

## 6.11: Exercises

### 6.2: Molecular Mass and Formula Mass

1. What is the total mass (amu) of carbon in each of the following molecules?

- a.  $\text{CH}_4$
- b.  $\text{CHCl}_3$
- c.  $\text{C}_{12}\text{H}_{10}\text{O}_6$
- d.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

**Answer**

- a. 12.01 amu
- b. 12.01 amu
- c. 144.1 amu
- d. 60.05 amu

2. What is the total mass of hydrogen in each of the molecules?

- a.  $\text{CH}_4$
- b.  $\text{CHCl}_3$
- c.  $\text{C}_{12}\text{H}_{10}\text{O}_6$
- d.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

**Answer**

- a. 4.032 amu
- b. 1.008 amu
- c. 10.08 amu
- d. 12.10 amu

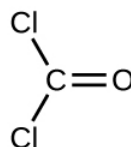
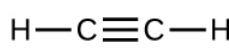
3. Calculate the molecular or formula mass of each of the following:

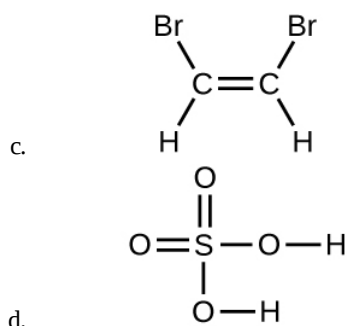
- a.  $\text{P}_4$
- b.  $\text{H}_2\text{O}$
- c.  $\text{Ca}(\text{NO}_3)_2$
- d.  $\text{CH}_3\text{CO}_2\text{H}$  (acetic acid)
- e.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  (sucrose, cane sugar)

**Answer**

- a. 123.9 amu
- b. 18.02 amu
- c. 164.10 amu
- d. 60.05 amu
- e. 342.3 amu

4. Determine the molecular mass of the following compounds:

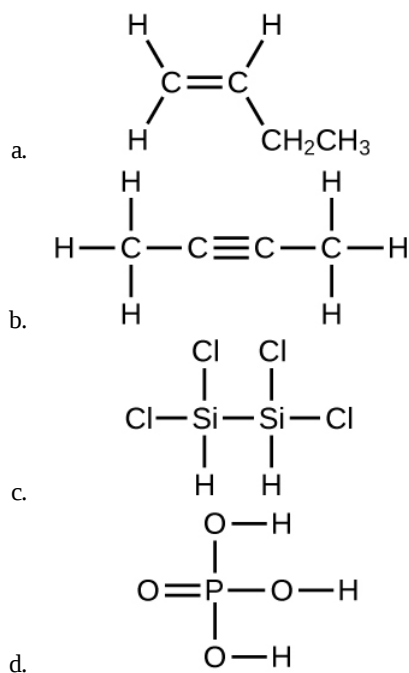
- a. 
- b. 



**Answer**

- a. 98.91 amu
- b. 26.04 amu
- c. 185.8 amu
- d. 98.09 amu

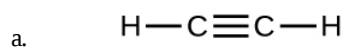
5. Determine the molecular mass of the following compounds:

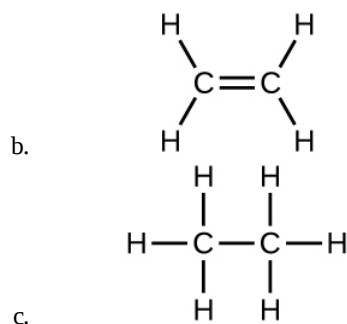


**Answer**

- a. 56.10 amu
- b. 54.09 amu
- c. 200.0 amu
- d. 97.99 amu

6. Which molecule has a molecular mass of 28.05 amu?





### Answer

molecule b

## 6.3: Counting Objects By Weighing

7. Compare 1 mole of  $\text{H}_2$ , 1 mole of  $\text{O}_2$ , and 1 mole of  $\text{F}_2$ .
- Which has the largest number of molecules? Explain why.
  - Which has the greatest mass? Explain why.

### Answer

- They all have the same number of molecules. One mole is  $6.022 \times 10^{23}$  particles, regardless of the identity of the particle.
- The  $\text{F}_2$  will have the greatest mass because a molecule of  $\text{F}_2$  weighs more than a molecule of  $\text{O}_2$  or  $\text{H}_2$ .

## 6.4: Molar Mass

8. How are the molecular mass and the molar mass of a compound similar and how are they different?

### Answer

The two masses have the same numerical value, but the units are different: the molecular mass is the mass of 1 molecule in amu while the molar mass is the mass of  $6.022 \times 10^{23}$  molecules in grams.

9. Determine the molar mass of each substance.
- Si
  - $\text{SiH}_4$
  - $\text{K}_2\text{O}$

### Answer

- 28.09 g
- 32.12 g
- 94.20 g

10. Determine the molar mass of each substance.
- $\text{Cl}_2$
  - $\text{SeCl}_2$
  - $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$

### Answer

- a. 70.90 g
- b. 149.86 g
- c. 158.17 g

11. Determine the molar mass of each substance.

- a. Al
- b.  $\text{Al}_2\text{O}_3$
- c.  $\text{CoCl}_3$

**Answer**

- a. 26.98 g
- b. 101.96 g
- c. 165.3 g

12. Calculate the molar mass of each of the following compounds:

- a. hydrofluoric acid, HF
- b. ammonia,  $\text{NH}_3$
- c. nitric acid,  $\text{HNO}_3$
- d. silver sulfate,  $\text{Ag}_2\text{SO}_4$
- e. boric acid,  $\text{B}(\text{OH})_3$

**Answer**

- a. 20.01 g
- b. 17.03 g
- c. 63.02 g
- d. 311.81 g
- e. 61.83 g

13. Calculate the molar mass of each of the following minerals:

- a. limestone,  $\text{CaCO}_3$
- b. halite,  $\text{NaCl}$
- c. beryl,  $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
- d. malachite,  $\text{Cu}_2(\text{OH})_2\text{CO}_3$
- e. turquoise,  $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8(\text{H}_2\text{O})_4$

**Answer**

- a. 100.09 g
- b. 58.44 g
- c. 537.5 g
- d. 813.4 g

14. Calculate the molar mass of each of the following:

- a. the anesthetic halothane,  $\text{C}_2\text{HBrClF}_3$
- b. the herbicide paraquat,  $\text{C}_{12}\text{H}_{14}\text{N}_2\text{Cl}_2$
- c. caffeine,  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$
- d. urea,  $\text{CO}(\text{NH}_2)_2$
- e. a typical soap,  $\text{C}_{17}\text{H}_{35}\text{CO}_2\text{Na}$

**Answer**

- a. 197.38 g
- b. 257.2 g
- c. 194.20 g
- d. 60.06 g
- e. 306.5 g

**6.5: Mole Calculations**

15. What is the mass of 4.44 mol of Mn?

**Answer**

244 g

16. What is the mass of 0.311 mol of Xe?

**Answer**

40.8 g

17. What is the mass of 12.34 mol of  $\text{Al}_2(\text{SO}_4)_3$ ?

**Answer**

4,222 g

18. What is the mass of 0.0656 mol of  $\text{PbCl}_2$ ?

**Answer**

18.2 g

19. How many moles are present in 45.6 g of CO?

**Answer**

1.63 mol

20. How many moles are present in 0.00339 g of LiF?

**Answer**

$1.31 \times 10^{-4}$  mol

21. How many moles are present in 1.223 g of  $\text{SF}_6$ ?

**Answer**

$8.37 \times 10^{-3}$  mol

22. How many moles are present in 48.8 g of  $\text{BaCO}_3$ ?

**Answer**

0.247 mol

23. Determine the mass of each of the following:

- a. 2.345 mol  $\text{LiCl}$
- b. 0.0872 mol acetylene,  $\text{C}_2\text{H}_2$
- c.  $3.3 \times 10^{-2}$  mol  $\text{Na}_2\text{CO}_3$
- d.  $1.23 \times 10^3$  mol fructose,  $\text{C}_6\text{H}_{12}\text{O}_6$
- e. 0.5758 mol  $\text{FeSO}_4(\text{H}_2\text{O})_7$

**Answer**

- a. 99.40 g
- b. 2.27 g
- c. 3.5 g
- d.  $2.22 \times 10^5$  g
- e. 160.1 g

24. The approximate minimum daily dietary requirement of the amino acid leucine,  $\text{C}_6\text{H}_{13}\text{NO}_2$ , is 1.1 g. What is this requirement in moles?

**Answer**

$8.4 \times 10^{-3}$  mol

25. Determine the mass in grams of each of the following:

- a. 0.600 mol of oxygen atoms
- b. 0.600 mol of oxygen molecules,  $\text{O}_2$
- c. 0.600 mol of ozone molecules,  $\text{O}_3$

**Answer**

- a. 9.60 g
- b. 19.2 g
- c. 28.8 g

26. How many moles are present in 54.8 mL of mercury if the density of mercury is 13.6 g/mL?

**Answer**

3.72 mol

27. How many moles are present in 56.83 mL of  $\text{O}_2$  if the density of  $\text{O}_2$  is 0.00133 g/mL?

**Answer**

$2.36 \times 10^{-3}$  mol

### 6.6: Counting Particles By Weighing

28. How many atoms are present in 4.55 mol of Fe?

**Answer**

$$2.740 \times 10^{24} \text{ atoms}$$

29. How many atoms are present in 0.0665 mol of K?

**Answer**

$$4.00 \times 10^{22} \text{ atoms}$$

30. How many molecules are present in 2.509 mol of H<sub>2</sub>S?

**Answer**

$$1.511 \times 10^{24} \text{ molecules}$$

31. How many molecules are present in 0.336 mol of acetylene (C<sub>2</sub>H<sub>2</sub>)?

**Answer**

$$2.02 \times 10^{23} \text{ molecules}$$

32. How many moles are present in  $3.55 \times 10^{24}$  Pb atoms?

**Answer**

$$5.90 \text{ mol}$$

33. How many moles are present in  $2.09 \times 10^{22}$  Ti atoms?

**Answer**

$$0.0347 \text{ mol}$$

34. How many moles are present in  $1.00 \times 10^{23}$  PF<sub>3</sub> molecules?

**Answer**

$$0.166 \text{ mol}$$

35. How many moles are present in  $5.52 \times 10^{25}$  penicillin molecules?

**Answer**

$$91.7 \text{ mol}$$

36. How many moles are present in 6.411 kg of CO<sub>2</sub>? How many molecules is this?

**Answer**

145.7 mol;  $8.772 \times 10^{25}$  molecules

37. How many moles are present in 2.998 mg of  $\text{SCl}_4$ ? How many molecules is this?

**Answer**

$1.724 \times 10^{-5}$  mol;  $1.038 \times 10^{19}$  molecules

38. What is the mass in milligrams of  $7.22 \times 10^{20}$  molecules of  $\text{CO}_2$ ?

**Answer**

52.8 mg

39. What is the mass in kilograms of  $3.408 \times 10^{25}$  molecules of  $\text{SiS}_2$ ?

**Answer**

5.220 kg

40. What is the mass in grams of 1 molecule of  $\text{H}_2\text{O}$ ?

**Answer**

$2.992 \times 10^{-23}$  g

41. What is the mass in grams of 1 atom of Al?

**Answer**

$4.480 \times 10^{-23}$  g

42. What is the volume in mL of 3.44 mol of Ga if the density of Ga is 6.08 g/mL?

**Answer**

39.4 mL

43. What is the volume in L of 0.662 mol of He if the density of He is 0.1785 g/L?

**Answer**

14.8 L

44. A 55-kg woman has  $7.5 \times 10^{-3}$  mol of hemoglobin (molar mass = 64,456 g/mol) in her blood. How many hemoglobin molecules is this? What is this quantity in grams?

**Answer**

$4.5 \times 10^{21}$  molecules;  $4.8 \times 10^2$  g



45. Diamond is one form of elemental carbon. An engagement ring contains a diamond weighing 1.25 carats (1 carat = 200 mg). How many atoms are present in the diamond?

**Answer**

$$1.25 \times 10^{22} \text{ atoms}$$

46. The Cullinan diamond was the largest natural diamond ever found (January 25, 1905). It weighed 3104 carats (1 carat = 200 mg). How many carbon atoms were present in the stone?

**Answer**

$$3.113 \times 10^{25} \text{ atoms}$$

47. One 55-gram serving of a particular cereal supplies 270 mg of sodium, 11% of the recommended daily allowance. How many moles and atoms of sodium are in the recommended daily allowance?

**Answer**

$$0.012 \text{ mol}; 7.1 \times 10^{21} \text{ atoms}$$

48. A certain nut crunch cereal contains 11.0 grams of sugar (sucrose,  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) per serving size of 60.0 grams. How many servings of this cereal must be eaten to consume 0.0278 moles of sugar?

**Answer**

$$0.865 \text{ servings}$$

49. Which of the following represents the least number of molecules?

- a. 20.0 g of  $\text{H}_2\text{O}$  (18.02 g/mol)
- b. 77.0 g of  $\text{CH}_4$  (16.06 g/mol)
- c. 68.0 g of  $\text{CaH}_2$  (42.09 g/mol)
- d. 100.0 g of  $\text{N}_2\text{O}$  (44.02 g/mol)
- e. 84.0 g of  $\text{HF}$  (20.01 g/mol)

**Answer**

$$20.0 \text{ g } \text{H}_2\text{O}$$

### 6.7: Using Chemical Formulas as Conversion Factors

50. Which contains the greatest mass of oxygen: 0.75 mol of ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ), 0.60 mol of formic acid ( $\text{HCO}_2\text{H}$ ), or 1.0 mol of water ( $\text{H}_2\text{O}$ )? Explain why.

**Answer**

Formic acid. Its formula has twice as many oxygen atoms as the other two compounds (one each). Therefore, 0.60 mol of formic acid would be equivalent to 1.20 mol of a compound containing a single oxygen atom.

51. Which contains the greatest number of moles of oxygen atoms: 1 mol of methanol ( $\text{CH}_3\text{OH}$ ), 1 mol of acetic acid ( $\text{CH}_3\text{CO}_2\text{H}$ ), or 1 mol of glycerol ( $\text{C}_3\text{H}_8\text{O}_3$ )? Explain why.

**Answer**

Glycerol. Each molecule of glycerol has three atoms of oxygen as compared to one atom of oxygen in a molecule of methanol and two atoms of oxygen in acetic acid.

52. Determine the number of moles of the compound and determine the number of moles of each type of atom in each of the following:

- a. 2.12 g of potassium bromide, KBr
- b. 0.1488 g of phosphoric acid,  $\text{H}_3\text{PO}_4$
- c. 23 kg of calcium carbonate,  $\text{CaCO}_3$
- d. 78.452 g of aluminum sulfate,  $\text{Al}_2(\text{SO}_4)_3$
- e. 0.1250 mg of caffeine,  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$

**Answer**

- a. 0.0178 mol KBr; 0.0178 mol K; 0.0178 mol Br
- b.  $1.478 \times 10^{-3}$  mol  $\text{H}_3\text{PO}_4$ ;  $4.433 \times 10^{-3}$  mol H;  $1.478 \times 10^{-3}$  mol P;  $5.911 \times 10^{-3}$  mol O
- c.  $2.3 \times 10^2$  mol  $\text{CaCO}_3$ ;  $2.3 \times 10^2$  mol Ca;  $2.3 \times 10^2$  mol C;  $6.9 \times 10^2$  mol O
- d. 0.2293 mol  $\text{Al}_2(\text{SO}_4)_3$ ; 0.4586 mol Al; 0.6878 mol S; 2.751 mol O
- e.  $6.437 \times 10^{-7}$  mol caffeine;  $5.149 \times 10^{-6}$  mol C;  $6.437 \times 10^{-6}$  mol H;  $2.575 \times 10^{-6}$  mol N;  $1.287 \times 10^{-6}$  mol O

53. Determine the number of atoms and the mass of zirconium, silicon, and oxygen found in 0.3384 mol of zircon,  $\text{ZrSiO}_4$ , a semiprecious stone.

**Answer**

zirconium:  $2.038 \times 10^{23}$  atoms; 30.87 g; silicon:  $2.038 \times 10^{23}$  atoms; 9.504 g; oxygen:  $8.151 \times 10^{23}$  atoms; 21.66 g

54. Determine which of the following contains the greatest mass of hydrogen: 1 mol of  $\text{CH}_4$ , 0.6 mol of  $\text{C}_6\text{H}_6$ , or 0.4 mol of  $\text{C}_3\text{H}_8$ .

**Answer**

1 mol  $\text{CH}_4$

55. Determine which of the following contains the greatest mass of aluminum: 122 g of  $\text{AlPO}_4$ , 266 g of  $\text{Al}_2\text{Cl}_6$ , or 225 g of  $\text{Al}_2\text{S}_3$ .

**Answer**

225 g  $\text{Al}_2\text{S}_3$

56. A tube of toothpaste contains 0.76 g of sodium monofluorophosphate ( $\text{Na}_2\text{PO}_3\text{F}$ ) in 100 mL.

- a. What mass of fluorine atoms in mg was present?
- b. How many fluorine atoms were present?

**Answer**

- a.  $1.0 \times 10^2$  mg F
- b.  $3.2 \times 10^{21}$  atoms F

### 6.8: Percent-By-Mass Composition

57. A 125 g sample of a compound known to contain only phosphorus and oxygen was shown to contain 54.5 g of phosphorus. What is the percent by mass composition of the compound?

**Answer**

43.6% P; 56.4% O

58. A compound containing only carbon and hydrogen was submitted for analysis. A 1.237 g sample of the compound was found to contain 1.140 g of carbon. What is the percent composition of the compound?

**Answer**

92.16% C; 7.84% H

59. Dichloroethane, a compound that is often used for dry cleaning, contains carbon, hydrogen, and chlorine. A 14.83 g sample of dichloroethane contained 3.60 g of carbon and 0.61 g of hydrogen. What is the percent by mass composition of dichloroethane?

**Answer**

24.3% C; 4.1% H; 71.6% Cl

60. A major textile dye manufacturer developed a new yellow dye containing carbon, nitrogen, and hydrogen. When 16.94 g of the dye was analyzed, it was found to contain 3.00 g of nitrogen and 1.07 g of hydrogen. What is the percent composition of the dye?

**Answer**

75.98% C; 17.7% N; 6.32% H

### 6.9: Mass Percent Composition from a Chemical Formula

61. Calculate the following to four significant figures:

- the percent composition of ammonia,  $\text{NH}_3$
- the percent composition of photographic "hypo,"  $\text{Na}_2\text{S}_2\text{O}_3$
- the percent of calcium ion in  $\text{Ca}_3(\text{PO}_4)_2$

**Answer**

- 82.25% N; 17.75% H
- 29.08% Na; 40.56% S; 30.36% O
- 38.76%  $\text{Ca}^{2+}$

62. Determine the following to four significant figures:

- the percent composition of hydrazoic acid,  $\text{HN}_3$
- the percent composition of TNT,  $\text{C}_6\text{H}_2(\text{CH}_3)(\text{NO}_2)_3$
- the percent of  $\text{SO}_4^{2-}$  in  $\text{Al}_2(\text{SO}_4)_3$

**Answer**

- 2.342% H; 97.66% N
- 37.01% C; 2.219% H; 18.50% N; 42.26% O
- 84.23%  $\text{SO}_4^{2-}$

63. Determine the percent ammonia,  $\text{NH}_3$ , in  $\text{Co}(\text{NH}_3)_6\text{Cl}_3$ , to three significant figures.

**Answer**

38.2%  $\text{NH}_3$

64. Determine the percent water in  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  to three significant figures.

**Answer**

36.1%  $\text{H}_2\text{O}$

65. Copper(I) iodide ( $\text{CuI}$ ) is often added to table salt as a dietary source of iodine. How many moles of  $\text{CuI}$  are contained in 1.00 lb (454 g) of table salt containing 0.0100%  $\text{CuI}$  by mass?

**Answer**

$2.38 \times 10^{-4}$  mol  $\text{CuI}$

66. A cough syrup contains 5.0% ethyl alcohol,  $\text{C}_2\text{H}_5\text{OH}$ , by mass. If the density of the solution is 0.9928 g/mL, how many grams of ethyl alcohol are contained in a 20.0 mL dose?

**Answer**

0.99 g ethyl alcohol

67. D5W is a solution used as an intravenous fluid. It is a 5.0% by mass solution of dextrose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , in water. If the density of D5W is 1.029 g/mL, calculate the mass of dextrose in a 1.00 L IV fluid bag.

**Answer**

51 g dextrose

68. Find the mass of sulfuric acid in 325 mL of a 40.0% by mass aqueous solution of sulfuric acid,  $\text{H}_2\text{SO}_4$ , for which the density is 1.3057 g/mL.

**Answer**

$1.70 \times 10^2$  g  $\text{H}_2\text{SO}_4$

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