

spray can, how many molecules are you releasing to the air when you empty the can?

33. Sulfur trioxide, SO_3 , is made in enormous quantities by combining oxygen and sulfur dioxide, SO_2 . The trioxide is not usually isolated but is converted to sulfuric acid. If you have 1.00 pound (454 g) of sulfur trioxide, how many moles does this represent? How many molecules? How many sulfur atoms? How many oxygen atoms?
34. Chlorofluorocarbons are strongly suspected of causing environmental damage. A substitute may be $\text{CF}_3\text{CH}_2\text{F}$. If you have 25.5 g of this new compound, how many moles does this represent? How many molecules? How many atoms of fluorine are contained in 25.5 g of the compound?
35. You use 0.55 g of vanillin, $\text{C}_8\text{H}_8\text{O}_3$, in some ice cream. How many moles does this represent? How many molecules? When you eat the vanillin, how many atoms of carbon are you consuming?
36. Glycerin, $\text{C}_3\text{H}_8\text{O}_3$, is a syrupy liquid used in cosmetics, as a sweetener, in glue, and in many other consumer products. If you have 250 g of the compound, how many moles does this represent? How many molecules? How many atoms of carbon are contained in 250 g of glycerin?

PERCENT COMPOSITION!

37. Calculate the molar mass of these compounds and the weight percent of each element.
- PbS , lead(II) sulfide, galena
 - C_2H_6 , ethane, a hydrocarbon fuel
 - CH_3COOH , acetic acid, an important ingredient in vinegar
 - NH_4NO_3 , ammonium nitrate
38. Calculate the molar mass of these compounds and the weight percent of each element.
- MgCO_3 , magnesium carbonate
 - $\text{C}_6\text{H}_5\text{OH}$, phenol, an organic compound used in some cleaners
 - $\text{C}_2\text{H}_3\text{O}_5\text{N}$, peroxyacetyl nitrate, an objectionable compound in photochemical smog
 - $\text{C}_4\text{H}_{10}\text{O}_3\text{NPS}$, acephate, an insecticide
39. Acrylonitrile, H_2CCHCN , is the basis of many important plastics and fibers. (a) Calculate the molar mass. (b) Calculate the weight percent of each element in the compound.
40. The copper-containing compound $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$ is a beautiful blue solid (see the photo). Calculate the molar mass of the compound and the weight percent of each element.
41. Hexachlorophene, $\text{C}_{13}\text{H}_6\text{Cl}_6\text{O}_2$, is a germicide in soaps. Calculate the weight percent of each element in the compound.



Copper-containing compound $\text{Cu}(\text{NH}_3)_4\text{SO}_4 \cdot \text{H}_2\text{O}$.

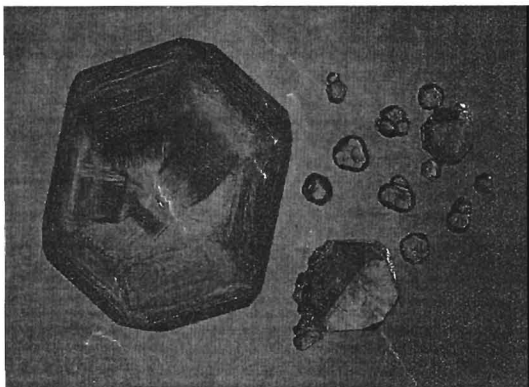
42. The formula of DDT, an insecticide that was once widely used, is $\text{C}_{14}\text{H}_9\text{Cl}_5$. Calculate the molar mass of the compound and the weight percent of each element.

EMPIRICAL AND MOLECULAR FORMULAS

43. The empirical formula of maleic acid is CHO . Its molar mass is 116.1 g/mol. What is its molecular formula?
44. A well known reagent in analytical chemistry, dimethylglyoxime, has the empirical formula $\text{C}_2\text{H}_4\text{NO}$. If its molar mass is 116.1 g/mol, what is the molecular formula of the compound?
45. Acetylene is a colorless gas that is used as a fuel in welding torches, among other things. It is 92.26% C and 7.74% H. Its molar mass is 26.04 g/mol. Calculate the empirical and molecular formulas.
46. There is a large family of boron-hydrogen compounds called boron hydrides. All have the formula B_xH_y and almost all react with air and burn or explode. One member of this family contains 88.5% B; the remainder is hydrogen. Which of the following is its empirical formula: BH_3 , B_4H_{10} , B_5H_7 , B_5H_{11} , or B_6H_{12} ?
47. Nitrogen and oxygen form a series of at least seven oxides with the general formula N_xO_y . One of them is a blue solid that comes apart, reversibly, in the gas phase. It contains 36.85% N. What is the empirical formula of this oxide?
48. Cumene is a hydrocarbon, a compound composed only of C and H. It is 89.94% carbon, and the molar mass is 120.2 g/mol. What are the empirical and molecular formulas of cumene?
49. Acetic acid is the important ingredient in vinegar. It is composed of carbon (40.0%), hydrogen (6.71%), and oxygen (53.28%). Its molar mass is 60.1 g/mol. Determine the empirical and molecular formulas of the acid.
50. An analysis of nicotine, a poisonous compound found in tobacco leaves, shows that it is 74.03% C, 8.70% H, and 17.27% N. Its molar mass is 162 g/mol. What are the empirical and molecular formulas of nicotine?
51. Cacodyl, a compound containing arsenic, was reported in 1842 by the German chemist Bunsen. It has an almost intolerable garlic-like odor. Its molar mass

- is 210 g/mol, and it is 22.88% C, 5.76% H, and 71.36% As. Determine its empirical and molecular formulas.
52. The action of bacteria on meat and fish produces a poisonous compound called cadaverine. As its name and origin imply, it stinks! It is 58.77% C, 13.81% H, and 27.42% N. Its molar mass is 102.2 g/mol. Determine the molecular formula of cadaverine.
 53. Vanillin is a common flavoring agent. It has a molar mass of 152 g/mol and is 63.15% C and 5.30% H; the remainder is oxygen. Determine the molecular formula of vanillin.
 54. Fluorocarbonyl hypofluorite was recently isolated, and analysis showed it to be 14.6% C, 39.0% O, and 46.3% F. If the molar mass of the compound is 82 g/mol, determine the empirical and molecular formulas of the compound.
 55. Naphthalene, best known in the form of "moth balls," is composed only of carbon (93.71%) and hydrogen (6.29%). If the molar mass of the compound is 128 g/mol, what is the molecular formula of naphthalene?
 56. A major oil company has used a gasoline additive called MMT to boost the octane rating of its gasoline. What is the empirical formula of MMT if it is 49.6% C, 3.20% H, 22.0% O, and 25.2% Mn?
 57. Ruthenium chemistry is quite interesting, and a good starting material for such studies is $\text{RuCl}_3 \cdot x \text{H}_2\text{O}$. If you heat 1.056 g of the hydrated salt and find that only 0.838 g of RuCl_3 remains when all of the water has been driven off, what is the value of x ?
 58. The "alum" used in cooking is potassium aluminum sulfate hydrate, $\text{KAl}(\text{SO}_4)_2 \cdot x \text{H}_2\text{O}$ (see the photo). To find the value of x , you can heat a sample of the compound to drive off all of the water and leave only $\text{KAl}(\text{SO}_4)_2$. Assume that you heat 4.74 g of the hydrated compound and that it loses 2.16 g of water. What is the value of x ?
 59. If "epsom salt," $\text{MgSO}_4 \cdot x \text{H}_2\text{O}$, is heated to 250 °C,

Alum, $\text{KAl}(\text{SO}_4)_2 \cdot x \text{H}_2\text{O}$ (for x see question 58).



- all the water of hydration is lost. On heating a 1.687-g sample of the hydrate, 0.824 g of MgSO_4 remains. How many molecules of water are there per formula unit of MgSO_4 ?
60. Copper sulfate as commonly used in the laboratory is the hydrated compound $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$ (see Figure 3.5). If you heat the solid to at least 150 °C, all of the water of hydration is lost. On heating 10.5 g of $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$ to this temperature, how many grams of water would be lost and how many grams of anhydrous CuSO_4 would remain?
 61. A package of baking soda contains 2.00 pounds (908 g) of NaHCO_3 . (a) What is the name of the compound NaHCO_3 ? (b) How many moles of NaHCO_3 are there in the package? (c) How many moles and how many grams of oxygen atoms are in the package?
 62. Monosodium glutamate, MSG, is a common food additive; its formula is $\text{HOOCCH}_2\text{CH}_2\text{CH}(\text{NH}_2)\text{COONa}$. (a) Calculate the molar mass for MSG. (b) How many moles of MSG are there in 2.00 g (about 1 teaspoonful) of MSG? (c) How many moles and how many atoms of O are there in 2.00 g of MSG?
 63. The mineral fluorite is calcium fluoride, CaF_2 . (a) Calculate the molar mass of the compound. (b) How many moles of CaF_2 are there in 1.56 g of the compound? (c) How many grams of CaF_2 must you have in order to have 12.0 g of fluoride ion?
 64. The most important beryllium-containing mineral is beryl, which occurs mostly as large blue-green crystals with the formula $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$. (a) What is the formula weight of beryl? (b) How many moles of beryl are there in a 0.25-g crystal? (c) How many grams of beryl must you have in order to have 10. g of beryllium?
 65. A 1.256-g sample of elemental sulfur is combined with fluorine, F_2 , to give a compound with the formula SF_x , a very stable, colorless gas. If you isolate 5.722 g of SF_x , what is the value of x ?
 66. A new compound containing xenon and fluorine was created by shining sunlight on a mixture of 0.526 g of Xe and an excess of F_2 gas. If you isolate 0.678 g of the new compound, what is its empirical formula?
 67. A chlorine-containing compound of sulfur, S_xCl_y , is prepared starting with SCl_2 . If you find the new compound is 52.51% chlorine, and its molar mass is 135.0 g/mol, what are its empirical and molecular formulas?
 68. Direct reaction of iodine (I_2) and chlorine (Cl_2) produces an iodine chloride, I_xCl_y , a bright yellow solid. If you completely used up 0.678 g of iodine, and produced 1.246 g of I_xCl_y , what is the empirical formula of the compound? Later experiment showed the molar mass of I_xCl_y was 467 g/mol. What is the molecular formula of the compound?