

3.E: Composition of Substances and Solutions (Exercises)

3.E.1: 3.1: Formula Mass and the Mole Concept

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

- (a) CH_4
 - (b) CHCl_3
 - (c) $\text{C}_{12}\text{H}_{10}\text{O}_6$
 - (d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- (a) 12.01 amu; (b) 12.01 amu; (c) 144.12 amu; (d) 60.05 amu

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


- (a) CH_4
- (b) CHCl_3
- (c) $\text{C}_{12}\text{H}_{10}\text{O}_6$
- (d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

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


- P_4
 - H_2O
 - $\text{Ca}(\text{NO}_3)_2$
 - $\text{CH}_3\text{CO}_2\text{H}$ (acetic acid)
 - $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ (sucrose, cane sugar).
- (a) 123.896 amu; (b) 18.015 amu; (c) 164.086 amu; (d) 60.052 amu; (e) 342.297 amu

Determine the molecular mass of the following compounds:


(a)

 A structure is shown. A C atom is bonded to two Cl atoms and forms a double bond with one O atom.


(b)

 A structure is shown. Two C atoms form a triple bond with each other. Each C atom also forms a single bond with an H atom.

(c)


 A structure is shown. Two C atoms form double bonds with each other. Each C atom also forms a single bond with an H atom and a Br atom.

(d)


 A structure is shown. An S atom forms double bonds with two O atoms. The S atom also forms a single bond with an O atom which forms a single bond with an H atom. The S atom also forms a single bond with another O atom which forms a single bond with another H atom.

Determine the molecular mass of the following compounds:


(a)

 A structure is shown. Two C atoms form double bonds with each other. The C atom on the left forms a single bond with two H atoms each. The C atom on the right forms a single bond with an H atom and with a C H subscript 2 C H subscript 3 group.


(b)

 A structure is shown. There is a C atom which forms single bonds with three H atoms each. This C atom is bonded to another C atom. This second C atom forms a triple bond with another C atom which forms a single bond with a fourth C atom. The fourth C atom forms single bonds with three H atoms each.

(c)

 A structure is shown. An Si atom forms a single bond with a Cl atom, a single bond with a Cl atom, a single bond with an H atom, and a single bond with another Si atom. The second Si atom forms a single bond with a Cl atom, a single bond with a Cl atom, and a single bond with an H atom.


(d)

 A structure is shown. A P atom forms a double bond with an O atom. It also forms a single bond with an O atom which forms a single bond with an H atom. It also forms a single bond with another O atom which forms a single bond with an H atom. It also forms a single bond with another O atom which forms a single bond with an H atom.


1. (a) 56.107 amu;
2. (b) 54.091 amu;
3. (c) 199.9976 amu;
4. (d) 97.9950 amu

Which molecule has a molecular mass of 28.05 amu?


(a)

 A structure is shown. A C atom forms a triple bond with another C atom. Each C atom also forms a single bond with an H atom.

(b)

 A structure is shown. Two C atoms form a double bond with each other. Each C atom also forms a single bond with two H atoms.

(c)

 A structure is shown. A C atom forms a single bond with three H atoms each and with another C atom. The second C atom also forms a single bond with three H atoms each.

Write a sentence that describes how to determine the number of moles of a compound in a known mass of the compound if we know its molecular formula.

Use the molecular formula to find the molar mass; to obtain the number of moles, divide the mass of compound by the molar mass of the compound expressed in grams.

Compare 1 mole of H_2 , 1 mole of O_2 , and 1 mole of F_2 .

1. (a) Which has the largest number of molecules? Explain why.
2. (b) Which has the greatest mass? Explain why.

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 (HCO_2H), or 1.0 mol of water (H_2O)? Explain why.

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.

Which contains the greatest number of moles of oxygen atoms: 1 mol of ethanol ($\text{C}_2\text{H}_5\text{OH}$), 1 mol of formic acid (HCO_2H), or 1 mol of water (H_2O)? Explain why.

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

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

Calculate the molar mass of each of the following compounds:

1. (a) hydrogen fluoride, HF
2. (b) ammonia, NH_3
3. (c) nitric acid, HNO_3
4. (d) silver sulfate, Ag_2SO_4
5. (e) boric acid, $\text{B}(\text{OH})_3$

Calculate the molar mass of each of the following:

1. (a) S_8
2. (b) C_5H_{12}
3. (c) $\text{Sc}_2(\text{SO}_4)_3$
4. (d) CH_3COCH_3 (acetone)
5. (e) $\text{C}_6\text{H}_{12}\text{O}_6$ (glucose)

(a) 256.528 g/mol; (b) 72.150 g mol^{-1} ; (c) 378.103 g mol^{-1} ; (d) 58.080 g mol^{-1} ; (e) 180.158 g mol^{-1}

Calculate the empirical or molecular formula mass and the molar mass of each of the following minerals:

1. (a) limestone, CaCO_3
2. (b) halite, NaCl
3. (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, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8(\text{H}_2\text{O})_4$

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, $\text{C}_{17}\text{H}_{35}\text{CO}_2\text{Na}$

(a) $197.382 \text{ g mol}^{-1}$; (b) $257.163 \text{ g mol}^{-1}$; (c) $194.193 \text{ g mol}^{-1}$; (d) $60.056 \text{ g mol}^{-1}$; (e) $306.464 \text{ g mol}^{-1}$

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

- (a) 25.0 g of propylene, C_3H_6
- (b) $3.06 \times 10^{-3} \text{ g}$ of the amino acid glycine, $\text{C}_2\text{H}_5\text{NO}_2$
- (c) 25 lb of the herbicide Treflan, $\text{C}_{13}\text{H}_{16}\text{N}_2\text{O}_4\text{F}$ (1 lb = 454 g)
- (d) 0.125 kg of the insecticide Paris Green, $\text{Cu}_4(\text{AsO}_3)_2(\text{CH}_3\text{CO}_2)_2$
- (e) 325 mg of aspirin, $\text{C}_6\text{H}_4(\text{CO}_2\text{H})(\text{CO}_2\text{CH}_3)$

Determine the mass of each of the following:

- (a) 0.0146 mol KOH
- (b) 10.2 mol ethane, C_2H_6
- (c) $1.6 \times 10^{-3} \text{ mol Na}_2\text{SO}_4$
- (d) $6.854 \times 10^3 \text{ mol}$ glucose, $\text{C}_6\text{H}_{12}\text{O}_6$
- (e) 2.86 mol $\text{Co}(\text{NH}_3)_6\text{Cl}_3$

- (a) 0.819 g;
- (b) 307 g;
- (c) 0.23 g;
- (d) $1.235 \times 10^6 \text{ g}$ (1235 kg);
- (e) 765 g

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, H_3PO_4
- (c) 23 kg of calcium carbonate, CaCO_3
- (d) 78.452 g of aluminum sulfate, $\text{Al}_2(\text{SO}_4)_3$
- (e) 0.1250 mg of caffeine, $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$

Determine the mass of each of the following:

- (a) 2.345 mol LiCl
- (b) 0.0872 mol acetylene, C_2H_2
- (c) $3.3 \times 10^{-2} \text{ mol Na}_2\text{CO}_3$
- (d) $1.23 \times 10^3 \text{ mol}$ fructose, $\text{C}_6\text{H}_{12}\text{O}_6$
- (e) 0.5758 mol $\text{FeSO}_4(\text{H}_2\text{O})_7$

- (a) 99.41 g;
- (b) 2.27 g;
- (c) 3.5 g;
- (d) 222 kg;
- (e) 160.1 g

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?

Determine the mass in grams of each of the following:

1. (a) 0.600 mol of oxygen atoms
2. (b) 0.600 mol of oxygen molecules, O_2
3. (c) 0.600 mol of ozone molecules, O_3

1.

(a) 9.60 g; (b) 19.2 g; (c) 28.8 g

A 55-kg woman has 7.5×10^{-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?

Determine the number of atoms and the mass of zirconium, silicon, and oxygen found in 0.3384 mol of zircon, $ZrSiO_4$, a semiprecious stone.

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

Determine which of the following contains the greatest mass of hydrogen: 1 mol of CH_4 , 0.6 mol of C_6H_6 , or 0.4 mol of C_3H_8 .

Determine which of the following contains the greatest mass of aluminum: 122 g of $AlPO_4$, 266 g of Al_2Cl_6 , or 225 g of Al_2S_3 .

$AlPO_4$: 1.000 mol

Al_2Cl_6 : 1.994 mol

Al_2S_3 : 3.00 mol

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?

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?

3.113×10^{25} C atoms

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?

A certain nut crunch cereal contains 11.0 grams of sugar (sucrose, $C_{12}H_{22}O_{11}$) per serving size of 60.0 grams. How many servings of this cereal must be eaten to consume 0.0278 moles of sugar?

0.865 servings, or about 1 serving.

A tube of toothpaste contains 0.76 g of sodium monofluorophosphate (Na_2PO_3F) in 100 mL.

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

Which of the following represents the least number of molecules?

- a. 20.0 g of H_2O (18.02 g/mol)
- b. 77.0 g of CH_4 (16.06 g/mol)
- c. 68.0 g of CaH_2 (42.09 g/mol)
- d. 100.0 g of N_2O (44.02 g/mol)
- e. 84.0 g of HF (20.01 g/mol)

20.0 g H_2O represents the least number of molecules since it has the least number of moles.

3.E.2: 3.2: Determining Empirical and Molecular Formulas

What information do we need to determine the molecular formula of a compound from the empirical formula?

Calculate the following to four significant figures:

- a. (a) the percent composition of ammonia, NH_3
- b. (b) the percent composition of photographic "hypo," $Na_2S_2O_3$
- c. (c) the percent of calcium ion in $Ca_3(PO_4)_2$

(a) % N = 82.24%

% H = 17.76%;

(b) % Na = 29.08%

% S = 40.56%

% O = 30.36%;

(c) % Ca^{2+} = 38.76%

Determine the following to four significant figures:

- the percent composition of hydrazoic acid, HN_3
- the percent composition of TNT, $\text{C}_6\text{H}_2(\text{CH}_3)(\text{NO}_2)_3$
- the percent of SO_4^{2-} in $\text{Al}_2(\text{SO}_4)_3$

Determine the percent ammonia, NH_3 , in $\text{Co}(\text{NH}_3)_6\text{Cl}_3$, to three significant figures.

% NH_3 = 38.2%

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

Determine the empirical formulas for compounds with the following percent compositions:

- 15.8% carbon and 84.2% sulfur
 - 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen
- CS_2
 - CH_2O

Determine the empirical formulas for compounds with the following percent compositions:

- 43.6% phosphorus and 56.4% oxygen
- 28.7% K, 1.5% H, 22.8% P, and 47.0% O

A compound of carbon and hydrogen contains 92.3% C and has a molar mass of 78.1 g/mol. What is its molecular formula?

C_6H_6

Dichloroethane, a compound that is often used for dry cleaning, contains carbon, hydrogen, and chlorine. It has a molar mass of 99 g/mol. Analysis of a sample shows that it contains 24.3% carbon and 4.1% hydrogen. What is its molecular formula?

Determine the empirical and molecular formula for chrysotile asbestos. Chrysotile has the following percent composition: 28.03% Mg, 21.60% Si, 1.16% H, and 49.21% O. The molar mass for chrysotile is 520.8 g/mol.

$\text{Mg}_3\text{Si}_2\text{H}_3\text{O}_8$ (empirical formula), $\text{Mg}_6\text{Si}_4\text{H}_6\text{O}_{16}$ (molecular formula)

Polymers are large molecules composed of simple units repeated many times. Thus, they often have relatively simple empirical formulas. Calculate the empirical formulas of the following polymers:

- Lucite (Plexiglas); 59.9% C, 8.06% H, 32.0% O
- Saran; 24.8% C, 2.0% H, 73.1% Cl
- polyethylene; 86% C, 14% H
- polystyrene; 92.3% C, 7.7% H
- Orlon; 67.9% C, 5.70% H, 26.4% N

A major textile dye manufacturer developed a new yellow dye. The dye has a percent composition of 75.95% C, 17.72% N, and 6.33% H by mass with a molar mass of about 240 g/mol. Determine the molecular formula of the dye.

$\text{C}_{15}\text{H}_{15}\text{N}_3$

3.E.3: 3.3: Molarity

3.E.3.1: Questions

Explain what changes and what stays the same when 1.00 L of a solution of NaCl is diluted to 1.80 L.

What information do we need to calculate the molarity of a sulfuric acid solution?

We need to know the number of moles of sulfuric acid dissolved in the solution and the volume of the solution.

What does it mean when we say that a 200-mL sample and a 400-mL sample of a solution of salt have the same molarity? In what ways are the two samples identical? In what ways are these two samples different?

Determine the molarity for each of the following solutions:

- 0.444 mol of CoCl_2 in 0.654 L of solution
- 98.0 g of phosphoric acid, H_3PO_4 , in 1.00 L of solution
- 0.2074 g of calcium hydroxide, $\text{Ca}(\text{OH})_2$, in 40.00 mL of solution
- 10.5 kg of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ in 18.60 L of solution
- 7.0×10^{-3} mol of I_2 in 100.0 mL of solution
- 1.8×10^4 mg of HCl in 0.075 L of solution

- (a) 0.679 M;
- (b) 1.00 M;
- (c) 0.06998 M;
- (d) 1.75 M;
- (e) 0.070 M;
- (f) 6.6 M

Determine the molarity of each of the following solutions:

- 1.457 mol KCl in 1.500 L of solution
- 0.515 g of H_2SO_4 in 1.00 L of solution
- 20.54 g of $\text{Al}(\text{NO}_3)_3$ in 1575 mL of solution
- 2.76 kg of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in 1.45 L of solution
- 0.005653 mol of Br_2 in 10.00 mL of solution
- 0.000889 g of glycine, $\text{C}_2\text{H}_5\text{NO}_2$, in 1.05 mL of solution

Answers:

- 0.9713 M
- 5.25×10^{-3} M
- 6.122×10^{-2} M
- 7.62 M
- 0.5653 M
- 1.13×10^{-2} M

Consider this question: What is the mass of the solute in 0.500 L of 0.30 M glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, used for intravenous injection?

- Outline the steps necessary to answer the question.
- Answer the question.

(a) determine the number of moles of glucose in 0.500 L of solution; determine the molar mass of glucose; determine the mass of glucose from the number of moles and its molar mass; (b) 27 g

Consider this question: What is the mass of solute in 200.0 L of a 1.556-M solution of KBr?

- (a) Outline the steps necessary to answer the question.
- (b) Answer the question.

Answer:

- Calculate to moles of KBr by multiplying the Molarity by the amount of solution (200.0 L)
 - Find the Molar Mass of KBr and convert moles of solute to grams
- (b)

$$\frac{1.556 \text{ moles KBr}}{1 \cancel{\text{ L}}} \times 200.0 \cancel{\text{ L}} = 311.2 \text{ moles KBr}$$

$$311.2 \cancel{\text{ moles KBr}} \times \frac{119.0 \text{ g KBr}}{1 \cancel{\text{ mole KBr}}} = 37,030 \text{ g}$$

37,030g; 37.03 kg

Calculate the number of moles and the mass of the solute in each of the following solutions:

1. (a) 2.00 L of 18.5 M H₂SO₄, concentrated sulfuric acid
2. (b) 100.0 mL of 3.8×10^{-5} M NaCN, the minimum lethal concentration of sodium cyanide in blood serum
3. (c) 5.50 L of 13.3 M H₂CO, the formaldehyde used to "fix" tissue samples
4. (d) 325 mL of 1.8×10^{-6} M FeSO₄, the minimum concentration of iron sulfate detectable by taste in drinking water

(a) 37.0 mol H₂SO₄;

3.63×10^3 g H₂SO₄;

(b) 3.8×10^{-6} mol NaCN;

1.9×10^{-4} g NaCN;

(c) 73.2 mol H₂CO;

2.20 kg H₂CO;

(d) 5.9×10^{-7} mol FeSO₄;

8.9×10^{-5} g FeSO₄

Calculate the number of moles and the mass of the solute in each of the following solutions:

- a. 325 mL of 8.23×10^{-5} M KI, a source of iodine in the diet
- b. 75.0 mL of 2.2×10^{-5} M H₂SO₄, a sample of acid rain
- c. 0.2500 L of 0.1135 M K₂CrO₄, an analytical reagent used in iron assays
- d. 10.5 L of 3.716 M (NH₄)₂SO₄, a liquid fertilizer

Answers:

a. 2.67×10^{-5} moles KI; 4.44×10^{-3} g KI

b. 1.7×10^{-6} moles H₂SO₄; 1.6×10^{-4} g H₂SO₄

c. 2.838×10^{-2} moles K₂CrO₄; 5.510g K₂CrO₄

d. 39.0 moles (NH₄)₂SO₄; 5,160 g (NH₄)₂SO₄

Consider this question: What is the molarity of KMnO₄ in a solution of 0.0908 g of KMnO₄ in 0.500 L of solution?

1. (a) Outline the steps necessary to answer the question.
2. (b) Answer the question.

(a) Determine the molar mass of KMnO₄; determine the number of moles of KMnO₄ in the solution; from the number of moles and the volume of solution, determine the molarity; (b) 1.15×10^{-3} M

Consider this question: What is the molarity of HCl if 35.23 mL of a solution of HCl contain 0.3366 g of HCl?

1. (a) Outline the steps necessary to answer the question.
2. (b) Answer the question.

Answer:

(a)

1. Convert g of HCl to moles of HCl and convert mL of solution to L of solution
2. Divide moles of HCl by L of solution

(b)

$$0.3366 \text{ g HCl} \times \frac{1 \text{ mole HCl}}{36.46 \text{ g HCl}} = 9.232 \times 10^{-3} \text{ moles HCl}$$

$$35.23 \text{ mL} = 0.03523 \text{ L}$$

$$\frac{9.232 \times 10^{-3} \text{ moles HCl}}{0.03523 \text{ L}} = 0.2621 \text{ M HCl}$$

0.2621 M ;

Calculate the molarity of each of the following solutions:

- (a) 0.195 g of cholesterol, $\text{C}_{27}\text{H}_{46}\text{O}$, in 0.100 L of serum, the average concentration of cholesterol in human serum
- (b) 4.25 g of NH_3 in 0.500 L of solution, the concentration of NH_3 in household ammonia
- (c) 1.49 kg of isopropyl alcohol, $\text{C}_3\text{H}_7\text{OH}$, in 2.50 L of solution, the concentration of isopropyl alcohol in rubbing alcohol
- (d) 0.029 g of I_2 in 0.100 L of solution, the solubility of I_2 in water at 20 °C
- (a) $5.04 \times 10^{-3} \text{ M}$;
- (b) 0.499 M;
- (c) 9.92 M;
- (d) $1.1 \times 10^{-3} \text{ M}$

Calculate the molarity of each of the following solutions:

- a. 293 g HCl in 666 mL of solution, a concentrated HCl solution
- b. 2.026 g FeCl_3 in 0.1250 L of a solution used as an unknown in general chemistry laboratories
- c. 0.001 mg Cd^{2+} in 0.100 L, the maximum permissible concentration of cadmium in drinking water
- d. 0.0079 g $\text{C}_7\text{H}_5\text{SNO}_3$ in one ounce (29.6 mL), the concentration of saccharin in a diet soft drink.

There is about 1.0 g of calcium, as Ca^{2+} , in 1.0 L of milk. What is the molarity of Ca^{2+} in milk?

0.025 M

What volume of a 1.00-M $\text{Fe}(\text{NO}_3)_3$ solution can be diluted to prepare 1.00 L of a solution with a concentration of 0.250 M?

If 0.1718 L of a 0.3556-M $\text{C}_3\text{H}_7\text{OH}$ solution is diluted to a concentration of 0.1222 M, what is the volume of the resulting solution?

0.5000 L

If 4.12 L of a 0.850 M- H_3PO_4 solution is be diluted to a volume of 10.00 L, what is the concentration the resulting solution?

What volume of a 0.33-M $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ solution can be diluted to prepare 25 mL of a solution with a concentration of 0.025 M?

1.9 mL

What is the concentration of the NaCl solution that results when 0.150 L of a 0.556-M solution is allowed to evaporate until the volume is reduced to 0.105 L?

What is the molarity of the diluted solution when each of the following solutions is diluted to the given final volume?

- a. (a) 1.00 L of a 0.250-M solution of $\text{Fe}(\text{NO}_3)_3$ is diluted to a final volume of 2.00 L
- b. (b) 0.5000 L of a 0.1222-M solution of $\text{C}_3\text{H}_7\text{OH}$ is diluted to a final volume of 1.250 L
- c. (c) 2.35 L of a 0.350-M solution of H_3PO_4 is diluted to a final volume of 4.00 L
- d. (d) 22.50 mL of a 0.025-M solution of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ is diluted to 100.0 mL
- 1. (a) 0.125 M;
- 2. (b) 0.04888 M;
- 3. (c) 0.206 M;
- 4. (e) 0.0056 M

What is the final concentration of the solution produced when 225.5 mL of a 0.09988-M solution of Na_2CO_3 is allowed to evaporate until the solution volume is reduced to 45.00 mL?

A 2.00-L bottle of a solution of concentrated HCl was purchased for the general chemistry laboratory. The solution contained 868.8 g of HCl. What is the molarity of the solution?

11.9 M

An experiment in a general chemistry laboratory calls for a 2.00-M solution of HCl. How many mL of 11.9 M HCl would be required to make 250 mL of 2.00 M HCl?

What volume of a 0.20-M K_2SO_4 solution contains 57 g of K_2SO_4 ?

1.6 L

The US Environmental Protection Agency (EPA) places limits on the quantities of toxic substances that may be discharged into the sewer system. Limits have been established for a variety of substances, including hexavalent chromium, which is limited to 0.50 mg/L. If an industry is discharging hexavalent chromium as potassium dichromate ($K_2Cr_2O_7$), what is the maximum permissible molarity of that substance?

3.E.4: 3.4: Other Units for Solution Concentrations

3.E.4.1: Questions

- Consider this question: What mass of a concentrated solution of nitric acid (68.0% HNO_3 by mass) is needed to prepare 400.0 g of a 10.0% solution of HNO_3 by mass?
 - Outline the steps necessary to answer the question.
 - Answer the question.
- What mass of a 4.00% NaOH solution by mass contains 15.0 g of NaOH?
- What mass of solid NaOH (97.0% NaOH by mass) is required to prepare 1.00 L of a 10.0% solution of NaOH by mass? The density of the 10.0% solution is 1.109 g/mL.
- What mass of HCl is contained in 45.0 mL of an aqueous HCl solution that has a density of 1.19 g cm^{-3} and contains 37.21% HCl by mass?
- The hardness of water (hardness count) is usually expressed in parts per million (by mass) of $CaCO_3$, which is equivalent to milligrams of $CaCO_3$ per liter of water. What is the molar concentration of Ca^{2+} ions in a water sample with a hardness count of 175 mg $CaCO_3/L$?
- The level of mercury in a stream was suspected to be above the minimum considered safe (1 part per billion by weight). An analysis indicated that the concentration was 0.68 parts per billion. Assume a density of 1.0 g/mL and calculate the molarity of mercury in the stream.
- In Canada and the United Kingdom, devices that measure blood glucose levels provide a reading in millimoles per liter. If a measurement of 5.3 mM is observed, what is the concentration of glucose ($C_6H_{12}O_6$) in mg/dL?
- A throat spray is 1.40% by mass phenol, C_6H_5OH , in water. If the solution has a density of 0.9956 g/mL, calculate the molarity of the solution.
- Copper(I) iodide (CuI) is often added to table salt as a dietary source of iodine. How many moles of CuI are contained in 1.00 lb (454 g) of table salt containing 0.0100% CuI by mass?
- A cough syrup contains 5.0% ethyl alcohol, C_2H_5OH , by mass. If the density of the solution is 0.9928 g/mL, determine the molarity of the alcohol in the cough syrup.
- D5W is a solution used as an intravenous fluid. It is a 5.0% by mass solution of dextrose ($C_6H_{12}O_6$) in water. If the density of D5W is 1.029 g/mL, calculate the molarity of dextrose in the solution.
- Find the molarity of a 40.0% by mass aqueous solution of sulfuric acid, H_2SO_4 , for which the density is 1.3057 g/mL.

3.E.4.2: Solutions

1

- (a) The dilution equation can be used, appropriately modified to accommodate mass-based concentration units:

$$\% \text{ mass}_1 \times \text{mass}_1 = \% \text{ mass}_2 \times \text{mass}_2 \quad (3.E.1)$$

This equation can be rearranged to isolate mass_1 and the given quantities substituted into this equation.

- (b) 58.8 g
3. 114 g 5. $1.75 \times 10^{-3} M$ 7 95 mg/dL 9 $2.38 \times 10^{-4} \text{ mol}$ 11 0.29 mol

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