

Chem 10 Chapter 6

Chemical Composition

Additional Practice 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.

Additional Practice Questions

Question 1

Iron is biologically important in the transport of oxygen by red blood cells from the lungs to the various organs of the body. In the blood of an adult human, there are approximately 2.64×10^{13} red blood cells with a total of 2.90 g of iron. On the average, how many iron atoms are present in each red blood cell? (molar mass Fe = 55.85 g/mol)

- A) 8.44×10^{-10}
- B) 1.18×10^9
- C) 3.13×10^{22}
- D) 2.64×10^{13}
- E) 6.14×10^{-2}

Question 2

A sample of ammonia has a mass of 43.5 g. How many molecules are in this sample?

- A) 2.55 molecules
- B) 2.62×10^{25} molecules
- C) 2.36×10^{23} molecules
- D) 1.54×10^{24} molecules
- E) 8.63×10^{-16} molecules

Question 3

Phosphorus has the molecular formula P_4 , and sulfur has the molecular formula S_8 . How many grams of phosphorus contain the same number of molecules as 4.23 g of sulfur?

- A) 2.04 g
- B) 0.490 g
- C) 4.08 g
- D) 4.23 g
- E) none of these

Question 4

How many atoms of hydrogen are present in 7.63 g of ammonia?

- A) 2.70×10^{23}
- B) 1.52×10^{24}
- C) 1.38×10^{25}
- D) 8.09×10^{23}
- E) 1.12×10^{20}

Question 5

One molecule of a compound weighs 2.93×10^{-22} g. The molar mass of this compound is:

- A) 2.06 g/mol
- B) 567 g/mol
- C) 168 g/mol
- D) 176 g/mol
- E) none of these

Question 6

A substance contains 35.0 g nitrogen, 5.05 g hydrogen, and 60.0 g of oxygen. How many grams of hydrogen are there in a 153-g sample of this substance?

- A) 7.72 g
- B) 767 g
- C) 15.4 g
- D) 5.05 g
- E) 30.3 g

Question 7

Chlorous acid, HClO_2 , contains what percent hydrogen by mass?

- A) 1.92%
- B) 25.0%
- C) 23.4%
- D) 1.47%
- E) 5.18%

Question 8

Which of the following compounds has the same percent composition by mass as styrene, C_8H_8 ?

- A) acetylene, C_2H_2
- B) benzene, C_6H_6
- C) cyclobutadiene, C_4H_4
- D) α -ethyl naphthalene, $\text{C}_{12}\text{H}_{12}$
- E) all of these

Question 9

Suppose you are given the percent by mass of the elements in a compound and you wish to determine the empirical formula. Which of the following is true?

- A) You must convert percent by mass to relative numbers of atoms.
- B) You must assume exactly 100.0 g of the compound.
- C) You must divide all of the percent by mass numbers by the smallest percent by mass.
- D) You cannot solve for the empirical formula without the molar mass.
- E) At least two of the above (A-D) are true.

Question 10

A hydrocarbon (a compound consisting solely of carbon and hydrogen) is found to be 85.6% carbon by mass. What is the empirical formula for this compound?

- A) CH
- B) CH_2
- C) C_2H
- D) C_3H
- E) CH_4

Question 11

The empirical formula of a group of compounds is CHCl . Lindane, a powerful insecticide, is a member of this group. The molar mass of lindane is 290.8 g/mol. How many atoms of carbon does a molecule of lindane contain?

- A) 2
- B) 3
- C) 4
- D) 6
- E) 8

Question 12

What amount, in moles, is represented by each sample?

- (a) 20.0 mg caffeine, $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$
- (b) 2.72×10^{21} molecules of ethanol, $\text{C}_2\text{H}_5\text{OH}$
- (c) 1.50 g of dry ice, CO_2

Question 13

Determine the molecular formula of a compound that contains 26.7% P, 12.1% N, and 61.2% Cl and has a molar mass of 580 g/mol.

Solutions

Find the solution with the same question number.

Question 1 Solution

B. First find the total number of iron atoms, then divide by the number of cells.

$$2.90 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{6.022 \times 10^{23} \text{ Fe atoms}}{1 \text{ mol Fe}} = 3.13 \times 10^{22} \text{ Fe atoms}$$

$$\frac{3.13 \times 10^{22} \text{ Fe atoms}}{2.64 \times 10^{13} \text{ cells}} = 1.18 \times 10^9 \text{ Fe atoms/cell}$$

Question 2 Solution

D.

$$43.5 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.04 \text{ g NH}_3} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol NH}_3} = 1.54 \times 10^{24} \text{ molecules}$$

Question 3 Solution

A. Equal numbers of molecules mean equal numbers of moles, so the mole ratio is 1:1. Keep sufficient precision in the molar masses.

$$M(\text{S}_8) = 8(32.07) = 256.56 \text{ g/mol}$$

$$M(\text{P}_4) = 4(30.97) = 123.88 \text{ g/mol}$$

$$4.23 \text{ g S}_8 \times \frac{1 \text{ mol S}_8}{256.56 \text{ g S}_8} \times \frac{1 \text{ mol P}_4}{1 \text{ mol S}_8} \times \frac{123.88 \text{ g P}_4}{1 \text{ mol P}_4} = 2.04 \text{ g P}_4$$

Question 4 Solution

D.

$$7.63 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.04 \text{ g NH}_3} \times \frac{3 \text{ mol H atoms}}{1 \text{ mol NH}_3} \times \frac{6.022 \times 10^{23} \text{ H atoms}}{1 \text{ mol H atoms}} = 8.09 \times 10^{23} \text{ H atoms}$$

Question 5 Solution

D.

$$\frac{2.93 \times 10^{-22} \text{ g}}{1 \text{ molecule}} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 176 \text{ g/mol}$$

Question 6 Solution

A. In a way, this is a simple proportionality problem encountered since elementary school. If we add up the masses of the elements making up the substance, we can use proportions and do it in the dimensional-analysis way.

$$\text{Mass of analyzed sample} = 35.0 + 5.05 + 60.0 = 100.05 \text{ g}$$

$$\text{Mass of H in 153 g} = \frac{5.05 \text{ g H}}{100.05 \text{ g substance}} \times 153 \text{ g substance} = 7.72 \text{ g H}$$

Question 7 Solution

D. To calculate percent by mass, we need the mass of the element divided by the mass of the substance, multiplied by 100. Taking one mole of HClO_2 gives one mole of H atoms.

$$M(\text{HClO}_2) = 1.008 + 35.45 + 2(16.00) = 68.46 \text{ g/mol}$$

$$\% \text{ H} = \frac{1.008 \text{ g H}}{68.46 \text{ g HClO}_2} \times 100 = 1.47\%$$

Alternatively, use dimensional analysis:

$$\frac{1 \text{ mol H}}{1 \text{ mol HClO}_2} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} \times \frac{1 \text{ mol HClO}_2}{68.46 \text{ g HClO}_2} = 0.0147 \text{ g H/g HClO}_2$$

Multiplying by 100 gives 1.47%.

Question 8 Solution

E. No need for calculations. Same empirical formula means same percent composition. All have the same empirical formula as C_8H_8 : CH.

Question 9 Solution

A. Percent by mass must be converted to relative numbers of atoms, using moles. A 100-g sample is convenient, but it is not required. Divide mole amounts, rather than mass percentages, by the smallest mole amount.

Question 10 Solution

B. Take a 100-g sample. The carbon mass is 85.6 g and the hydrogen mass is $100 - 85.6 = 14.4 \text{ g}$.

$$85.6 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 7.13 \text{ mol C}$$

$$14.4 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 14.3 \text{ mol H}$$

Divide both mole amounts by the smallest mole amount:

$$\text{C:H} = \frac{7.13}{7.13} : \frac{14.3}{7.13} \approx 1:2$$

The empirical formula is CH_2 .

Question 11 Solution

D. We need the molecular formula. Empirical formula and molar mass can give us that.

$$M(\text{empirical formula CHCl}) = 12.01 + 1.008 + 35.45 = 48.47 \text{ g/mol}$$

$$\frac{M(\text{molecular formula})}{M(\text{empirical formula})} = \frac{290.8}{48.47} \approx 6$$

One C in the empirical formula, multiplied by 6, gives 6 C atoms in the molecular formula. The molecular formula is $\text{C}_6\text{H}_6\text{Cl}_6$.

Question 12 Solution

(a) To go from mass to moles, we need the molar mass.

$$M(\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2) = 8(12.01) + 10(1.01) + 4(14.01) + 2(16.00) = 194.22 \text{ g/mol}$$

$$20.0 \text{ mg} \times \frac{10^{-3} \text{ g}}{1 \text{ mg}} \times \frac{1 \text{ mol}}{194.22 \text{ g}} = 1.03 \times 10^{-4} \text{ mol}$$

(b) To connect the number of molecules and the number of moles, we need Avogadro's number, but we do not need molar mass.

$$2.72 \times 10^{21} \text{ molecules} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ molecules}} = 4.52 \times 10^{-3} \text{ mol}$$

(c)

$$M(\text{CO}_2) = 12.01 + 2(16.00) = 44.01 \text{ g/mol}$$

$$1.50 \text{ g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} = 3.41 \times 10^{-2} \text{ mol CO}_2$$

Question 13 Solution

When masses of constituent elements are given as percentages, it is natural and convenient to use a sample mass of 100 g (exact). We can find the empirical formula from the masses alone.

$$\text{Mass of P} = (0.267)(100 \text{ g}) = 26.7 \text{ g}$$

$$\text{Moles of P} = 26.7 \text{ g P} \times \frac{1 \text{ mol P}}{30.97 \text{ g P}} = 0.8621 \text{ mol}$$

$$\text{Mass of N} = (0.121)(100 \text{ g}) = 12.1 \text{ g}$$

$$\text{Moles of N} = 12.1 \text{ g N} \times \frac{1 \text{ mol N}}{14.01 \text{ g N}} = 0.8637 \text{ mol}$$

$$\text{Mass of Cl} = (0.612)(100 \text{ g}) = 61.2 \text{ g}$$

$$\text{Moles of Cl} = 61.2 \text{ g Cl} \times \frac{1 \text{ mol Cl}}{35.45 \text{ g Cl}} = 1.726 \text{ mol}$$

To find the empirical formula, we divide each mole amount by the smallest mole amount.

$$\text{P: } 0.8621/0.8621 = 1; \text{ N: } 0.8637/0.8621 \approx 1; \text{ Cl: } 1.726/0.8621 \approx 2$$

The empirical formula is PNCl_2 .

$$M(\text{empirical formula}) = 30.97 + 14.01 + 2(35.45) = 115.88 \text{ g/mol}$$

The number of atoms in the molecular formula divided by the number in the empirical formula equals the ratio of their molar masses.

$$580/115.88 \approx 5$$

The molecular formula is $\text{P}_5\text{N}_5\text{Cl}_{10}$.

Or, we could use the molar mass as sample mass and bypass finding the empirical formula, because we are given molar-mass information. For a 580-g sample:

$$n(\text{P}) = (0.267)(580)/30.97 \approx 5 \text{ mol}$$

$$n(\text{N}) = (0.121)(580)/14.01 \approx 5 \text{ mol}$$

$$n(\text{Cl}) = (0.612)(580)/35.45 \approx 10 \text{ mol}$$

One mole of compound contains 5 mol P, 5 mol N, and 10 mol Cl: $\text{P}_5\text{N}_5\text{Cl}_{10}$.