SI Chemistry - Full Discipline Demo

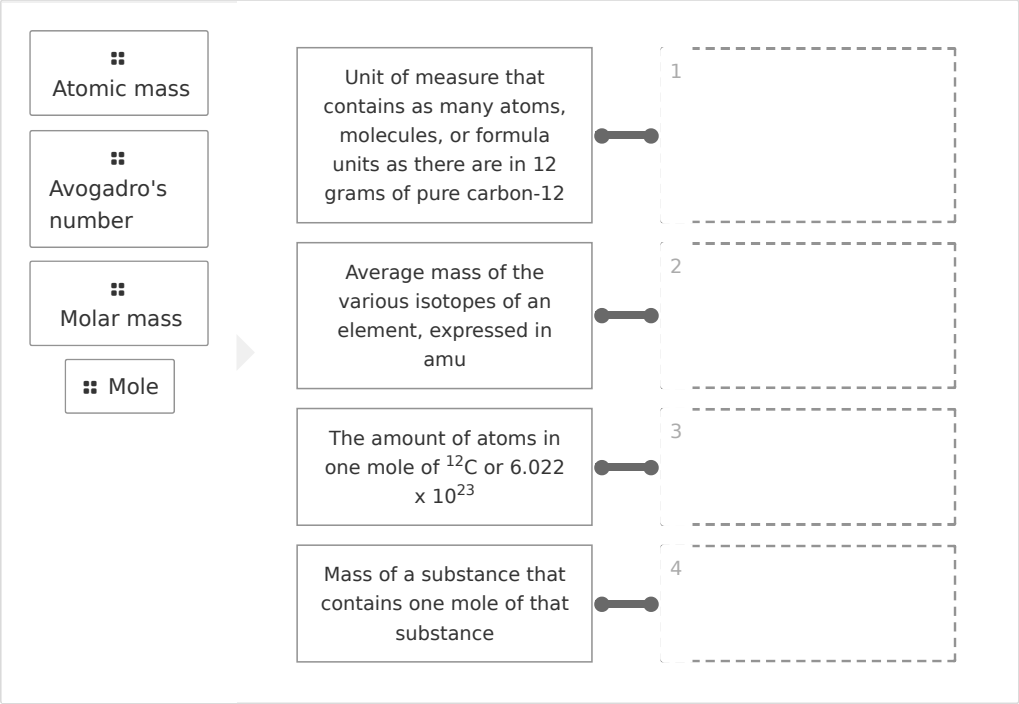
Mass Conversions to Moles and Atoms

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

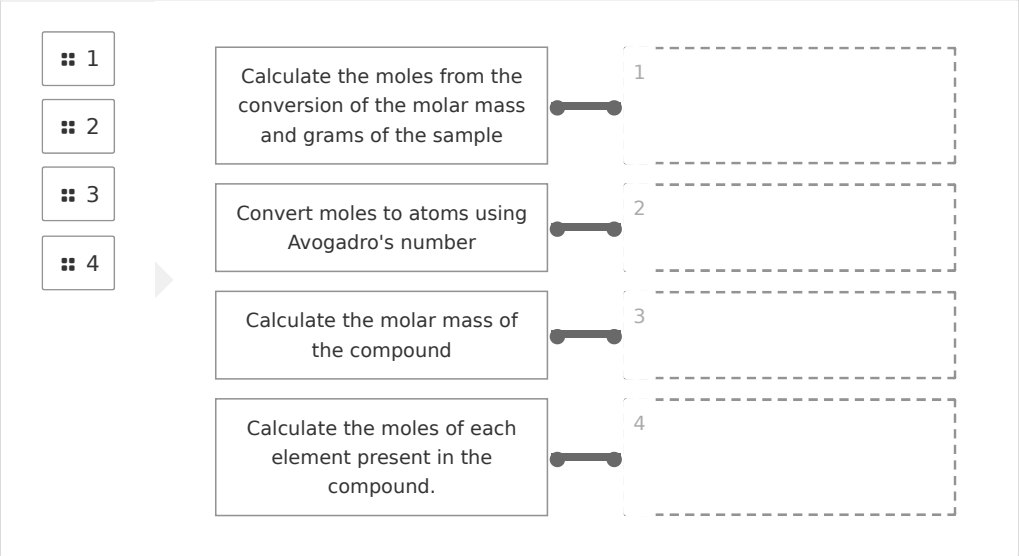
Match each term with the best description.



Correct answers:

1 Mole 2 Atomic mass 3 Avogadro's number 4 Molar mass

Order the steps for calculating the atoms of an element present in a compound.



Correct answers:

1 2 2 4 3 1 4 3

Exploration

A mole is a unit of measure describing the amount of a chemical substance that contains as many atoms, molecules, or formula units as there are in 12 grams of pure carbon-12.

- True ✔
- False

The atomic mass unit is standardized to equal ____.

- exactly the mass of ^{12}C
- $1/12^{th}$ the mass of ^{12}C ✔
- 1/2 the mass of ^{12}C
- None of the above

One mole of an element or compound is equal to its ____.

- atomic mass
- molecular mass
- molar mass
- atomic or molecular mass ✔
- All of the above

To determine the molar mass of a compound, you must first ____.

- identify the molar mass of each element in the compound ✔
- add the molar masses of each element in the compound together
- calculate the molar mass of each element by multiplying by 1 g/mol

Avogadro's number, ____, is used to convert moles to atoms.

- 6.023×10^{24}
- 6.22×10^{23}
- 6.022×10^{23} ✔
- 6.002×10^{23}

Exercise 1

Describe the relationship between moles and atoms.

The unit of measure referred to as a mole is used for the counting of atoms. A mole (n) is a unit of measure, describing the amount of a chemical substance that contains as many atoms, molecules, or formula units as there are in exactly 12 grams of pure carbon-12 (^{12}C). This amount of atoms (6.022×10^{23}) is referred to as Avogadro's number. Thus, a 12.01 g sample of the average, naturally occurring carbon contains 6.022×10^{23} atoms.

Which item in Data Table 1 contains the largest quantity of moles?

The glass stirring rod contains the largest quantity of moles.

Which item in Data Table 1 contains the least amount of oxygen atoms?

The cotton ball contains the least amount of oxygen atoms.

Data Table 1: Conversions to Moles and Atoms
(SAMPLE ANSWER BELOW)

Item	Formula	Molar Mass (g/mol)	Mass of Sample (g)	Moles of Sample (mol)	Moles of Each Element (mol)	Atoms of Each Element
Aluminum Cup	Al	26.982	2.35	0.0871	Al:0.0871	Al:5.25x10^22
Glass Stirring Rod	SiO_2	60.084	6.89	0.115	Si:0.115	Si:6.93x10^22
					O:0.230	O:1.39x10^23
Cotton Ball	$C_6H_{10}O_5$	162.081	0.59	0.0036	C:0.022	C:1.3x10^22
					H:0.036	H:2.2x10^22
					O:0.018	O:1.1x10^22

Exercise 2

A sample of 2 tsp of sugar ($C_{12}H_{22}O_{11}$) weighs 9.00 g.

a. Record each step needed to calculate the moles and atoms of all elements present in the sample.

b. Then, calculate the moles and atoms of each element in the sample of sugar on a sheet of paper. Show all work to answer this question. Take a photo of your work and upload the image into Photo 2.

The first step to calculate the number of moles and atoms of elements present in a sample is to calculate the molar mass of the compound by using the Periodic Table to determine the atomic mass of each element and multiplying by 1 g/mol. Then the sum of the molar masses is added (included multiplying any elements by the number of atoms present in the compound) to determine the molar mass of the compound. The molar mass is then used to convert the grams of the sample to moles by dividing the grams of the sample by the molar mass of the compound. Once the moles of the compound are calculated, then the moles of each element can be calculated by individually multiplying the moles of the compound by the number of atoms of the element present in the compound. The atoms can then be calculated by multiplying the moles of each element by Avogadro's number (6.022×10^{23}).

Panel 1: Experimental Design

(SAMPLE ANSWER BELOW)

Students should write an experimental design that begins by determining the mass of the chalk before writing their name by weighing it on a digital scale. Students would then write their name with chalk on a piece of paper. Then, students should weigh the piece of chalk to determine the mass of the chalk after writing their name. The difference in mass would be the mass of chalk required to write their name.
Students will need to calculate the molar mass of the chalk. After calculating the molar mass students can determine the number of moles of chalk by dividing the mass of chalk used by the molar mass. Then, the number of moles of calcium can be calculated by multiplying the number of moles of chalk by 1 mol calcium. Students can finally determine the atoms of calcium by multiplying the moles of calcium by Avogadro's number (6.022×10^{23}).

Photo 1: Calculations

(SAMPLE ANSWER BELOW)

0.20 g of chalk:

$$\text{Molar mass of } CaCO_3 = 40.078\text{ g} + 12.011\text{ g} + (3 \times 15.999)\text{ g} = 100.076\text{ g}$$

$$0.20\ \cancel{\text{g } CaCO_3} \times \frac{1\text{ mol } CaCO_3}{100.086\ \cancel{\text{g } CaCO_3}} = 0.0020\text{ mol of } CaCO_3$$

$$0.0020\ \cancel{\text{mol of } CaCO_3} \times \frac{1\text{ mol Ca}}{1\ \cancel{\text{mol } CaCO_3}} = 0.0020\text{ mol of Ca}$$

$$0.0020\ \cancel{\text{mol Ca}} \times \frac{6.022 \times 10^{23}\text{ atoms}}{1\ \cancel{\text{mol}}} = 1.2 \times 10^{22}\text{ atoms of Ca}$$

1 mol Ca

Panel 2: Conclusion Statement

(SAMPLE ANSWER BELOW)

Student's should include a conclusion statement, such as:
The number of calcium atoms required to write my name is 1.2×10^{22}.

Photo 2: Question 1 Calculations

(SAMPLE ANSWER BELOW)

Sample of 2 tsp of $C_{12}H_{22}O_{11}$ weighing 9.00 g:

Atomic mass of carbon (C): 12.011
Atomic mass of hydrogen (H): 1.008
Atomic mass of oxygen (O): 15.999

Molar mass of carbon (C): 12.011 x 1 g/mol
Molar mass of hydrogen (H): 1.008 x 1 g/mol
Molar mass of oxygen (O): 15.999 x 1 g/mol

$$\text{Molar mass of } C_{12}H_{22}O_{11} = (12 \times 12.011 \text{ g/mol}) + (22 \times 1.008 \text{ g/mol}) + (11 \times 15.999 \text{ g/mol}) = 342.297 \text{ g/mol}$$

$$9.00 \text{ g } C_{12}H_{22}O_{11} \times \frac{1 \text{ mol } C_{12}H_{22}O_{11}}{342.297 \text{ g } C_{12}H_{22}O_{11}} = 0.0263 \text{ mol of } C_{12}H_{22}O_{11}$$

$$0.0263 \text{ mol of } C_{12}H_{22}O_{11} \times \frac{12 \text{ mol C}}{1 \text{ mol } C_{12}H_{22}O_{11}} = 0.316 \text{ mol of C}$$

$$0.0263 \cancel{\text{ mol of } C_{12}H_{22}O_{11}} \times \frac{22 \text{ mol H}}{1 \cancel{\text{ mol } C_{12}H_{22}O_{11}}} = 0.579 \text{ mol of H}$$

$$0.0263 \cancel{\text{ mol of } C_{12}H_{22}O_{11}} \times \frac{11 \text{ mol O}}{1 \cancel{\text{ mol } C_{12}H_{22}O_{11}}} = 0.289 \text{ mol of O}$$

$$0.316 \cancel{\text{ mol C}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \cancel{\text{ mol C}}} = 1.90 \times 10^{23} \text{ atoms of C}$$

$$0.579 \cancel{\text{ mol H}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \cancel{\text{ mol H}}} = 3.49 \times 10^{23} \text{ atoms of H}$$

$$0.289 \cancel{\text{ mol O}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \cancel{\text{ mol O}}} = 1.74 \times 10^{23} \text{ atoms of O}$$

Competency Review

There are ____ atoms in 12 grams of pure carbon (^{12}C).

- 12.022 x 10^{23}
- 6.022 x 10^{23} ✔
- 4.023 x 10^{23}

One mole of a substance is equal to its atomic mass in grams.

- [x] True
- [ ] False

The element oxygen has a molar mass of 15.999 grams, thus one mole of oxygen is equal to _____ grams.

- [ ] 31.998
- [ ] 15.999×10^{23}
- [x] 15.999
- [ ] 6.023×10^{23}

The atomic mass unit was standardized to $1/12^{th}$ of the mass of one _____ atom.

- [x] ^{12}C
- [ ] ^{13}C
- [ ] ^{14}C
- [ ] C

The molar mass of $MgCl_2$ is _____. (Mg = 24.305 g/mol; Cl = 35.453 g/mol)

- [ ] 59.758 g/mol
- [ ] 90.213 g/mol
- [x] 95.211 g/mol

The second step in converting between the mass of a compound and moles of a compound is to _____.

- [ ] determine the number of atoms in the compound
- [x] use the molar mass to convert grams to moles
- [ ] determine the molar mass of a compound

An 18.0 g sample of tin(II) fluoride (SnF_2) has _____ moles of tin. (Sn = 118.711 g/mol; F = 18.998 g/mol)

- 0.115 ✔
- 0.230
- 8.71

There are _____ atoms of potassium in 0.307 mol of potassium.

- 1.84×10^{22}
- 5.10×10^{-25}
- 1.85×10^{23} ✔
- 1.84×10^{-25}

A cookie containg 4.0 g of baking soda ($NaHCO_3$) has _____ mol of $NaHCO_3$.

- 0.048 ✔
- 336.02
- 84.007
- 1

In order to determine how many moles of calcium are required to write your name on paper with a piece of chalk, you must first _____.

- calculate the number of moles of chalk
- weigh the piece of chalk ✔
- write your name on a piece of paper

Extension Questions

Explain the relationship between moles of a compound and moles of an individual element within that compound. Can the number of moles of a compound ever be equal to the number of moles of one of its components? Why or why not?

(Consider the moles of chalk that you used to write your name while answering this question.)

(SAMPLE ANSWER BELOW)

The number of moles of a compound, and the number of moles of an individual element within that compound, are determined by mole ratios. If the ratio is 1:1, as was the case with $CaCO_3$ and Ca, then the number of moles will be the same for the element and the entire compound.