



Mole Problems

The concept of a mole is an important one for chemistry. While we work with grams or millilitres in human terms, using chemical substances, chemical reactions happen among molecules. We use moles to perform calculations about reactions, and that means we have to translate our human measurements into moles and back again to know what's going on in the lab.

A mole is 6.022×10^{23} of something. For a metal, like silver, a mole represents 6.022×10^{23} atoms of silver. For molecular compounds, like carbon dioxide, a mole is 6.022×10^{23} molecules. For an ionic substance in solution, a mole is 6.022×10^{23} of any ion that results from dissociation.

Example 1: Determine the number of molecules in 5.25 moles of water (H_2O).

Solution: Since a mole is a fixed number of molecules, we can use a simple conversion fraction to calculate the answer:

$$5.25 \text{ mol H}_2\text{O} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 3.16 \times 10^{24} \text{ molecules H}_2\text{O}$$

Example 2: Determine the number of moles of sodium ions in 0.565 moles of Na_2SO_4 .

Solution: When sodium sulfate dissociates, it produces two Na^+ ions, so:

$$0.565 \text{ mol Na}_2\text{SO}_4 \times \frac{2 \text{ Na}^+ \text{ ions}}{1 \text{ Na}_2\text{SO}_4 \text{ "molecule"}} = 1.13 \text{ mol Na}^+$$

When we are asked to convert grams into moles, we need to find the **molar mass** of the substance in the question, using the periodic table.

Example 3: Determine the number of moles in 78.5 g of potassium benzoate ($\text{C}_7\text{H}_5\text{KO}_2$).

Solution: First, we need the molar mass of potassium benzoate. We calculate this by adding the atomic weights of all the atoms in the molecule:

$$\begin{aligned} & (7 \text{ carbon}) + (5 \text{ hydrogen}) + (1 \text{ potassium}) + (2 \text{ oxygen}) \\ = & (7 \times 12.011) + (5 \times 1.008) + (39.098) + (2 \times 16.000) \\ = & 160.215 \text{ g/mol} \end{aligned}$$

hydrogen	1.008
carbon	12.011
oxygen	16.000
potassium	39.098

We can now use this as a conversion fraction to find the number of moles:

$$78.5 \text{ g C}_7\text{H}_5\text{KO}_2 \times \frac{1 \text{ mol C}_7\text{H}_5\text{KO}_2}{160.215 \text{ g C}_7\text{H}_5\text{KO}_2} = 0.490 \text{ mol C}_7\text{H}_5\text{KO}_2$$



EXERCISES

A. Determine the number of:

- 1) atoms in 1 molecule of benzene (C_6H_6)
- 2) carbon atoms in 1 molecule of benzene
- 3) hydrogen atoms in 15 molecules of benzene
- 4) atoms in 1 mole of benzene
- 5) atoms in 0.793 mol of oxygen gas (O_2)

B. Determine the number of moles of:

- 1) molecules in 3.77×10^{23} molecules of H_2O
- 2) carbon atoms in 3.5 mol propane (C_3H_8)
- 3) hydrogen ions in 2.67 mol of phosphoric acid (H_3PO_4)
- 4) ions in 1.98 mol of aluminum sulphate ($Al_2(SO_4)_3$)

C. Determine, to three decimal places, the molar mass of:

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|--|--------------------------------------|
| 1) water (H_2O) | 7) iodine (I_2) |
| 2) carbon dioxide (CO_2) | 8) nitrogen trioxide (NO_3) |
| 3) methane (CH_4) | 9) chloroethane (C_2H_5Cl) |
| 4) hydrocyanic acid (HCN) | 10) sodium hydroxide ($NaOH$) |
| 5) calcium nitrate ($Ca(NO_3)_2$) | 11) ammonium chloride (NH_4Cl) |
| 6) phenolphthalein ($C_{20}H_{14}O_4$) | 12) sucrose ($C_{12}H_{22}O_{11}$) |



D. Determine the number of moles in:

1) 18.1 g of water

2) 30.75 g of carbon dioxide

3) 12.98 g of methane

4) 10.2 g of hydrocyanic acid

5) 5.87 g of calcium nitrate

6) 142.6 g of phenolphthalein



E. Determine the mass of:

- 1) 0.875 mol of iodine

- 2) 1.86 mol of nitrogen trioxide

- 3) 0.433 mol of chloroethane

- 4) 0.952 mol of sodium hydroxide

- 5) 2.00 mol of ammonium chloride

- 6) 0.667 mol of sucrose

SOLUTIONS

- A. (1) 12 (2) 6 (3) 90 (4) 7.2264×10^{24} (5) 9.55×10^{23}
- B. (1) 0.626 mol (2) 11 mol (3) 8.01 mol (4) 9.90 mol
- C. (1) 18.106 %_{mol} (2) 44.011 %_{mol} (3) 16.043 %_{mol} (4) 27.026 %_{mol} (5) 164.092 %_{mol}
(6) 318.332 %_{mol} (7) 253.808 %_{mol} (8) 62.007 %_{mol} (9) 64.515 %_{mol} (10) 39.998 %_{mol}
(11) 53.492 %_{mol} (12) 342.308 %_{mol}
- D. (1) 1.00 mol H₂O (2) 0.6987 mol CO₂ (3) 0.8091 mol CH₄ (4) 0.377 mol HCN
(5) 0.0358 mol Ca(NO₃)₂ (6) 0.4480 mol C₂₀H₁₄O₄
- E. (1) 222 g I₂ (2) 115 g NO₃ (3) 27.9 g C₂H₅Cl (4) 38.1 g NaOH (5) 107 g NH₄Cl
(6) 228 g C₁₂H₂₂O₁₁

