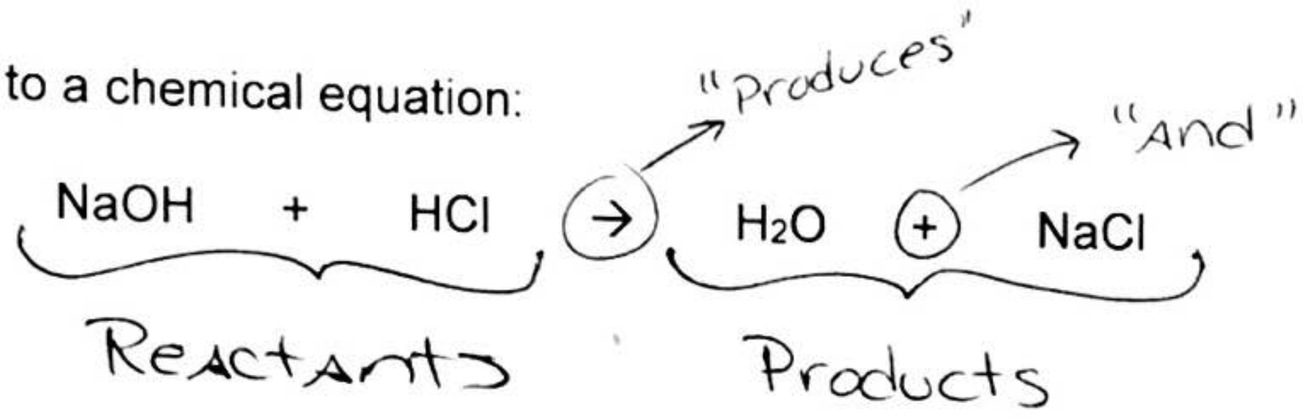
Chemical Equations: Part 2

There are two parts to a chemical equation:



Energy & Reactions: In a chemical reaction, energy is either released or absorbed. (Table I)

Exothermic Reaction: Releases energy / heat

"Heat of Reaction"

*Burning (combustion); The reaction feels warm.

* ΔH is Negative

* "HEAT" of an amount of heat is written on the PRODUCT side of the reaction.
Ex $H_2 + O_2 \rightarrow H_2O$ + Heat

Endothermic Reaction: Absorbs energy / heat

*Chemical ice pack; The reaction feels cooler.

* ΔH is Positive

* "HEAT" / amount of heat is written on the REACTANT side of the reaction.

Highlight

***3 parts of Table I → Combustion, Synthesis, Dissolving in Water

Question: *Write down an example of each type of reaction on Table I that is EXOTHERMIC and ENDOTHERMIC.*

EXOTHERMIC	ENDOTHERMIC
C:	C:
S:	S:
D:	D:

TYPES OF CHEMICAL EQUATIONS

Synthesis: A + B → AB

*Substances combine to produce a single product

Example: $2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$

Decomposition: AB → A + B

*Single reactant breaks down into multiple products
*Mostly endothermic (required energy)

Example: $CuCO_3\,(s) \rightarrow CO_2\,(g) + CuO\,(s)$

Single Replacement: A + BC → B + AC

*Single element replaces a cation in the compound

* Element + Comp. → Element + Comp.

Example: $Mg\,(s) + 2HCl\,(aq) \rightarrow MgCl_2\,(aq) + H_2\,(g)$

Double Replacement: AB + CD → AD + CB

*Cations trade places

* 2 compounds ↔ 2 compounds

Example: $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

Introduction to Chemical Reactions & Types of Chemical Reactions

Identify the *reactants & products* for each of the following chemical reactions, then identify the *type of reaction (synthesis, decomposition, single replacement, double replacement)*

1. $AlCl_3 + LiOH \rightarrow Al(OH)_3 + LiCl$

Reactants $AlCl_3$, $LiOH$ Products $Al(OH)_3$, $LiCl$

Type of reaction Double replacement

2. $Ag_2O \rightarrow Ag + O_2$

Reactants Ag_2O Products Ag, O_2

Type of reaction Decomposition

3. $AlF_3 + K_2SO_4 \rightarrow KF + Al_2(SO_4)_3$

Reactants AlF_3, K_2SO_4 Products KF, $Al_2(SO_4)_3$

Type of reaction Double replacement

4. $CaCl_2 + K_3P \rightarrow Ca_3P_2 + KCl$

Reactants $CaCl_2$, K_3P Products Ca_3P_2, KCl

Type of reaction Double replacement

5. $C_6H_{12}O_6 \rightarrow C + H_2O$

Reactants $C_6H_{12}O_6$ Products C, H_2O

Type of reaction Decomposition

6. $Fe(OH)_3 \rightarrow Fe_2O_3 + H_2O$

Reactants $Fe(OH)_3$ Products Fe_2O_3, H_2O

Type of reaction Decomposition

7. $Fe + O_2 \rightarrow Fe_2O_3$

Reactants Fe, O_2 Products Fe_2O_3

Type of reaction Synthesis

8. $Al(OH)_3 \rightarrow Al_2O_3 + H_2O$

Reactants $Al(OH)_3$ Products Al_2O_3 , H_2O

Type of reaction Decomposition

9. $(NH_4)_3PO_4 + Mg(NO_3)_2 \rightarrow Mg_3(PO_4)_2 + NH_4NO_3$

Reactants $(NH_4)_3PO_4$, $Mg(NO_3)_2$ Products $Mg_3(PO_4)_2$, NH_4NO_3

Type of reaction Double replacement

10. $Ca + HCl \rightarrow CaCl_2 + H_2$

Reactants Ca, HCl Products $CaCl_2$, H_2

Type of reaction Single replacement

Chemistry: Form WS5.4.1A Name Answers

CHEMICAL FORMULAS AND EQUATIONS Date _____ Period ____

Identifying Reaction Types

Chemical reactions can be grouped into four basic types. They are direct combination or synthesis, decomposition, single replacement or substitution, and double replacement or exchange of ions.

An example of **synthesis** is shown below:

$$\mathbf{N_2}(g) + \mathbf{3H_2}(g) \xrightarrow[\Delta]{catalyst} \mathbf{2NH_3}(g)$$

Synthesis often results in the formation of only one product from two reactants, but not always. Combustion, as in the following example, $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O$, is also a form of synthesis because the oxygen combines with both the metal and the nonmetal to form two oxides.

Decomposition is the reverse of synthesis. One reactant breaks apart to form several products. This is what happens when hydrogen peroxide decomposes over time to leave behind plain, ordinary water [$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$].

During a **single replacement** reaction, 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. This is what happens when a metal becomes corroded by an acid [$2Fe(s) + 6HCl(aq) \rightarrow 2FeCl_3(aq) + 3H_2(g)$]. In single replacement reactions, an element is reacting with a compound.

Double replacement reactions occur between aqueous compounds. The cations and anions switch partners. If an insoluble precipitate forms, the reaction is an end reaction, otherwise the result is an aqueous mixture of ions. An example of a double replacement reaction is $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$.

Patterns of the Reaction Types

Legend:

- **A** and **C** = *metals*
- **B** and **D** = *nonmetals*

— ◆ —

Direct combination (synthesis)

A + B → AB *or*

AB + D → AD + BD

Decomposition

AB → A + B

Single Replacement (substitution)

AB + C → CB + A *or*

AB + D → AD + B

Double Replacement (Exchange of Ions)

AB + CD → AD + CB

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

1. $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$ ..... Double Rep.
2. $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$ ..... Single Rep.
3. $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$ .... Double Rep.
4. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ ..... Synthesis
5. $H_2CO_3(aq) \rightarrow H_2O(\ell) + CO_2(g)$ ..... Decomposition
6. $H_2O(\ell) + N_2O_5(g) \rightarrow 2HNO_3(aq)$ ..... Synthesis
7. $Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(\ell)$ ..... Single Rep.
8. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ ..... Decomp.
9. $2K(s) + 2H_2O(\ell) \rightarrow 2KOH(aq) + H_2(g)$ ..... Single Rep.

BALANCING EQUATIONS

Why Balance Equations??? *We have to show conservation of matter by balancing the number of elements.*

* Subscripts CANNOT be added or changed

<u>*ONLY</u> coefficients can be added to multiply the elements in the compounds

STEPS FOR BALANCING EQUATIONS:

$Al_{(s)} + O_{2(g)} \rightarrow Al_2O_3$

$1 = Al = 2$

$2 = O = 3$

1) Count the number of Atoms of each element. Set-up A chart.

<u>2</u> $Al_{(s)} + O_{2(g)} \rightarrow Al_2O_3$

$2X = Al = 2$

$2 = O = 3$

2) Add coefficients to the formulas to multiply each element by that value.

Adjust #'s on table AS needed.

<u>4</u> $Al_{(s)} + \underline{3}O_{2(g)} \rightarrow \underline{2}Al_2O_3$

$2X = Al = 4$

$6 \quad O = 6$

3) Continue until the # of Atoms is equal from reactant to product side.

Things that might help you…

*Start with elements that are found in compounds on both sides.

*Finish with elements that are uncombined; You will not affect other atoms with your last coefficient written.

*If a polyatomic ion <u>does not</u> break apart, you can count it as one ion.

Chemistry: Form WS5.5.3A

Name Answers

CHEMICAL FORMULAS and EQUATIONS

Date _____ Period ____

Balancing Equations & Identifying Reaction Types

Balance the equations below by writing coefficients greater than one in front of the formulas where needed. Identify the reaction type in the answer space to the left of the equation [*Synthesis* (S), *Decomposition* (D), *Single Replacement* (SR), or *Double Replacement* (DR)].

SR **1.** $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2\uparrow$

SR **2.** $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2\uparrow$

S **3.** $2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$

S **4.** $N_2 + 3H_2 \rightarrow 2NH_3$

S **5.** $3H_2O + P_2O_5 \rightarrow 2H_3PO_4$

D **6.** $NH_4NO_2 \xrightarrow{\Delta} 2H_2O + N_2\uparrow$

DR **7.** $3Ba(NO_3)_2 + Fe_2(SO_4)_3 \rightarrow 3BaSO_4\downarrow + 2Fe(NO_3)_3$

DR **8.** $ZnCl_2 + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2AgCl\downarrow$

S **9.** $Na_2O + H_2O \rightarrow 2NaOH$

DR **10.** $3NiCO_3 + 2Al(OH)_3 \rightarrow 3Ni(OH)_2 + Al_2(CO_3)_3$

D **11.** $Ca(ClO_3)_2 \xrightarrow{\Delta} CaCl_2 + 3O_2\uparrow$

SR **12.** $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2\uparrow$

Name_____

Date_____

Chemistry Worksheet

Balancing Equations

REACTION TYPES
Double Replacement(Exchange of ions)
Single Replacement
Direct Union(Synthesis)
Decomposition

BALANCE THESE EQUATIONS AND INDICATE THE TYPE OF REACTION

1. $2AgNO_3 + Cu \longrightarrow 2Ag + Cu(NO_3)_2$ → Single Rep.

2. $S + O_2 \longrightarrow SO_2$ Balanced → Synthesis

3. $2NaBr + Cl_2 \longrightarrow 2NaCl + Br_2$ → Single Rep.

4. $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$ Balanced → Double Rep.

5. $C_6H_{12}O_6 \longrightarrow 6C + 6H_2O$ → Decomposition

6. $H_2S + 2AgCl \longrightarrow Ag_2S + 2HCl$ → Double Rep.

7. $ZnS + 2HCl \longrightarrow H_2S + ZnCl_2$ → Double Rep.

8. $2Mg + O_2 \longrightarrow 2MgO$ → Synthesis

9. $CaCO_3 \longrightarrow CaO + CO_2$ Balanced → Decomposition

10. $2CO + O_2 \longrightarrow 2CO_2$ → Synthesis

11. $N_2 + 3H_2 \longrightarrow 2NH_3$ → Synthesis

12. $CuO + H_2 \longrightarrow H_2O + Cu$ Balanced → Single Rep.

13. $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$ → Double Rep.

14. $2HgO \longrightarrow 2Hg + O_2$ → Decomposition

Chemistry: Form WS5.5.2A

Name Answers

CHEMICAL REACTIONS

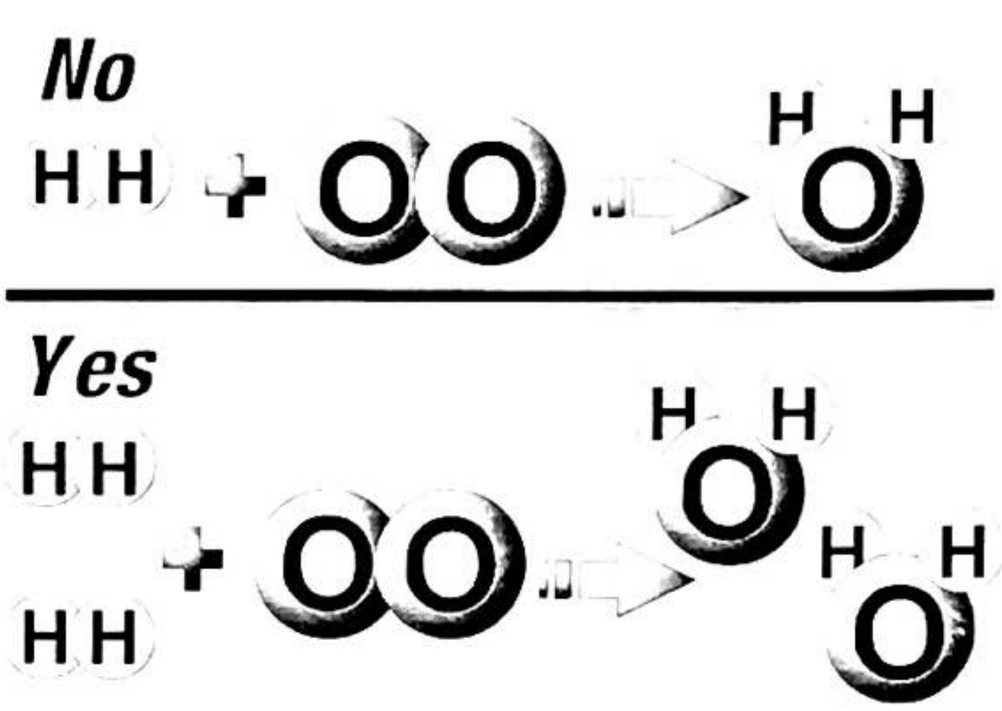
Date _____ Period ____

Balancing Equations

During a chemical change, there is no change in mass. A properly written chemical equation shows this. The equation below is not properly written. It does not show conservation of mass.

$$H_2 + O_2 \rightarrow H_2O$$
$$2 + 32 \neq 18$$

The reason the equation doesn't work is simple. There are two atoms of oxygen in the reactants, but only one in the product. If two molecules of hydrogen react with a molecule of oxygen to form two molecules of water, there are no atoms missing and mass is conserved. The number of molecules is shown with a number to the left of the formula known as a coefficient. A coefficient behaves like a multiplier. It's not necessary to check the mass to get a properly written equation. Counting atoms is sufficient. When the equation for the formation of water is written properly, $2H_2 + O_2 \rightarrow 2H_2O$, there are 4 hydrogen atoms and two oxygen atoms on both sides of the equation and the mass of the reactants is the same as the mass of the products. Making the number of atoms equal on both sides of the equation is all that is needed. The process is called balancing.



$$2H_2 + O_2 \rightarrow 2H_2O$$
$$2(2) + 32 = 2(18)$$

Balance the equations below by writing the correct coefficient in the space before each formula. Coefficient "1" need not be written.

1. ____ H_2 + ____ Cl_2 → 2 HCl
2. ____ $Ca(NO_3)_2$ + ____ H_2SO_4 → ____ $CaSO_4$ + 2 HNO_3
3. 2 Fe + 3 Cl_2 → 2 $FeCl_3$
4. 4 Fe + 3 O_2 → 2 Fe_2O_3
5. ____ Zn + 2 HCl → ____ $ZnCl_2$ + ____ H_2
6. ____ Cu + 2 $AgCH_3COO$ → ____ $Cu(CH_3COO)_2$ + 2 Ag
7. ____ H_2SO_4 + 2 NaOH → ____ Na_2SO_4 + 2 H_2O
8. ____ N_2 + 3 H_2 → 2 NH_3 H(OH)
9. ____ CH_4 + 2 O_2 → ____ CO_2 + 2 H_2O
10. 2 S + 3 O_2 → 2 SO_3

Balancing Equations

Answer Key

1. Which chemical equation is correctly balanced?

A) $H_2(g) + O_2(g) \rightarrow H_2O(g)$

B) $N_2(g) + H_2(g) \rightarrow NH_3(g)$

C) $2NaCl(s) \rightarrow Na(s) + Cl_2(g)$

D) $2KCl(s) \rightarrow 2K(s) + Cl_2(g)$

2. Given the unbalanced equation:

$2\,Al + 3\,CuSO_4 \rightarrow \_\_\, Al_2(SO_4)_3 + 3\,Cu$

When the equation is balanced using the *smallest* whole-number coefficients, what is the coefficient of Al?

A) 1 B) 2 C) 3 D) 4

3. When the equation

$2\,H_2O_2 \rightarrow 2\,H_2O + 1\,O_2$

is completely balanced, the sum of all the coefficients will be

A) 5 B) 8 C) 3 D) 4

4. Given the unbalanced equation:

$\_\_\, Al_2(SO_4)_3 + 3\,Ca(OH)_2 \rightarrow 2\,Al(OH)_3 + 3\,CaSO_4$

What is the coefficient in front of the $CaSO_4$ when the equation is completely balanced with the smallest whole-number coefficients?

A) 1 B) 2 C) 3 D) 4

5. When the equation

$\_\_\, Fe_2O_3(s) + 3\,CO(g) \rightarrow 2\,Fe(l) + 3\,CO_2(g)$

is correctly balanced using the smallest whole numbers, the coefficient of $Fe(l)$ is

A) 1 B) 2 C) 3 D) 4

6. When the equation

$\_\_\, Ca(ClO_3)_2 \rightarrow \_\_\, CaCl_2 + 3\,O_2$

is correctly balanced, the coefficient in front of the O_2 will be

A) 1 B) 2 C) 3 D) 4

Balancing Equations

7. When the equation

$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

is completely balanced using the smallest whole numbers, the coefficient of the O_2 will be

A) 1 B) 2 C) 3 D) 4

8. Which equation is correctly balanced?

A) $CaO + 2H_2O \rightarrow Ca(OH)_2$

B) $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

C) $Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3H_2O$

D) $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2O + SO_2$

9. Given the unbalanced equation:

$\_\_ C_3H_8(g) + \_5\ O_2(g) \rightarrow \_4\ H_2O(g) + \_3\ CO_2(g)$

When the equation is completely balanced using smallest whole numbers, the coefficient of O_2 is

A) 5 B) 2 C) 3 D) 10

Formula & Equations Review

A 1. Every water molecule has two hydrogen atoms bonded to one oxygen atom. This fact supports the concept that elements in a compound are

A) chemically combined in a fixed proportion
B) chemically combined in proportions that vary
C) physically mixed in a fixed proportion
D) physically mixed in proportions that vary

D 2. Which formula represents strontium phosphate? Sr^{+2} PO_4^{-3}

A) $SrPO_4$ B) Sr_3PO_8
C) $Sr_2(PO_4)_3$ **D) $Sr_3(PO_4)_2$**

C 3. The compound *X*Cl is classified as ionic if *X* represents the element Metal + Nonmetal

A) H B) I **C) Rb** D) Br

B 4. What is the chemical formula for iron(III) oxide? Fe^{+3} O^{-2}

A) FeO **B) Fe_2O_3**
C) Fe_3O D) Fe_3O_2

A 5. In which compound is the ratio of metal ions to nonmetal ions 1 to 2?

A) calcium bromide (Ca^{+2} Br^{-1}) B) calcium oxide (Ca^{+2} O^{-2})
C) calcium phosphide (Ca^{+2} P^{-3}) D) calcium sulfide (Ca^{+2} S^{-2})

A 6. Which group on the Periodic Table of the Elements contains elements that react with oxygen to form compounds with the general formula X_2O? $X^{?}$ O^{-2} X^{+1}

A) Group 1 B) Group 2
C) Group 14 D) Group 18

C 7. What is the total number of different elements present in NH_4NO_3?

A) 7 B) 9 **C) 3** D) 4

B 8. What is the chemical formula for sodium sulfate? Na^{+} SO_4^{-2}

A) Na_2SO_3 **B) Na_2SO_4**
C) $NaSO_3$ D) $NaSO_4$

D 9. What is the chemical formula for copper(II) hydroxide? Cu^{+2} OH^{-}

A) CuOH B) $CuOH_2$
C) $Cu_2(OH)$ **D) $Cu(OH)_2$**

B 10. Which formula correctly represents the composition of iron (III) oxide? Fe^{+3} O^{-2}

A) FeO_3 **B) Fe_2O_3**
C) Fe_3O D) Fe_3O_2

B 11. The chemical formula for nickel (II) bromide is Ni^{+2} Br^{-1}

A) Ni_2Br **B) $NiBr_2$**
C) N_2Br D) NBr_2

B 12. Atoms of metals tend to

A) lose electrons and form negative ions
B) lose electrons and form positive ions
C) gain electrons and form negative ions
D) gain electrons and form positive ions

B 13. If *M* represents an element in Group 2, the formula of its chloride would be M^{+2} Cl^{-1}

A) *M*Cl **B) MCl_2**
C) M_2Cl D) M_2Cl_2

D 14. Which is the formula for the compound that forms when magnesium bonds with phosphorus? $^{+2}$ $^{-3}$

A) Mg_2P B) MgP_2
C) Mg_2P_3 **D) Mg_3P_2**

A 15. What is the IUPAC name for the compound $^{+2}\,^{-2}$ZnO?

A) zinc oxide B) zinc oxalate
C) zinc peroxide D) zinc hydroxide

B 16. What is the chemical formula of iron^{+3}(III) sulfide^{-2}?

A) FeS **B) Fe_2S_3**
C) $FeSO_3$ D) $Fe_2(SO_3)_3$

C 17. Which formula represents copper^{+1}(I) oxide^{-2}?

A) CuO B) CuO_2
C) Cu_2O D) Cu_2O_2

D 18. What is the name of the polyatomic ion in the compound Na_2O_2? O_2^{-2}

A) hydroxide B) oxalate
C) oxide **D) peroxide**

A 19. Which formula represents lead^{+2}(II) chromate^{-2}?

A) $PbCrO_4$ B) $Pb(CrO_4)_2$
C) Pb_2CrO_4 D) $Pb_2(CrO_4)_3$

C 20. What is the IUPAC name for the compound $^{-2}$FeS? Fe^{+2}

A) iron(II) sulfate B) iron(III) sulfate
C) iron(II) sulfide D) Iron(III) sulfide

Formula & Equations Review

A 21. What is the formula of titanium(II) oxide?

A) TiO B) TiO_2
C) Ti_2O D) Ti_2O_3

A 22. Which is a binary compound?

A) $CaCl_2$ B) KOH
C) $NaNO_3$ D) $MgSO_4$

D 23. What is the correct formula for ammonium carbonate?

A) $NH_4(CO_3)_2$ B) NH_4CO_3
C) $(NH_4)_2(CO_3)_2$ **D) $(NH_4)_2CO_3$**

B 24. What is the chemical formula for nickel (II) hypochlorite?

A) $NiCl_2$ **B) $Ni(ClO)_2$**
C) $NiClO_2$ D) $Ni(ClO)_3$

B 25. The correct name for the compound $NaClO_3$ is sodium

A) chloride **B) chlorate**
C) perchlorate D) chlorite

C 26. In which Group do the elements usually form oxides which have the general formula M_2O_3?

A) 1 B) 2 **C) 13** D) 14

A 27. The correct formula for nickel (II) oxide is

A) NiO B) Ni_2O
C) NiO_2 D) Ni_3O_2

C 28. The correct formula for aluminum sulfate is

A) Al_2S_3 B) Al_3S_2
C) $Al_2(SO_4)_3$ D) $Al_3(SO_4)_2$

C 29. Which compound contains only two elements?

A) potassium hydroxide
B) magnesium sulfate
C) aluminum oxide
D) ammonium chloride

C 30. What is the name for $NaClO_3$?

A) sodium chlorite B) sodium chloride
C) sodium chlorate D) sodium perchlorate

A 31. Which is the formula for magnesium sulfide?

A) MgS B) $MgSO_3$
C) MnS D) $MnSO_3$

D 32. The correct formula for calcium phosphate is

A) $CaPO_4$ B) $Ca_2(PO_4)_3$
C) Ca_3P_2 **D) $Ca_3(PO_4)_2$**

B 33. What is the correct name for the compound with the formula $CrPO_4$?

A) chromium (II) phosphate
B) chromium (III) phosphate
C) chromium (II) phosphide
D) chromium (III) phosphide

B 34. What is the correct name of the compound with the formula NH_4NO_2?

A) ammonia nitrite **B) ammonium nitrite**
C) ammonia nitrate D) ammonium nitrate

C 35. The correct formula for lead (IV) oxide is

A) PbO B) Pb_2O
C) PbO_2 D) Pb_2O_2

B 36. Which formula represents the compound aluminum iodide?

A) AlI **B) AlI_3** C) Al_3I D) Al_3I_3

C 37. Which formula represents sodium sulfate?

A) $NaSO_4$ B) $NaSO_3$
C) Na_2SO_4 D) Na_2SO_3

B 38. In a sample of solid $Ba(NO_3)_2$, the ratio of barium ions to nitrate ions is

A) 1:1 **B) 1:2** C) 1:3 D) 1:6

A 39. Which is the correct formula for titanium (III) oxide?

A) Ti_2O_3 B) TiO
C) Ti_3O_2 D) Ti_2O_4

C 40. Given the word equation:

sodium chlorate → sodium chloride + oxygen

Which type of chemical reaction is represented by this equation?

A) double replacement
B) single replacement
C) decomposition
D) synthesis

Formula & Equations Review

C 41. Given the balanced equation representing a reaction:

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

Which type of reaction is represented by this equation?

A) decomposition B) double replacement
C) single replacement D) synthesis

D 42. Given the balanced equation representing a reaction:

$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

Which type of chemical reaction is represented by this equation?

A) double replacement
B) single replacement
C) substitution
D) synthesis

D 43. Given the balanced equation:

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

This reaction is classified as

A) synthesis
B) decomposition
C) single replacement
D) double replacement

C 44. Which equation represents a double replacement reaction?

A) $2\,Na + 2\,H_2O \rightarrow 2\,NaOH + H_2$
B) $CaCO_3 \rightarrow CaO + CO_2$
C) $LiOH + HCl \rightarrow LiCl + H_2O$ 2 Comp. → 2 comp.
D) $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$

C 45. Given the incomplete equation representing a reaction:

$2C_6H_{14} + \underline{19}\ O_2 \rightarrow 12CO_2 + 14H_2O$

24 14 38

What is the coefficient of O_2 when the equation is completely balanced using the smallest whole-number coefficients?

A) 13 B) 14 C) 19 D) 26

C 46. Given the incomplete equation for the combustion of ethane:

✓12 14 ✓8
$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6\,H_2O$

What is the formula of the missing product?

A) CH_3OH B) $HCOOH$
C) H_2O D) H_2O_2

C 47. Given the unbalanced equation:

$\_\_ Fe_2O_3 + \underline{3}\ CO \rightarrow \underline{2}\ Fe + \underline{3}\ CO_2$

When the equation is correctly balanced using the *smallest* whole-number coefficients, what is the coefficient of CO?

A) 1 B) 2 C) 3 D) 4

A 48. If an equation is balanced properly, both sides of the equation must have the same number of

A) atoms B) coefficients
C) molecules D) moles of molecules

B 49. Given the unbalanced equation:

$\underline{2}\ Na + \underline{2}\ H_2O \rightarrow \_\_ H_2 + \underline{2}\ NaOH$

When the equation is correctly balanced using the smallest whole-number coefficients, the coefficient for H_2O is

A) 1 B) 2 C) 3 D) 4

B 50. Given the unbalanced equation:

$\underline{2}\ N_2(g) + \underline{5}\ O_2(g) \rightarrow \underline{2}\ N_2O_5(g)$

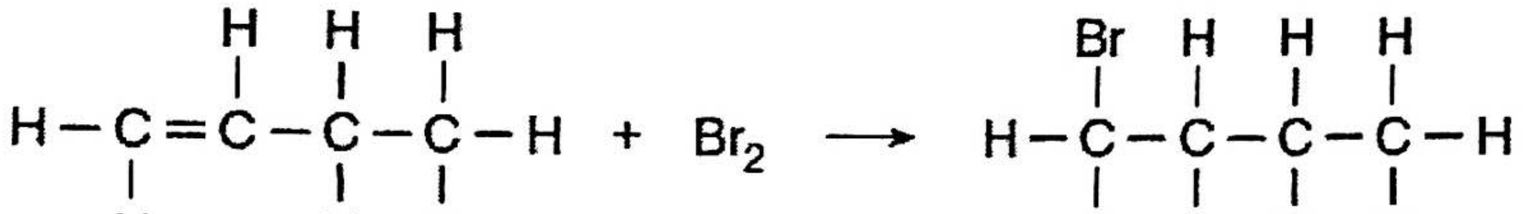
When the equation is balanced using smallest whole numbers, the coefficient of $N_2(g)$ will be

A) 1 B) 2 C) 5 D) 4

Formulas & Equations
Constructed Response

1. Base your answer to the following question on the information below.

The equation below represents the reaction between 1-butene and bromine to form the compound 1,2-dibromobutane, $C_4H_8Br_2$.



Write the empirical formula for the product.

$C_4H_8Br_2 \rightarrow C_2H_4Br$

2. Base your answer to the following question on the information below.

The reaction between aluminum and an aqueous solution of copper(II) sulfate is represented by the unbalanced equation below.

$$Al(s) + CuSO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + Cu(s)$$

Balance the equation below, using the smallest whole-number coefficients.

$2\,Al(s) + 3\,CuSO_4(aq) \rightarrow \_\_\_\_\,Al_2(SO_4)_3(aq) + 3\,Cu(s)$

3. Base your answer to the following question on the information below.

Vitamin C, also known as ascorbic acid, is water soluble and cannot be produced by the human body. Each day, a person's diet should include a source of vitamin C, such as orange juice. Ascorbic acid has a molecular formula of $C_6H_8O_6$ and a gram-formula mass of 176 grams per mole.

Write the empirical formula for ascorbic acid. $C_3H_4O_3$

4. Base your answer to the following question on the information below.

In an experiment, 2.54 grams of copper completely reacts with sulfur, producing 3.18 grams of copper(I) sulfide.

Write the chemical formula of the compound produced.

$Cu^{+1}\ S^{-2} \rightarrow Cu_2S$

5. Base your answer to the following question on the information below.

The Solvay process is a multistep industrial process used to produce washing soda, $Na_2CO_3(s)$. In the last step of the Solvay process, $NaHCO_3(s)$ is heated to 300°C, producing washing soda, water, and carbon dioxide. This reaction is represented by the balanced equation below.

$2NaHCO_3(s) + \text{heat} \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

Identify the type of chemical reaction represented by the equation. Decomposition

6. Base your answer to the following question on the information below.

Arsenic is often obtained by heating the ore arsenopyrite, FeAsS. The decomposition of FeAsS is represented by the balanced equation below.

$FeAsS(s) \xrightarrow{\text{heat}} FeS(s) + As(g)$

In the solid phase, arsenic occurs in two forms. One form, yellow arsenic, has a density of 1.97 g/cm^3 at STP. The other form, gray arsenic, has a density of 5.78 g/cm^3 at STP. When arsenic is heated rapidly in air, arsenic(III) oxide is formed.

Although arsenic is toxic, it is needed by the human body in very small amounts. The body of a healthy human adult contains approximately 5 milligrams of arsenic.

Write the formula for the compound produced when arsenic is heated rapidly in air. $As^{+3}\ O^{-2}$ As_2O_3

7. Base your answer to the following question on the information below.

A 4.86-gram sample of calcium reacted completely with oxygen to form 6.80 grams of calcium oxide. This reaction is represented by the balanced equation below.

$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

Determine the total mass of oxygen that reacted. 4.86 + ? → 6.80 1.94

8. Base your answer to the following question on the following information.

A piece of magnesium ribbon is reacted with excess hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas. The volume of the dry hydrogen gas produced is 45.6 milliliters. The temperature of the gas is 293 K, and the pressure is 99.5 kilopascals.

Balance below using the smallest whole-number coefficients.

____ $Mg(s)$ + 2 $HCl(aq) \rightarrow$ ____ $MgCl_2(aq)$ + ____ $H_2(g)$

9. Base your answer to the following question on the information below.

Some dry chemicals can be used to put out forest fires. One of these chemicals is $NaHCO_3$. When $NaHCO_3(s)$ is heated, one of the products is $CO_2(g)$, as shown in the balanced equation below.

$$2NaHCO_3(s) + heat \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

Identify the type of chemical reaction represented by this equation. Decomposition

10. Write the empirical formula for the compound C_8H_{18}. C_4H_9

11. Base your answer to the following question on the information below.

Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

Identify the type of chemical reaction represented by this equation. SYNTHESIS

12. Write the empirical formula for the compound $C_6H_{12}O_6$. CH_2O

13. Base your answer to the following question on the information and equation below.

Antacids can be used to neutralize excess stomach acid. Brand A Antacid contains the acid-neutralizing agent magnesium hydroxide, $Mg(OH)_2$. It reacts with HCl(aq) in the stomach, according to the following balanced equation:

$$2\ HCl(aq) + Mg(OH)_2(s) \rightarrow MgCl_2(aq) + 2\ H_2O(\ell)$$

Brand *B* antacid contains the acid-neutralizing agent sodium hydrogen carbonate. Write the chemical formula for sodium hydrogen carbonate. $NaHCO_3$

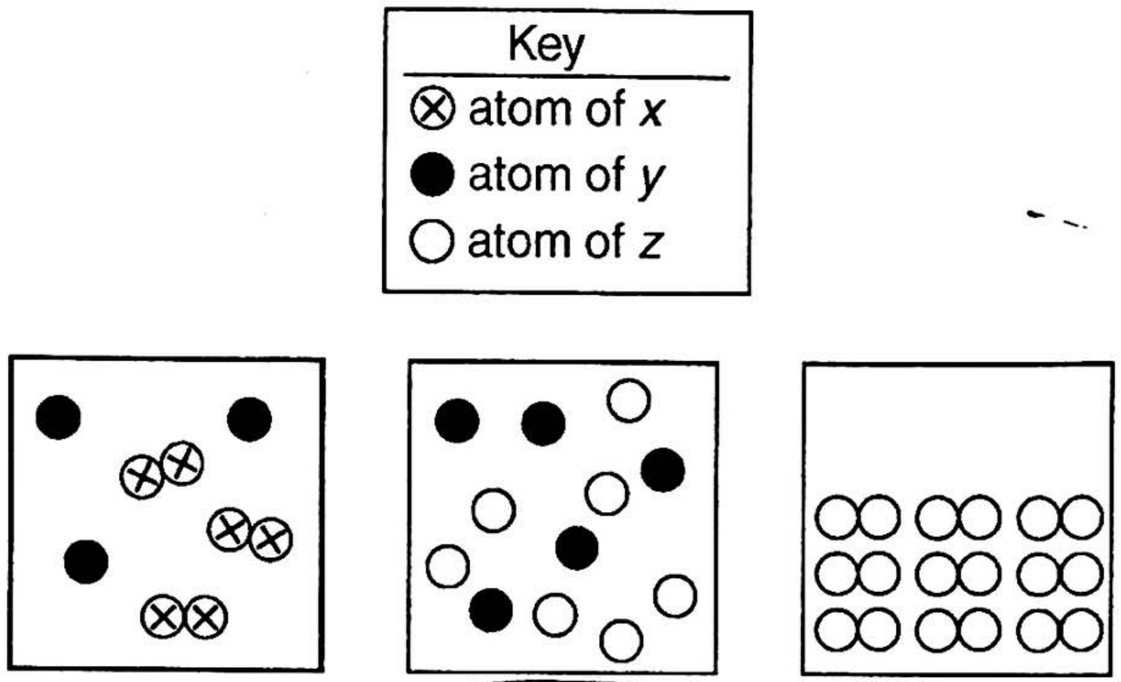
Na^+ HCO_3^-

14. Base your answer to the following question on the balanced chemical equation below.

$$2\ H_2O \rightarrow 2\ H_2 + O_2$$

What type of reaction does this equation represent? Decomposition

15. Base your answer to the following question on the particle diagrams below, which show atoms and/or molecules in three different samples of matter at STP.



Sample 1 (Sample 2) Sample 3

When two atoms of *y* react with one atom of *z*, a compound forms. Using the number of atoms shown in sample 2, what is the maximum number of molecules of this compound that can be formed?

Y = 5 atoms → Y_2Z → Can make 2 compounds

Z = 7 atoms → Can make 7

2 compounds