

10.1 The Mole: A Measurement of Matter

Objectives

10.1.1 Describe methods of measuring the amount of something.

10.1.2 Define Avogadro's number as it relates to a mole of a substance.

10.1.3 Distinguish between the atomic mass of an element and its molar mass.

10.1.4 Describe how the mass of a mole of a compound is calculated.

Nov 6-8:29 PM

Table 10.1 P290

Representative Particles and Moles

Substance	Representative particle	Chemical formula	Representative particles in 1.00 mole
Atomic nitrogen	Atom	N	6.02×10^{23}
Nitrogen gas	Molecule	N ₂	6.02×10^{23}
Water	Molecule	H ₂ O	6.02×10^{23}
Calcium ion	Ion	Ca ²⁺	6.02×10^{23}
Calcium fluoride	Formula unit	CaF ₂	6.02×10^{23}
Sucrose	Molecule	C ₁₂ H ₂₂ O ₁₁	6.02×10^{23}

One mole of any atom or molecule contains 6.02×10^{23} atoms or molecules.

$$(2)(6.02 \times 10^{23}) = (1)(x)$$

$$\frac{1 \text{ mole}}{6.02 \times 10^{23}} = \frac{2 \text{ mole}}{x}$$

$$x = 1.204 \times 10^{24}$$

Nov 6-8:31 PM

Cross Multiplication

$$\frac{x}{2} = \frac{2}{4}$$

$$\frac{\cancel{4}x}{\cancel{4}} = \frac{4}{\cancel{4}} \quad x = 1$$

Mar 19-8:32 AM

P291

Converting Number of Atoms to Moles

Magnesium is a light metal used in the manufacture of aircraft, automobile wheels, tools, and garden furniture. How many moles of magnesium is 1.25×10^{23} atoms of magnesium?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{n \text{ mol}}{1.25 \times 10^{23}}$$

6.02×10^{23}

$n = 0.21 \text{ moles}$

Nov 6-8:32 PM

P291

Converting Number of Atoms to Moles

Magnesium is a light metal used in the manufacture of aircraft, automobile wheels, tools, and garden furniture. How many moles of magnesium is 1.25×10^{23} atoms of magnesium?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{n \text{ mol}}{1.25 \times 10^{23}}$$

$$n = 0.21 \text{ moles}$$

P291:3-4

Mar 24-12:56 PM

P291

3. How many moles is 2.80×10^{24} atoms of silicon?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{n \text{ mol}}{2.80 \times 10^{24}}$$

$$n = 4.65 \text{ mol}$$

4. How many moles is 2.17×10^{23} representative particles of bromine?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{n \text{ mol}}{2.17 \times 10^{23}}$$

$$n = 0.36$$

$$\frac{1}{2} = \frac{2}{4} \quad (2 \times 2) (4 \times 1)$$

$$(6.02 \times 10^{23})(n) = (1 \text{ mol})(2.80 \times 10^{24})$$

$$\frac{6.02 \times 10^{23} (n)}{6.02 \times 10^{23}} = \frac{2.80 \times 10^{24}}{6.02 \times 10^{23}}$$

$$\frac{\cancel{6.02} \times 10^{\cancel{23}} (n)}{\cancel{6.02} \times 10^{\cancel{23}}} = \frac{2.80 \times 10^{\cancel{24}}}{\cancel{6.02} \times 10^{\cancel{23}}}$$

Nov 6-8:32 PM

P291

3. How many moles is
 2.80×10^{24} atoms of silicon?

$$\frac{1 \text{ mol}}{6.024 \times 10^{23}} =$$

4. How many moles is 2.17×10^{23}
representative particles of
bromine?

$$\frac{1 \text{ mole}}{6.024 \times 10^{23}} =$$

Mar 20-10:00 AM

Answers

3. 2.80×10^{24} atoms Si $\times 1 \text{ mol} / 6.02 \times 10^{23}$ atoms = 4.65 mol Si

4. 2.17×10^{23} representative particles
 $\times 1 \text{ mol} / 6.02 \times 10^{23}$ representative
particles = 0.360 mol Br₂

Nov 6-8:32 PM

Converting Moles to Number of Atoms

P272

Propane is a gas used for cooking and heating. How many atoms are in 2.12 mol of propane (C_3H_8)?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{2.12 \text{ moles}}{X}$$

$$X = 1.28 \times 10^{24}$$

- atoms Fe
- Particle
- molecules H_2O

p292: 5-6

Nov 6-8:33 PM

Converting Moles to Number of Atoms

P272

Propane is a gas used for cooking and heating. How many atoms are in 2.12 mol of propane (C_3H_8)?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{2.12 \text{ moles}}{X}$$

$$X = 1.28 \times 10^{24}$$

- atoms Fe
- Particle
- molecules H_2O

p292: 5-6

Nov 6-8:33 PM

5. How many atoms are in
1.14 mol SO_3 ?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{1.14 \text{ mol}}{x}$$

$$x = 6.86 \times 10^{23}$$

6. How many moles are in ^{P292}
 4.65×10^{24} molecules of NO_2 ?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23}} = \frac{n \text{ mol}}{4.65 \times 10^{24}}$$

$$n = 7.72$$

Nov 6-8:33 PM







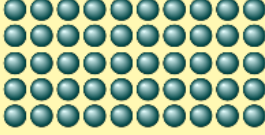

Answers

5. $1.14 \text{ mol} \times 6.02 \times 10^{23} \text{ molecules/mol} \times 4 \text{ atoms/molecule} = 2.75 \times 10^{24} \text{ atoms}$

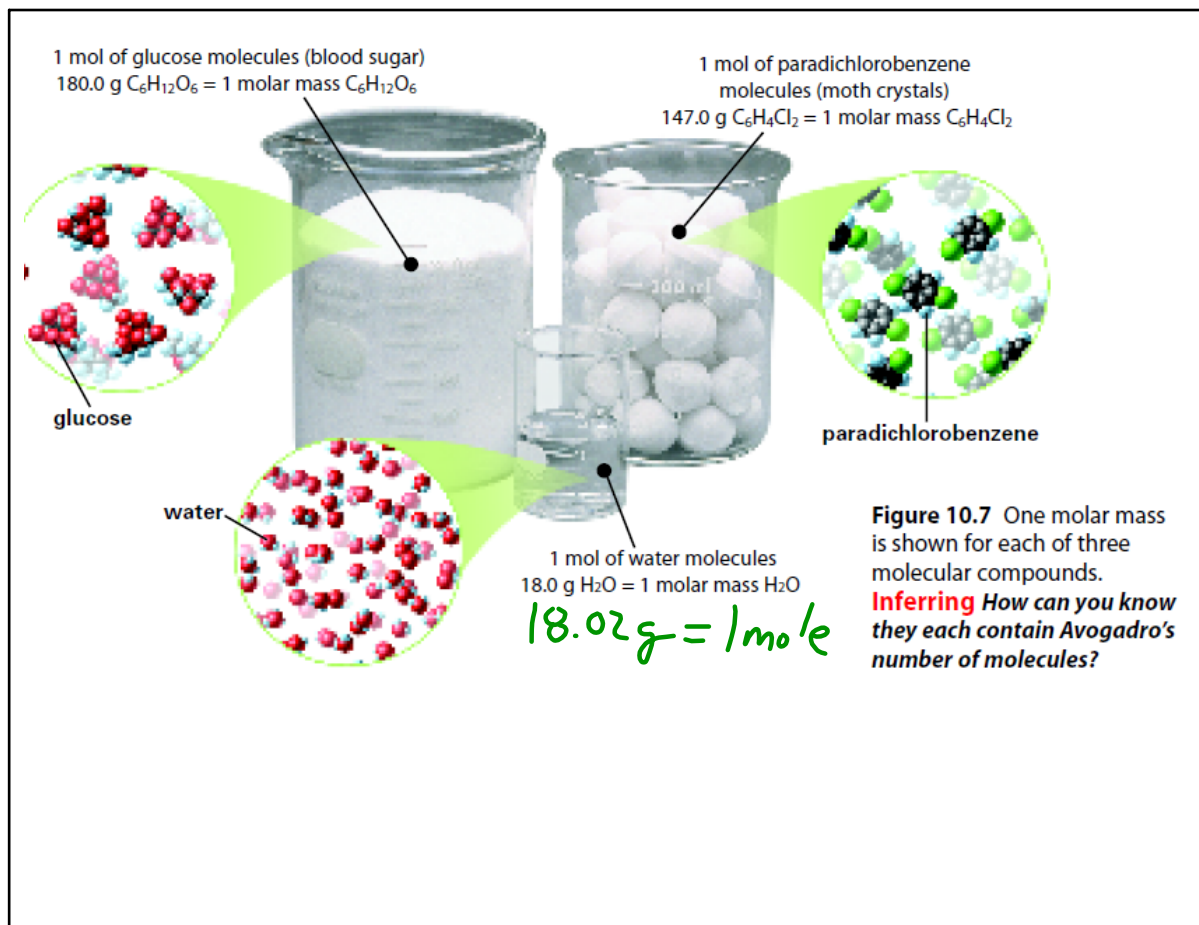
6. $4.65 \times 10^{24} \text{ molecules NO}_2 \times 1 \text{ mol} / 6.02 \times 10^{23} \text{ molecules} = 7.72 \text{ mol NO}_2$

Nov 6-8:34 PM

P293

CARBON ATOMS		HYDROGEN ATOMS		MASS RATIO
Number	Mass (amu)	Number	Mass (amu)	$\frac{\text{Mass carbon}}{\text{Mass hydrogen}}$
	12		1	$\frac{12 \text{ amu}}{1 \text{ amu}} = \frac{12}{1}$
	24 [2 × 12]		2 [2 × 1]	$\frac{24 \text{ amu}}{2 \text{ amu}} = \frac{12}{1}$
	120 [10 × 12]		10 [10 × 1]	$\frac{120 \text{ amu}}{10 \text{ amu}} = \frac{12}{1}$
	600 [50 × 12]		50 [50 × 1]	$\frac{600 \text{ amu}}{50 \text{ amu}} = \frac{12}{1}$
Avogadro's number	$(6.02 \times 10^{23}) \times (12)$	Avogadro's number	$(6.02 \times 10^{23}) \times (1)$	$\frac{(6.02 \times 10^{23}) \times (12)}{(6.02 \times 10^{23}) \times (1)} = \frac{12}{1}$

Nov 6-8:35 PM

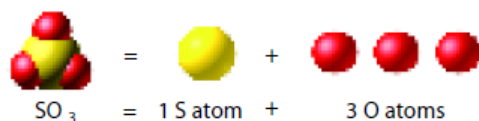


Nov 6-8:40 PM

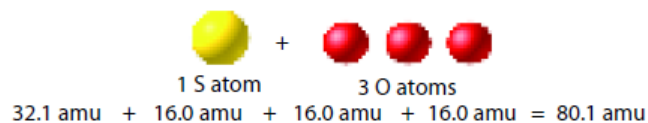
P295

The Mass of a Mole of a Compound

To find the mass of a mole of a compound, you must know the formula of the compound. The formula of sulfur trioxide is SO_3 . A molecule of SO_3 is composed of one atom of sulfur and three atoms of oxygen.



You can calculate the mass of a molecule of SO_3 by adding the atomic masses of the atoms making up the molecule. From the periodic table, the atomic mass of sulfur (S) is 32.1 amu. The mass of three atoms of oxygen is three times the atomic mass of a single oxygen atom (O): $3 \times 16.0 \text{ amu} = 48.0 \text{ amu}$. So, the molecular mass of SO_3 is $32.1 \text{ amu} + 48.0 \text{ amu} = 80.1 \text{ amu}$.



Nov 6-8:42 PM

What is the mass of 1 mole or 6.02×10^{23} molecules of H_2O ?

H	$2 \times 1.01 \text{ g}$	2.02 g
O	1×16.00	16.00
H_2O		18.02 g

What is the mass of 1 mole or 6.02×10^{23} molecules of CO_2 ?

$$\text{C} : 1 \times 12.01 \text{ g} = 12.01 \text{ g}$$

$$\text{O} : 2 \times 16.00 \text{ g} = 32.00 \text{ g}$$

$$44.01 \text{ g}$$

P296
7-8

Apr 18-10:37 AM

What is the mass of 1 mole or
 6.02×10^{23} molecules of H_2O ?

$6020000000000000000000000$

$$H: 2 \times 1.01g = 2.02g$$

$$O: 1 \times 16.00g = 16.00g$$

$$\text{Molar mass of } H_2O = 18.02g$$

What is the mass of 1 mole or
 6.02×10^{23} molecules of CO_2 ?

$$C: 1 \times 12.01g = 12.01g$$

$$O: 2 \times 16.00g = 32.00g$$

$$44.01g$$

P^{296}
 7^{-8}

Apr 18-10:37 AM

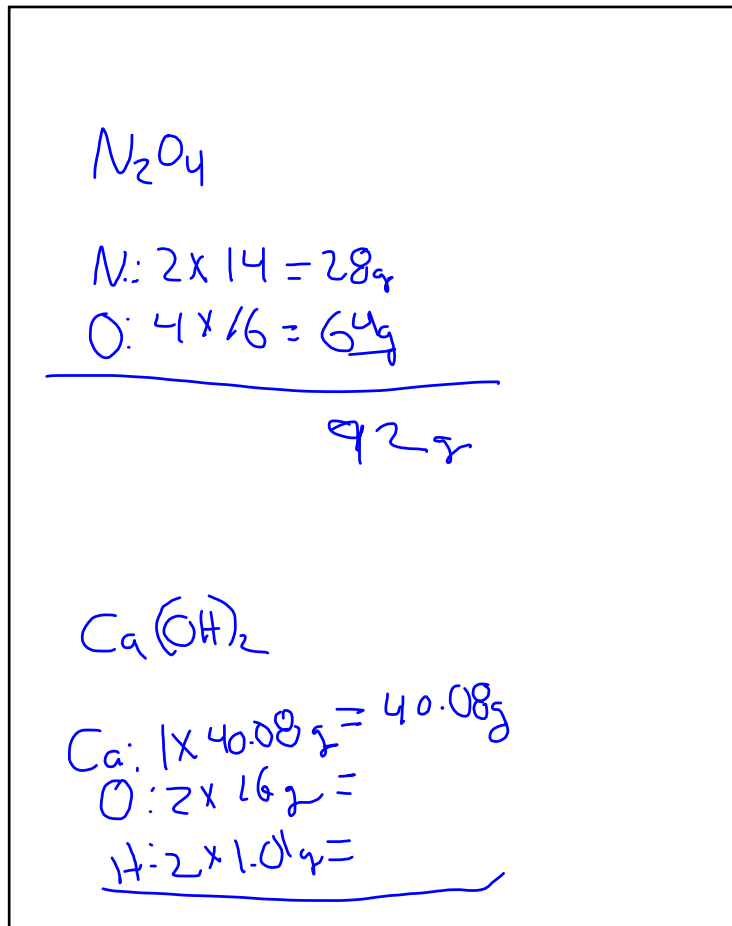
What is the molar mass of SO_2 ?

$$S: 1 \times 32.065g = 32.065g$$

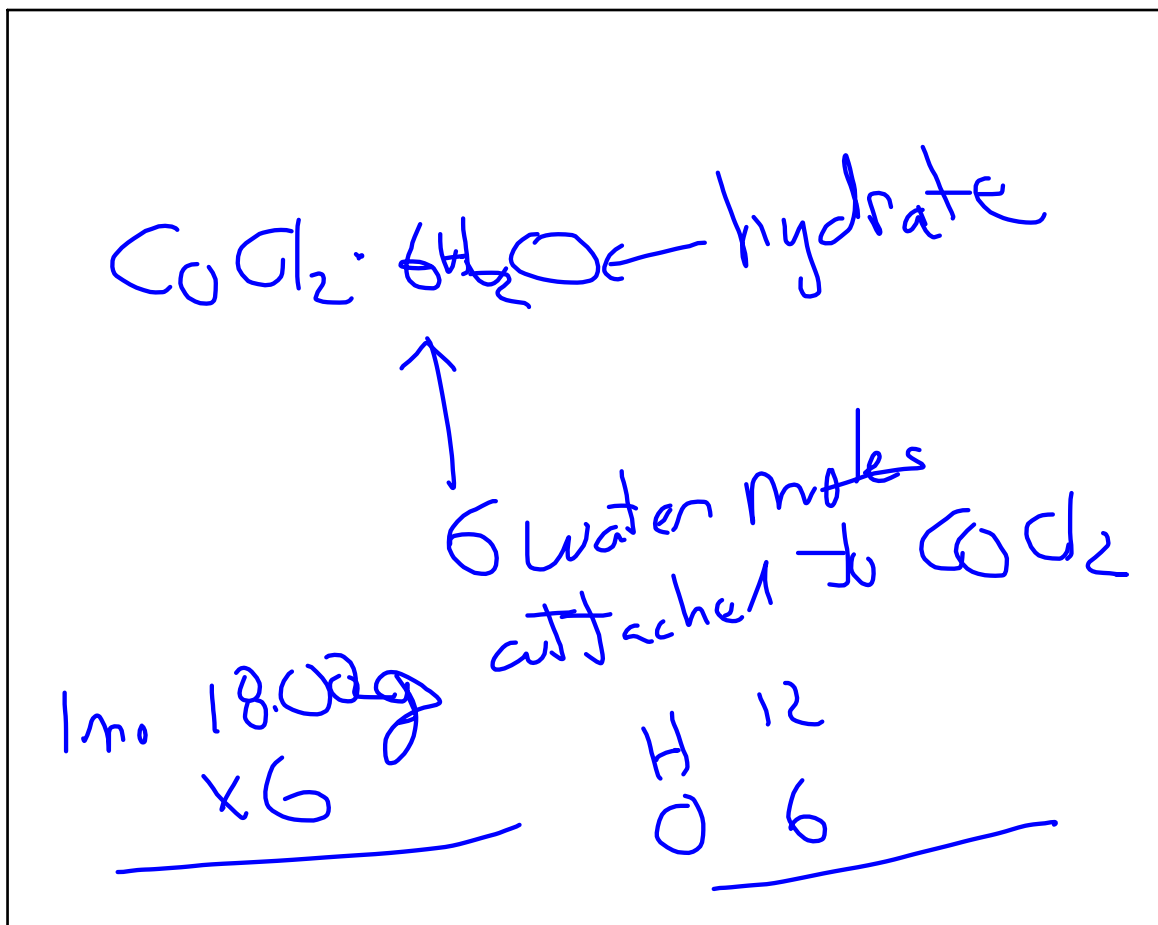
$$O: 3 \times 16.00g = 48.00g$$

$$\text{1 mole of } SO_2 \text{ has a mw: } 80.065g$$

Mar 24-1:11 PM



Apr 18-10:42 AM



Apr 18-10:49 AM

SAMPLE PROBLEM 10.4

p296

Finding the Molar Mass of a Compound

The decomposition of hydrogen peroxide (H_2O_2) provides sufficient energy to launch a rocket. What is the molar mass of hydrogen peroxide?



$$\text{H: } 2 \times 1.01\text{g} = 2.02\text{g}$$

$$\text{O: } 2 \times 16.00\text{g} = 32\text{g}$$

$$\text{mw H}_2\text{O}_2 \quad 34.02\text{g}$$

Nov 1-2:39 PM

p296

Practice Problems

7. Find the molar mass of PCl_3 .

8. What is the mass of 1.00 mol of sodium hydrogen carbonate?

$$\text{P: } 1 \times 30.97\text{g} = 30.97\text{g}$$

$$\text{Cl: } 3 \times 35.45\text{g} = 106.35\text{g}$$

$$137.32\text{g}$$

Nov 1-2:39 PM

14. How many atoms are in 1.75 mol CHCl_3 ?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} = \frac{1.75 \text{ mol}}{X}$$

$$X = 1.05 \times 10^{24}$$

Apr 11-2:28 PM

15. What is the molar mass of CaSO_4 ?



Nov 2-2:08 PM

Sodium Carbonate



$$\text{Na}: 2$$

$$\text{C}: 1$$

$$\text{O}_3:$$

Mar 24-1:20 PM

Calcium Bromate



$$\text{Ca}: 1 \times 40.078 \text{ g} = 40.078 \text{ g}$$

$$\text{Br}: 2 \times 79.904 = 159.808 \text{ g}$$

$$\text{O}: 6 \times 16.00 = 96.00 \text{ g}$$

$$295.886 \text{ g}$$

Mar 24-1:22 PM

14. How many atoms are in 1.75 mol CHCl_3 ?

$$\frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} = \frac{1.75 \text{ mol}}{x \text{ atoms}}$$

↑ 5 atoms

$$x = 1.05 \times 10^{24}$$

x 5

$$5.25 \times 10^{24} \text{ atoms}$$

Please do not write

$$1.05 \text{ E } 24$$

Nov 2-2:05 PM

P296

Section 10.1 Assessment

- | | |
|---|---|
| 9. by count, by mass, and by volume | 12. Add together the masses, expressed in grams, of each element in one mole of the compound. |
| 10. One mole of any substance contains Avogadro's number (6.02×10^{23}) of representative particles. | 13. $2.49 \times 10^{-1} \text{ mol NH}_3 = 0.249$ |
| 11. The molar mass of an element is its atomic mass expressed in grams. | 14. $5.27 \times 10^{24} \text{ atoms}$ |
| | 15. 136.2 g/mol |

Nov 6-8:43 PM