _____

15) Mg_3P_2 _____

16) $Ga(NO_2)_3$ _____

17) Ag_2SO_3 _____

18) NH_4OH _____

19) $Al(CN)_3$ _____

20) $Be(CH_3COO)_2$ _____

Writing Formulas

1) potassium fluoride _____

2) ammonium sulfate _____

3) magnesium iodide _____

4) copper (II) sulfide _____

5) aluminum phosphate _____

6) lead (II) nitrite _____

7) cobalt (II) selenide _____

8) silver cyanide _____

9) copper (II) bicarbonate or copper (II) hydrogen carbonate _____

10) iron (II) oxide _____

11) lithium carbonate _____

12) lead (IV) sulfite _____

13) chromium III carbonate _____

14) calcium sulfide _____

15) iron III oxide _____

16) ammonium nitrate _____

17) potassium oxalate _____

18) aluminum acetate _____

19) strontium phosphide _____

20) tin IV oxide _____

Naming Covalent Compounds Worksheet

Write the formulas for the following covalent compounds:

1) antimony tribromide _____

2) tetraboron trisilicide _____

3) chlorine dioxide _____

4) hydrogen iodide _____

5) iodine pentafluoride _____

6) dinitrogen trioxide _____

7) ammonia _____

8) phosphorus triiodide _____

*Write the names for the following covalent compounds using **both** IUPAC **and** prefixes:*

9) P_2S_5 _____

10) CO_2 _____

11) SeF_6 _____

12) Si_2Br_6 _____

13) SCl_4 _____

14) CH_4 _____

15) N_2O_5_____

16) NF_3 _____

Naming Acids and Complex Ions

Write the names for the following acids and complex ions.

1. $HClO_{(aq)}$ _____
2. $FeCl_4^-$ _____
3. $Ni(NH_3)_6^{2+}$ _____
4. $H_3PO_{4(aq)}$ _____
5. $H_2C_2O_{4(aq)}$ _____
6. $Al(OH)_4^-$ _____
7. $HI_{(aq)}$ _____

Write the formulas for the following acids and complex ions.

1. Hydrochloric acid _____
2. Chloric acid _____
3. hydrosulfuric acid _____
4. nitrous acid _____
5. carbonic acid _____
6. acetic acid _____
7. hexaquairon(III) ion _____
8. tetracyanonickelate(II) ion _____
9. tetraamminedichloroplatinum(IV) ion_____

Topic 3: Identifying Reaction Types

A chemical reaction indicates how substances undergo chemical changes. The parts to a chemical reaction are shown below.

Reactants → Products

$$2\ Na_{(s)} + 2\ H_2O_{(l)} \rightarrow 2\ NaOH_{(aq)} + H_{2(g)}$$

The large number in front of a formula is called the COEFFICIENT, which indicates how many of that substance are present. The lower-case number IN the formula is the SUBSCRIPT which is determined when the formula is written. The phases of matter can also be indicated. (s = solid, l = liquid, g = gas, aq = aqueous solution)

Chemical reactions can be grouped into five basic types. They are synthesis, decomposition, single replacement, double replacement and complete combustion. You will also be expected to write a complex ion formation equation.

1. **Synthesis**: results in the formation of one product from 2 or more reactants.

   $$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$$

2. **Decomposition** : the reverse of synthesis. One reactant breaks apart to form several products.

   $$2\ H_2O_{2(aq)} \rightarrow 2\ H_2O_{(l)} + O_{2(g)}$$
   $$2\ KClO_3 \rightarrow KCl + 3\ O_2$$

3. **Single replacement** : a more active metal replaces a less active metal in a compound, or a more active nonmetal replaces a less active nonmetal in a compound. In single replacement reaction, an element is reacting with a compound to produce a new element and new compound. (Least reactive metals – Cu, Ag, Au, Hg, Pt)

   $$2Fe(s) + 6HCl(aq) \rightarrow 2FeCl_{3(aq)} + 3H_{2(g)}$$

4. **Double replacement** : reactions occur between aqueous compounds. The cations and anions switch partners. If an insoluble precipitate forms, the reaction occurs otherwise the result is an aqueous mixture of ions.

   In double replacement reactions, two compounds form two new product compounds.

   $$AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$$

   Special case of a double replacement reaction is the acid-base **neutralization reaction**. (An acid will have H^{+1} in formula and a base will have OH^{-1} in formula)

$HCl_{(aq)} + NaCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O$

Special cases: If the following substances are formed, an additional reaction occurs. You must REMEMBER to do these.

$H_2CO_{3(aq)} \rightarrow H_2O + CO_2$
$NH_4OH_{(aq)} \rightarrow NH_{3(g)} + H_2O$
$H_2SO_{3(aq)} \rightarrow SO_{2(g)} + H_2O$

SOLUBILITY RULES

Soluble:

- All Nitrates (NO_3^{-1}), Acetates ($C_2H_3O_2^{-1}$), Ammonium (NH_4^{+1}), and Group 1 (IA) salts
- All Chlorides (Cl^{-1}), Bromides (Br^{-1}), and Iodides (I^{-1}), except Silver, Mercury(I) and Lead(II)
- All Fluorides (F^{-1}) except Group 2 (IIA), Lead(II), and Iron(III)
- All Sulfates (SO_4^{-2}) except Calcium, Strontium, Barium(to remember think CBS), Mercury, Lead(II), and Silver

Insoluble (0.10 *M* or greater):

- All Carbonates (CO_3^{-2}) and Phosphates (PO_4^{-3}) except Group 1 (IA) and Ammonium
- All Hydroxides (OH^{-1}) except Group 1 (IA),Strontium, Barium, and Ammonium (Calcium hydroxide is slightly soluble)
- All Sulfides (S^{-2}) except Group 1 (IA),2 (IIA), and Ammonium
- All Oxides (O^{-2}) except Group 1 (IA)

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5. **Combustion:** Complete combustion or burning has a fuel combining with oxygen gas to form CO_2 and H_2O.

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O$

6. **Complex Ion Formation:** Most of these reactions can be recognized by the choice of reactants –generally a transition metal ion (or the amphoteric species form Group13 – Al) and a source of ligands. The key to recognizing such a reaction is often the word "excess" or concentration indicating that enough of the complexation agent has been added.

Example: A concentrated solution of ammonia is added to a solution of copper (II)chloride

$4\ NH_3 + Cu^{2+} \rightarrow [Cu(NH_3)_4]^{2+}$

Excess concentrated potassium hydroxide solution is added to a precipitate of zinc hydroxide

$2\ OH^- + Zn(OH)_2 \rightarrow [Zn(OH)_4]^{2-}$

LEGEND

Synthesis

$A + B \rightarrow AB$

Decomposition

$AB \rightarrow A + B$

Single Replacement

$AB + C \rightarrow CB + A$ *or*

$AB + D \rightarrow AD + B$

Double Replacement (Exchange of Ions)

$AB + CD \rightarrow AD + CB$

Combustion

$Fuel + O_2 \rightarrow CO_2 + H_2O$

***** It is imperative you know your solubility rules plus the strong acids in order to ionize the substances properly. You need to start memorizing the solubility rules and the strong acids in order to do this.

Also start memorizing the polyatomic ions and their charges.

Six Types of Chemical Reaction Worksheet

For each of the reactions shown below, identify the type of reaction.

1. $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI(s) + 2KNO_3(aq)$ _____

2. $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$ _____

3. $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3\ NaCl(aq)$ _____

4. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ _____

5. $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$ _____

6. $H_2O(l) + N_2O_5(g) \rightarrow 2HNO_3(aq)$ _____

7. $Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(l)$ _____

8. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ _____

9. $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$ _____

10. $2\ NaBr + Ca(OH)_2 \rightarrow CaBr_2 + 2\ NaOH$ _____

11. $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ _____

12. $4\ C_5H_9O + 27\ O_2 \rightarrow 20\ CO_2 + 18\ H_2O$ _____

13. $3\ Pb + 2H_3PO_4 \rightarrow 3\ H_2 + Pb_3(PO_4)_2$ _____

15. $3\ HBr + Al(OH)_3 \rightarrow 3H_2O + AlBr_3$ _____

Reaction Products Worksheet

For each of the following reactions, determine what the products of each reaction will be. When you have predicted the products, balance the equation and use a table of solubility products to determine which of the double replacement products (if any) will precipitate. Use the solubility rules. Assume all reactions take place in water.

1) ____ $Ca(OH)_2$ + ____ HF →

2) ____ Pb+ ____ Ag_2 CrO4 →

3) ____ $NaC_2H_3O_2$ + ____ H_2SO_4 →

4) ____ $Cu(OH)_2$ + ____ H_3PO_4 →

5) ____ $AgNO_3$ + ____ Na_2CO_3 →

6) ____ Zn + ____ H_2CO_3 →

7) ____ $Pb(OH)_2$ + ____ Hg_2S →

8) Cl_2 + K →

9) $Ca(ClO_3)_2$ →

10) A solution of iron (III) chloride reacts with a solution of potassium phosphate

11) Aluminum metal reacts with hydrochloric acid

12) Magnesium oxide decomposes

13) Nitric acid reacts with solid sodium carbonate

14) Octane undergoes combustion