

Chem 10 Chapter 6

Chemical Composition

Practice and End of Chapter Questions

Worked solutions at the end

Use your course periodic table and a calculator as needed. Show the setup, include units, and round at the end. Question numbers match the numbers in the solutions. Use heading navigation to move between sections.

Practice Questions

Question 1

How many atoms are in 5.80 moles of He?

- A) 3.49×10^{24}
- B) 1.03×10^{23}
- C) 6.02×10^{23}
- D) 4.00
- E) none of the above

Question 2

How many atoms are in 1.50 moles of fluorine gas?

- A) 18.98
- B) 9.03×10^{23}
- C) 6.022×10^{23}
- D) 1.81×10^{24}
- E) none of the above

Question 3

What is the mass of 0.560 moles of chlorine gas?

- A) 127
- B) 63.3
- C) 39.7
- D) 19.9
- E) none of the above

Question 4

You have 10.0 g each of Na, C, Pb, Cu and Ne. Which contains the largest number of moles?

- A) Cu
- B) C
- C) Pb
- D) Ne
- E) Na

Question 5

How many atoms are in 15.6 grams of silicon?

- A) 438
- B) 0.555
- C) 2.64×10^{26}
- D) 3.34×10^{23}
- E) none of the above

Question 6

What is the mass of 1.56×10^{21} atoms of magnesium in grams?

- A) 0.0630
- B) 0.142
- C) 4.72×10^{-5}
- D) 1.07×10^{-4}
- E) none of the above

Question 7

Calculate the molar mass of ammonium carbonate.

- A) 78.05 g/mol
- B) 96.09 g/mol
- C) 112.09 g/mol
- D) 88.05 g/mol
- E) none of the above

Question 8

How many molecules of nitrogen monoxide are in a 22.5 gram sample?

- A) 7.33×10^{23}
- B) 5.86×10^{23}
- C) 4.06×10^{23}
- D) 4.51×10^{23}
- E) none of the above

Question 9

One mole of potassium sulfate contains:

- A) 1 mole of potassium.
- B) 3 moles of potassium.
- C) 4 moles of oxygen.
- D) 2 moles of sulfur.
- E) none of the above

Question 10

An iron ore sample is found to be 35.00% Fe by mass. How many grams of ore are needed to obtain 454.0 grams of Fe?

- A) 1297
- B) 350.0
- C) 158.9
- D) 295.1
- E) none of the above

Question 11

What is the mass percent of chlorine in hydrochloric acid?

- A) 70.1
- B) 35.5
- C) 97.2
- D) 2.8
- E) none of the above

Question 12

Which of the following is already in its empirical formula?

- A) C_6H_6
- B) $\text{C}_5\text{H}_{12}\text{O}_2$
- C) $\text{C}_{22}\text{H}_{34}\text{O}_{10}$
- D) $\text{C}_6\text{H}_{12}\text{O}_3$
- E) none of the above

Question 13

Determine the correct empirical formula of a compound containing 26.68% carbon, 2.24% hydrogen, and 71.08% oxygen.

- A) CHO
- B) CHO_2
- C) $\text{C}_2\text{H}_2\text{O}_4$
- D) $\text{C}_{0.5}\text{H}_{0.5}\text{O}_1$
- E) none of the above

End of Chapter Questions

Question 14

What is the mass of 1 mol of atoms of each element?

- (a) P
- (b) Pt
- (c) C
- (d) Cr

Question 15

What is the mass of 1 mol of molecules of each compound?

- (a) CO_2
- (b) CH_2Cl_2
- (c) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- (d) SO_2

Question 16

Write the conversion factors between moles of each constituent element and moles of the compound for $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

Question 17

You can use mass percent composition as a conversion factor between grams of a constituent element and grams of the compound. Write the conversion factor, including units, inherent in each mass percent composition.

- (a) Water is 11.19% hydrogen by mass.
- (b) Fructose is 53.29% oxygen by mass.
- (c) Octane is 84.12% carbon by mass.
- (d) Ethanol is 52.14% carbon by mass.

Question 18

How many moles of atoms are in each elemental sample?

- (a) 4.6×10^{24} Pb atoms
- (b) 2.87×10^{22} He atoms
- (c) 7.91×10^{23} K atoms
- (d) 4.41×10^{21} Ca atoms

Question 19

How many atoms are in each elemental sample?

- (a) 3.4 mol Cu
- (b) 9.7×10^{-3} mol C
- (c) 22.9 mol Hg
- (d) 0.215 mol Na

Question 20

Consider these definitions: 1 dozen = 12; 1 gross = 144; 1 ream = 500; 1 mol = 6.022×10^{23} . Suppose you have 872 sheets of paper. How many of each unit of paper sheets do you have?

- (a) dozens
- (b) gross
- (c) reams
- (d) moles

Question 21

How many moles of atoms are in each elemental sample?

- (a) 1.34 g Zn
- (b) 24.9 g Ar
- (c) 72.5 g Ta
- (d) 0.0223 g Li

Question 22

A pure silver ring contains 0.0134 mmol (millimol) Ag. How many silver atoms does it contain?

Question 23

How many aluminum atoms are in 3.78 g of aluminum?

Question 24

Determine the number of moles of molecules or formula units in each sample.

- (a) 38.2 g sodium chloride
- (b) 36.5 g nitrogen monoxide
- (c) 4.25 kg carbon dioxide
- (d) 2.71 mg carbon tetrachloride

Question 25

A mothball, composed of naphthalene (C_{10}H_8), has a mass of 1.32 g. How many naphthalene molecules does it contain?

Question 26

A sugar crystal contains approximately 1.8×10^{17} sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) molecules. What is its mass in milligrams?

Question 27

Determine the number of moles of Cl in 2.7 mol CaCl_2 .

Question 28

Determine the number of moles of C in each sample.

- (a) 2.5 mol CH_4
- (b) 0.115 mol C_2H_6
- (c) 5.67 mol C_4H_{10}
- (d) 25.1 mol C_8H_{18}

Question 29

Calculate the number of grams of sodium in 1.00 g of each sodium-containing food additive.

- (a) NaCl (table salt)
- (b) Na_3PO_4 (sodium phosphate)
- (c) $\text{NaC}_7\text{H}_5\text{O}_2$ (sodium benzoate)
- (d) $\text{Na}_2\text{C}_6\text{H}_6\text{O}_7$ (sodium hydrogen citrate)

Question 30

A 2.45-g sample of strontium completely reacts with oxygen to form 2.89 g of strontium oxide. Use these data to calculate the mass percent composition of strontium in strontium oxide.

Question 31

A 1.912-g sample of calcium chloride is decomposed into its constituent elements and found to contain 0.690 g Ca and 1.222 g Cl. Calculate the mass percent composition of Ca and Cl in calcium chloride.

Question 32

Copper(II) fluoride contains 37.42% F by mass. Use this percentage to calculate the mass of fluorine in grams contained in 28.5 g of copper(II) fluoride.

Question 33

A compound containing nitrogen and oxygen is decomposed in the laboratory and produces 1.78 g of nitrogen and 4.05 g of oxygen. Calculate the empirical formula.

Question 34

Samples of several compounds are decomposed and the masses of their constituent elements are measured. Calculate the empirical formula of each compound.

- (a) 1.245 g Ni, 5.381 g I
- (b) 1.443 g Se, 5.841 g Br
- (c) 2.128 g Be, 7.557 g S, 15.107 g O

Question 35

A compound containing carbon and hydrogen has a molar mass of 56.11 g/mol and an empirical formula of CH_2 . Determine its molecular formula.

Question 36

The molar masses and empirical formulas of several compounds containing carbon and chlorine are listed. Find the molecular formula of each.

- (a) 284.77 g/mol, CCl
- (b) 131.39 g/mol, C_2HCl_3
- (c) 181.44 g/mol, C_2HCl

Question 37

A drop of water has a volume of approximately 0.05 mL. How many water molecules does it contain? The density of water is 1.0 g/cm^3 .

Question 38

The rock in a particular iron ore deposit contains 78% Fe_2O_3 by mass. How many kilograms of rock must a mining company process to obtain $1.0 \times 10^3 \text{ kg}$ of iron?

Question 39

Butanedione, a component of butter and body odor, has a cheesy smell. Elemental analysis gave the mass percent composition C: 55.80%; H: 7.03%; O: 37.17%. The molar mass is 86.09 g/mol. Determine the molecular formula.

Question 40

Nicotine, a stimulant found in tobacco, has the mass percent composition C: 74.03%; H: 8.70%; N: 17.27%. The molar mass is 162.26 g/mol. Find its molecular formula.

Solutions

Find the solution with the same question number.

Question 1 Solution

A. Convert moles of atoms to a number of atoms with Avogadro's number.

$$5.80 \text{ mol He} \times \frac{6.022 \times 10^{23} \text{ He atoms}}{1 \text{ mol He}} = 3.49 \times 10^{24} \text{ He atoms}$$

Question 2 Solution

D. Fluorine gas is F_2 , so each molecule contains two atoms.

$$1.50 \text{ mol F}_2 \times \frac{2 \text{ mol F atoms}}{1 \text{ mol F}_2} \times \frac{6.022 \times 10^{23} \text{ F atoms}}{1 \text{ mol F atoms}} = 1.81 \times 10^{24} \text{ F atoms}$$

Question 3 Solution

C. Chlorine gas is Cl_2 . Its molar mass is twice the atomic molar mass of chlorine.

$$0.560 \text{ mol Cl}_2 \times \frac{70.90 \text{ g Cl}_2}{1 \text{ mol Cl}_2} = 39.7 \text{ g Cl}_2$$

Question 4 Solution

B. Moles = mass/molar mass. When all masses are equal, the smallest molar mass gives the most moles. Carbon has the smallest molar mass among these elements.

Question 5 Solution

D. First convert grams to moles, then moles to atoms.

$$15.6 \text{ g Si} \times \frac{1 \text{ mol Si}}{28.09 \text{ g Si}} \times \frac{6.022 \times 10^{23} \text{ Si atoms}}{1 \text{ mol Si}} = 3.34 \times 10^{23} \text{ Si atoms}$$

Question 6 Solution

A. Convert atoms to moles before converting to grams.

$$1.56 \times 10^{21} \text{ Mg atoms} \times \frac{1 \text{ mol Mg}}{6.022 \times 10^{23} \text{ Mg atoms}} \times \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}} = 0.0630 \text{ g Mg}$$

Question 7 Solution

B. Ammonium carbonate is $(\text{NH}_4)_2\text{CO}_3$. Count 2 N, 8 H, 1 C, and 3 O.

$$M = 2(14.01) + 8(1.008) + 12.01 + 3(16.00) = 96.09 \text{ g/mol}$$

Question 8 Solution

D. Nitrogen monoxide is NO, with molar mass $14.01 + 16.00 = 30.01$ g/mol.

$$22.5 \text{ g NO} \times \frac{1 \text{ mol NO}}{30.01 \text{ g NO}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol NO}} = 4.51 \times 10^{23} \text{ molecules}$$

Question 9 Solution

C. Potassium sulfate is K_2SO_4 . One mole of formula units contains 2 mol K, 1 mol S, and 4 mol O.

Question 10 Solution

A. The mass percent supplies a conversion factor between iron and ore. Put iron in the denominator so its unit cancels.

$$454.0 \text{ g Fe} \times \frac{100.00 \text{ g ore}}{35.00 \text{ g Fe}} = 1297 \text{ g ore}$$

Question 11 Solution

C. The formula here is HCl. The question asks for the percentage within HCl, not within an aqueous solution of unspecified concentration.

$$\% \text{ Cl} = \frac{35.45}{1.008 + 35.45} \times 100 = 97.2\%$$

Question 12 Solution

B. An empirical formula has the smallest whole-number ratio of atoms. The subscripts 5, 12, and 2 share no common divisor greater than 1. The other formulas can all be reduced.

Question 13 Solution

B. Use a 100.00-g sample so each percentage becomes a mass in grams. Convert masses to moles before comparing atom counts.

$$n(\text{C}) = \frac{26.68 \text{ g}}{12.01 \text{ g/mol}} = 2.221 \text{ mol}$$

$$n(\text{H}) = \frac{2.24 \text{ g}}{1.008 \text{ g/mol}} = 2.22 \text{ mol}$$

$$n(\text{O}) = \frac{71.08 \text{ g}}{16.00 \text{ g/mol}} = 4.4425 \text{ mol}$$

Divide all three by the smallest amount. The ratio is C:H:O $\approx$ 1:1:2, giving CHO_2 . $\text{C}_2\text{H}_2\text{O}_4$ has the same ratio but is not reduced.

Question 14 Solution

The mass of 1 mol of atoms is the element's molar mass expressed in grams.

(a) P: 30.97 g.

(b) Pt: 195.08 g.

(c) C: 12.01 g.

(d) Cr: 52.00 g.

Question 15 Solution

Sum the atomic molar masses, multiplying each by its subscript. The resulting molar mass tells us the mass of 1 mol.

(a) $12.01 + 2(16.00) = 44.01$ g.(b) $12.01 + 2(1.008) + 2(35.45) = 84.93$ g.(c) $12(12.01) + 22(1.008) + 11(16.00) = 342.30$ g.(d) $32.07 + 2(16.00) = 64.07$ g.**Question 16 Solution**

Each molecule has 12 C, 22 H, and 11 O atoms. The same numerical ratios apply to moles.

$$\frac{12 \text{ mol C}}{1 \text{ mol C}_{12}\text{H}_{22}\text{O}_{11}}$$

$$\frac{22 \text{ mol H}}{1 \text{ mol C}_{12}\text{H}_{22}\text{O}_{11}}$$

$$\frac{11 \text{ mol O}}{1 \text{ mol C}_{12}\text{H}_{22}\text{O}_{11}}$$

Their reciprocals convert moles of the constituent element back to moles of the compound.

Question 17 Solution

“Percent by mass” means grams of the element per 100 g of the compound.

(a)

$$\frac{11.19 \text{ g H}}{100 \text{ g water}}$$

(b)

$$\frac{53.29 \text{ g O}}{100 \text{ g fructose}}$$

(c)

$$\frac{84.12 \text{ g C}}{100 \text{ g octane}}$$

(d)

$$\frac{52.14 \text{ g C}}{100 \text{ g ethanol}}$$

Each reciprocal is also a valid conversion factor. Choose the orientation that cancels the starting unit.

Question 18 Solution

Divide the number of atoms by Avogadro's number.

(a)

$$4.6 \times 10^{24} \text{ atoms} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 7.6 \text{ mol Pb}$$

(b)

$$2.87 \times 10^{22} \text{ atoms} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 0.0477 \text{ mol He}$$

(c)

$$7.91 \times 10^{23} \text{ atoms} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 1.31 \text{ mol K}$$

(d)

$$4.41 \times 10^{21} \text{ atoms} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 7.32 \times 10^{-3} \text{ mol Ca}$$

Question 19 Solution

Multiply the number of moles by Avogadro's number; the mol unit cancels.

(a)

$$3.4 \text{ mol} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 2.0 \times 10^{24} \text{ Cu atoms}$$

(b)

$$9.7 \times 10^{-3} \text{ mol} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 5.8 \times 10^{21} \text{ C atoms}$$

(c)

$$22.9 \text{ mol} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 1.38 \times 10^{25} \text{ Hg atoms}$$

(d)

$$0.215 \text{ mol} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 1.29 \times 10^{23} \text{ Na atoms}$$

Question 20 Solution

A dozen, a gross, a ream, and a mole are counting units. Divide by the number of sheets in one unit.

(a)

$$872 \text{ sheets} \times \frac{1 \text{ dozen}}{12 \text{ sheets}} = 72.666... \text{ dozen}$$

(b)

$$872 \text{ sheets} \times \frac{1 \text{ gross}}{144 \text{ sheets}} = 6.0555... \text{ gross}$$

(c)

$$872 \text{ sheets} \times \frac{1 \text{ ream}}{500 \text{ sheets}} = 1.744 \text{ reams}$$

(d)

$$872 \text{ sheets} \times \frac{1 \text{ mol sheets}}{6.022 \times 10^{23} \text{ sheets}} = 1.448 \times 10^{-21} \text{ mol sheets}$$

The sheet count and the definitions of dozen, gross, and ream are exact counts, not measured masses.

Question 21 Solution

Convert grams to moles using the molar mass of each element.

(a)

$$1.34 \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.38 \text{ g Zn}} = 0.0205 \text{ mol Zn}$$

(b)

$$24.9 \text{ g Ar} \times \frac{1 \text{ mol Ar}}{39.95 \text{ g Ar}} = 0.623 \text{ mol Ar}$$

(c)

$$72.5 \text{ g Ta} \times \frac{1 \text{ mol Ta}}{180.95 \text{ g Ta}} = 0.401 \text{ mol Ta}$$

(d)

$$0.0223 \text{ g Li} \times \frac{1 \text{ mol Li}}{6.94 \text{ g Li}} = 3.21 \times 10^{-3} \text{ mol Li}$$

Question 22 Solution

Do not use millimoles directly with atoms per mole. First convert mmol to mol.

$$0.0134 \text{ mmol Ag} \times \frac{1 \text{ mol Ag}}{1000 \text{ mmol Ag}} \times \frac{6.022 \times 10^{23} \text{ Ag atoms}}{1 \text{ mol Ag}} = 8.07 \times 10^{18} \text{ Ag atoms}$$

Question 23 Solution

Convert grams to moles, then moles to atoms.

$$3.78 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \frac{6.022 \times 10^{23} \text{ Al atoms}}{1 \text{ mol Al}} = 8.44 \times 10^{22} \text{ Al atoms}$$

Question 24 Solution

Write the formula, find its molar mass, and make the starting mass unit agree with that molar mass.

(a)

$$38.2 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} = 0.654 \text{ mol NaCl}$$

NaCl is counted in formula units, not molecules.

(b)

$$36.5 \text{ g NO} \times \frac{1 \text{ mol NO}}{30.01 \text{ g NO}} = 1.22 \text{ mol NO}$$

(c)

$$4.25 \text{ kg CO}_2 \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} = 96.6 \text{ mol CO}_2$$

(d)

$$2.71 \text{ mg CCl}_4 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol CCl}_4}{153.81 \text{ g CCl}_4} = 1.76 \times 10^{-5} \text{ mol CCl}_4$$

Question 25 Solution

Molar mass = $10(12.01) + 8(1.008) = 128.16 \text{ g/mol}$.

$$1.32 \text{ g C}_{10}\text{H}_8 \times \frac{1 \text{ mol C}_{10}\text{H}_8}{128.16 \text{ g C}_{10}\text{H}_8} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol C}_{10}\text{H}_8} = 6.20 \times 10^{21} \text{ molecules}$$

Question 26 Solution

The molar mass of sucrose is 342.30 g/mol. Convert molecules to moles, moles to grams, and finally grams to milligrams.

$$1.8 \times 10^{17} \text{ molecules} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ molecules}} \times \frac{342.30 \text{ g}}{1 \text{ mol}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 0.10 \text{ mg}$$

Question 27 Solution

Each formula unit contains two chloride ions, so the mole ratio is also 2 to 1.

$$2.7 \text{ mol CaCl}_2 \times \frac{2 \text{ mol Cl}}{1 \text{ mol CaCl}_2} = 5.4 \text{ mol Cl}$$

Question 28 Solution

Multiply moles of compound by the carbon subscript, which is an exact atom ratio.

(a) $2.5 \times 1 = 2.5 \text{ mol C.}$

(b) $0.115 \times 2 = 0.230 \text{ mol C.}$

(c) $5.67 \times 4 = 22.7 \text{ mol C.}$

(d) $25.1 \times 8 = 201 \text{ mol C.}$

Question 29 Solution

The sodium mass fraction is the sodium contribution to one formula unit divided by the total formula mass.

(a)

$$1.00 \text{ g NaCl} \times \frac{22.99 \text{ g Na}}{58.44 \text{ g NaCl}} = 0.393 \text{ g Na}$$

(b)

$$1.00 \text{ g Na}_3\text{PO}_4 \times \frac{68.97 \text{ g Na}}{163.94 \text{ g Na}_3\text{PO}_4} = 0.421 \text{ g Na}$$

(c)

$$1.00 \text{ g NaC}_7\text{H}_5\text{O}_2 \times \frac{22.99 \text{ g Na}}{144.10 \text{ g NaC}_7\text{H}_5\text{O}_2} = 0.160 \text{ g Na}$$

(d)

$$1.00 \text{ g Na}_2\text{C}_6\text{H}_6\text{O}_7 \times \frac{45.98 \text{ g Na}}{236.09 \text{ g Na}_2\text{C}_6\text{H}_6\text{O}_7} = 0.195 \text{ g Na}$$

Question 30 Solution

Use the measured strontium mass as the part and the oxide mass as the whole.

$$\% \text{ Sr} = \frac{2.45 \text{ g Sr}}{2.89 \text{ g oxide}} \times 100 = 84.8\%$$

The remaining mass is oxygen: $2.89 - 2.45 = 0.44 \text{ g}$, corresponding to about 15.2% of the sample.

Question 31 Solution

Divide each constituent mass by the whole sample mass. The two constituent masses add to 1.912 g.

$$\% \text{ Ca} = \frac{0.690}{1.912} \times 100 = 36.1\%$$

$$\% \text{ Cl} = \frac{1.222}{1.912} \times 100 = 63.91\%$$

Their unrounded percentages add to 100%. Small differences after rounding are expected.

Question 32 Solution

Use the given mass percentage as a conversion factor.

$$28.5 \text{ g CuF}_2 \times \frac{37.42 \text{ g F}}{100 \text{ g CuF}_2} = 10.7 \text{ g F}$$

Question 33 Solution

A formula compares numbers of atoms, so convert the masses to moles first.

$$n(\text{N}) = 1.78/14.01 = 0.127 \text{ mol}$$

$$n(\text{O}) = 4.05/16.00 = 0.253 \text{ mol}$$

Divide by 0.127: N:O $\approx$ 1:1.99 $\approx$ 1:2. The empirical formula is NO₂.

Question 34 Solution

For each sample, divide each mass by its atomic molar mass, then divide all mole amounts by the smallest.

(a) Ni: $1.245/58.69 = 0.02121 \text{ mol}$; I: $5.381/126.90 = 0.04240 \text{ mol}$. The ratio is 1:2, giving NiI₂.

(b) Se: $1.443/78.96 = 0.01828 \text{ mol}$; Br: $5.841/79.90 = 0.07310 \text{ mol}$. The ratio is 1:4, giving SeBr₄.

(c) Be: $2.128/9.012 = 0.2361 \text{ mol}$; S: $7.557/32.07 = 0.2356 \text{ mol}$; O: $15.107/16.00 = 0.9442 \text{ mol}$. The ratio is approximately 1:1:4, giving BeSO₄.

Question 35 Solution

The empirical-unit molar mass is $12.01 + 2(1.008) = 14.026 \text{ g/mol}$.

$$\text{Multiplier} = 56.11/14.026 \approx 4$$

Multiply every empirical subscript by 4: C₄H₈.

Question 36 Solution

Divide the molar mass by the empirical-unit molar mass; multiply all subscripts by that whole-number factor.

(a) Empirical-unit mass = $12.01 + 35.45 = 47.46 \text{ g/mol}$. Factor = $284.77/47.46 \approx 6$.
Molecular formula: C₆Cl₆.

(b) Empirical-unit mass = $2(12.01) + 1.008 + 3(35.45) = 131.378 \text{ g/mol}$. Factor ≈ 1 .
Molecular formula: C₂HCl₃.

(c) Empirical-unit mass = $2(12.01) + 1.008 + 35.45 = 60.478 \text{ g/mol}$. Factor = $181.44/60.478 \approx 3$. Molecular formula: C₆H₃Cl₃.

Question 37 Solution

Since $1 \text{ mL} = 1 \text{ cm}^3$, the drop's mass is approximately 0.05 g.

$$0.05 \text{ mL} \times \frac{1.0 \text{ g}}{1 \text{ mL}} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol H}_2\text{O}} = 1.67 \times 10^{21} \text{ molecules}$$

The volume has only one significant figure, so report about 2×10^{21} water molecules.

Question 38 Solution

There are two mass fractions to account for: iron within Fe_2O_3 , then Fe_2O_3 within the rock. Assume complete recovery of the iron, as implied by the question.

$$M(\text{Fe}_2\text{O}_3) = 2(55.85) + 3(16.00) = 159.70 \text{ g/mol}$$

$$1.0 \times 10^3 \text{ kg Fe} \times \frac{159.70 \text{ kg Fe}_2\text{O}_3}{111.70 \text{ kg Fe}} \times \frac{100 \text{ kg rock}}{78 \text{ kg Fe}_2\text{O}_3} = 1.8 \times 10^3 \text{ kg rock}$$

Question 39 Solution

Use a 100-g sample, so the percentages become grams.

$$n(\text{C}) = 55.80/12.01 = 4.646 \text{ mol}$$

$$n(\text{H}) = 7.03/1.008 = 6.974 \text{ mol}$$

$$n(\text{O}) = 37.17/16.00 = 2.323 \text{ mol}$$

Divide by 2.323. The ratio is 2:3:1, giving empirical formula $\text{C}_2\text{H}_3\text{O}$.

$$M(\text{empirical unit}) = 2(12.01) + 3(1.008) + 16.00 = 43.044 \text{ g/mol}$$

$$\text{Multiplier} = 86.09/43.044 \approx 2$$

The molecular formula is $\text{C}_4\text{H}_6\text{O}_2$.

Question 40 Solution

Use a 100-g sample and convert each mass to moles.

$$n(\text{C}) = 74.03/12.01 = 6.164 \text{ mol}$$

$$n(\text{H}) = 8.70/1.008 = 8.631 \text{ mol}$$

$$n(\text{N}) = 17.27/14.01 = 1.233 \text{ mol}$$

Divide by the smallest amount. The ratio is 5:7:1, giving $\text{C}_5\text{H}_7\text{N}$.

$$M(\text{empirical unit}) = 5(12.01) + 7(1.008) + 14.01 = 81.116 \text{ g/mol}$$

$$\text{Multiplier} = 162.26/81.116 \approx 2$$

The molecular formula is $\text{C}_{10}\text{H}_{14}\text{N}_2$.