Name _____

Class _____ Date _____

The Mole

Solve each of the following problems. Show your work in the space provided, and write your final answer on the blank line.

Part A

1. If the mass of a stone is 2.603 kg, and that of a pencil is 5.15 g, calculate the mass of the stone relative to that of the pencil.

_____

2. If the mass of a lithium atom is 6.94 amu, and that of a uranium atom is 238.1 amu, calculate the mass of the lithium atom relative to that of the uranium atom.

_____

Part B

3. Calculate the number of fluorine atoms in 4.25 moles of fluorine gas.

_____

4. a. Calculate the number of moles of methane, CH_4, in 8.71×10^{22} molecules of methane.

_____

b. Calculate the number of atoms of hydrogen present in this same sample of methane.

_____

Part D continued from back

8. A 7.00-g sample of a molecular compound whose molar mass is 32.0 g/mol is analyzed, and is found to yield 6.13 of nitrogen and 0.87 of hydrogen. Determine the empirical and molecular formulas of the compound.

empirical formula: _____

molecular formula: _____

9. 18.48 g of carbon and 58.52 g of fluorine are obtained from the analysis of a molecular compound whose molar mass is 150.0 g/mol.
a. Determine the empirical and molecular formulas of the compound.

empirical formula: _____

molecular formula: _____

b. Calculate the percent composition of carbon and of fluorine in the compound.

_____

_____

Part B.

c. Calculate the number of moles of hydrogen atoms present in the sample.

f potassium sulfide, K_2S, suffi-

Part C

5. How many moles are present in 288.9 g of sodium carbonate, Na_2CO_3?

in 755 mL of a 0.64*M* solution?

6. What mass of $Fe(NO_3)_2$ is present in 0.0157 mole of this substance?

to make a 0.885*M* solution.

Part D

7. Sulfur combines chemically with oxygen to produce an oxide of sulfur. Determine the empirical formula of this compound, given that 22.7 g of the sulfur produces 45.3 g of the sulfur oxide.

The Mole

A. Molar Mass

The mass of a mole of a substance is equal to the total mass, in grams, of the moles of atoms that make it up. This total mass, or mass of 6.02×10^{23} formula units of a substance, is called molar mass, and is usually expressed in grams.

1. Complete each of the accompanying charts, filling in the items listed and determine the molar mass, in g, of each substance.

AMMONIA, NH_3			
NAME OF COMPONENT ATOM	MASS OF 1 MOLE OF SINGLE COMPONENT ATOM	NUMBER OF THAT KIND OF ATOM IN MOLECULE	TOTAL MASS OF THE MOLES OF THAT KIND OF ATOM IN 1 MOLE OF THE COMPOUND

Molar mass = _____

GLUCOSE, $C_6H_{12}O_6$			
NAME OF COMPONENT ATOM	MASS OF 1 MOLE OF SINGLE COMPONENT ATOM	NUMBER OF THAT KIND OF ATOM IN MOLECULE	TOTAL MASS OF THE MOLES OF THAT KIND OF ATOM IN 1 MOLE OF THE COMPOUND

Molar mass = _____

SULFURIC ACID, H_2SO_4			
NAME OF COMPONENT ATOM	MASS OF 1 MOLE OF SINGLE COMPONENT ATOM	NUMBER OF THAT KIND OF ATOM IN MOLECULE	TOTAL MASS OF THE MOLES OF THAT KIND OF ATOM IN 1 MOLE OF THE COMPOUND

Molar mass = _____

SODIUM BICARBONATE, $NaHCO_3$			
NAME OF COMPONENT ATOM	MASS OF 1 MOLE OF SINGLE COMPONENT ATOM	NUMBER OF THAT KIND OF ATOM IN MOLECULE	TOTAL MASS OF THE MOLES OF THAT KIND OF ATOM IN 1 MOLE OF THE COMPOUND

Molar mass = _____

2. Complete the chart below and answer the questions that follow it.

SUBSTANCE	FORMULA	MOLAR MASS
methane (marsh gas)	CH_4	
hydrochloric acid	HCl	
benzene	C_6H_6	
oxygen gas	O_2	
ozone	O_3	
ethanol	C_2H_5OH	
sodium hydroxide	NaOH	
acetylene	C_2H_2	

a. How many particles of methane are found in 16.0 grams of the gas? _____

In 32 grams of the gas? _____

b. How many atoms of carbon are found in one mole of methane gas? _____

How many atoms of hydrogen are found in the same sample? _____

c. How many atoms of oxygen are found in one mole of oxygen gas? _____

How many atoms of oxygen are found in one mole of _____?

d. How many moles of acetylene are found in 130 grams of the gas? _____

How many particles of acetylene are present? _____

e. What is the mass, in grams, of 3.01×10^{23} formula units of benzene?

_____

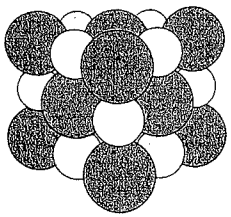
f. What is the mass, in grams, of 6.02×10^{25} formula units of sodium hydroxide?

_____

Fill in the table with the molecular formula and molar mass of each of the following elementary gases, which exist as molecules composed of two atoms.

ELEMENT	MOLECULAR FORMULA	MOLAR MASS
astatine		
bromine		
chlorine		
fluorine		
hydrogen		
iodine		
nitrogen		
oxygen		

4. The diagram illustrates the ion arrangement found in the salt potassium bromide. Examine the illustration and answer the following questions.



Bromide ions

Potassium ions

a. What is the ratio of bromide ions to potassium ions in this salt? _____

b. What is the formula unit of this salt?

_____

c. Calculate, in grams to the nearest whole number, the molar mass of this salt.

_____ _____

d. How many moles of this salt are present in 238 grams?

_____

e. How many bromide ions are present in 238 grams?

_____

f. How many moles of potassium bromide are present in 1.19 grams of this salt?

_____

g. How many potassium ions are present in the 1.19 grams?

_____

h. How many moles of potassium bromide are present in 595 grams of this salt?

_____

i. What is the total number of ions present in the 595 grams?

_____

B. Mole Calculations

One mole of a molecular substance contains 6.02×10^{23} molecules. Given a sample with a certain mass, it is possible to calculate the number of moles in the sample by dividing the mass of the sample by the molar mass. The number of molecules can then be calculated by multiplying 6.02×10^{23}.

Fill into the table the molar mass for each of the following substances. Next, calculate the number of moles and molecules present in the given sample mass and fill these quantities into the table. Use the blank space below for your calculations.

SUBSTANCE	FORMULA	MOLAR MASS	MASS OF GIVEN SAMPLE	NUMBER OF MOLES	NUMBER OF MOLECULES
bromine	Br_2		40.0 g		
carbon dioxide	CO_2		17.6 g		
nitrogen	N_2		154.0 g		
water	H_2O		360.0 g		
helium	He		0.10 g		
sucrose	$C_{12}H_{22}O_{11}$		684.0 g		
sulfur trioxide	SO_3		2.0 g		
hydrogen peroxide	H_2O_2		510.0 g		

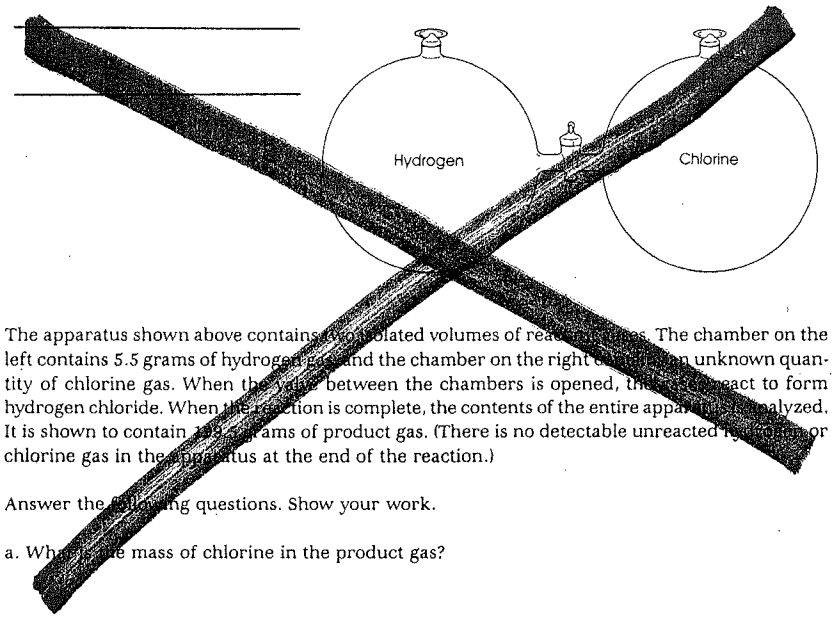
C. Empirical Formulas

The empirical formula of a substance indicates the simplest whole number ratios of the different kinds of atoms that make up the substance. The empirical formula of a substance with the molecular formula N_2O_4, for example, is NO_2.

1. Fill in the table with the empirical formula for each of the following hydrogen-carbon compounds.

COMPOUND	MOLECULAR FORMULA	EMPIRICAL FORMULA
methane	CH_4	
benzene	C_6H_6	
ethane	C_2H_6	
ethylene (ethene)	C_2H_4	
octane	C_8H_{18}	
acetylene (ethyne)	C_2H_2	
naphthalene	$C_{10}H_8$	
cyclohexane	C_6H_{12}	

Which of the above compounds have the same empirical formulas?



The apparatus shown above contains two isolated volumes of reactant gases. The chamber on the left contains 5.5 grams of hydrogen gas and the chamber on the right contains an unknown quantity of chlorine gas. When the valve between the chambers is opened, the gases react to form hydrogen chloride. When the reaction is complete, the contents of the entire apparatus are analyzed. It is shown to contain 14.6 grams of product gas. (There is no detectable unreacted hydrogen or chlorine gas in the apparatus at the end of the reaction.)

Answer the following questions. Show your work.

a. What is the mass of chlorine in the product gas?

The molarity (*M*) of a solution is defined as the number of moles of dissolved substance per liter of solution. This quantity can be calculated by dividing grams of dissolved substance by its molar mass, and then dividing the result by the volume of the solution.

Complete the following table by carrying out the appropriate calculations.

100 g 100 g

E. Molar Volume Relationships

The volume occupied by 6.02×10^{23} molecules of a substance is called molar volume. The molar volume of all gases at STP is approximately 22.4 L/mol. Given the information in the table below, fill in the missing information. Find the number of moles present, then determine the volume occupied by the given gas at STP. Use the space below the table to carry out calculations.

SUBSTANCE	MASS OF SAMPLE	MOLECULAR FORMULA	MOLAR MASS	NUMBER OF MOLES IN GIVEN MASS	VOLUME OCCUPIED BY MASS AT STP
Ammonia	340 grams				
Methane	0.80 grams				
Ozone	16.0 grams				
Oxygen	16.0 grams				
Argon	0.040 grams				
Hydrogen	5.0 grams				