The mole: mass and particle number

Student activity • calculation workshop

YEAR 10 / LESSON 42 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

How can a measurable mass tell us the number of particles?

Connect amount of substance, mass and specified entities. Use the modern mole definition, a rounded Avogadro constant for practice and units throughout. Oxygen atoms and oxygen molecules must not be counted as the same entity.

Equipment

- Booklet, calculator with exponent key and periodic table

Desk activity only; no chemicals or practical equipment.

Course coverage: 1.27–1.29: mole as amount-of-substance unit, mass–amount calculations and equation ratios; particle counting supports the school objectives.

Plan, model or apparatus sketch

Show how mass, amount in moles and number of entities are connected.

Method and reasoning

Read the whole sequence before starting

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1. State what entity you are counting: atoms, molecules, ions or formula units. Write the unit mol for amount of substance.

2. Read the exact mole definition in the reference box. Use Avogadro constant ≈ 6.02×10^{23} mol^{-1} for these practice calculations and keep that rounding consistent.

3. Use n = m/M to calculate amounts from masses, showing g divided by g mol^{-1}. Use m = nM for the reverse calculation.

4. Use N = n × Avogadro constant to calculate entity counts. Enter exponents carefully and report the named entity alongside the number.

5. For O_2, distinguish moles of molecules from moles of oxygen atoms: each molecule contains two atoms.

6. Complete the four table cases, then interpret the mole ratio in $2H_2 + O_2 \rightarrow 2H_2O$ without treating coefficients as masses.

7. Check answers by estimating magnitude, reversing a calculation and checking units.

Cleanup

- Keep corrected calculations and return shared materials.

Record your evidence

Blank spaces are for your own work

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Reference and task data

One mole contains exactly $6.02214076 \times 10^{23}$ specified elementary entities (BIPM). For these exercises use Avogadro constant $\approx 6.02 \times 10^{23}$ mol^{-1}. n = m/M; N = n × Avogadro constant. M is molar mass in g mol^{-1}, while A_r and M_r are dimensionless. Use M(Mg)=24, M(H_2O)=18, M(CO_2)=44 and M(O_2)=32 g mol^{-1}.

Given case	Amount n / mol	Entity count N
12.0 g Mg; M = 24 g mol^{-1}		
9.0 g H_2O; M = 18 g mol^{-1}		
0.250 mol CO_2 molecules		
2.00 mol O_2 molecules		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Complete the amounts and entity counts in the table; name each entity.

2. Find the mass of 0.250 mol CO_2.

3. Find the amount and mass of 1.204×10^{24} O_2 molecules.

4. How many oxygen atoms are in 2.00 mol O_2 molecules? Show both stages.

5. Use $2H_2 + O_2 \rightarrow 2H_2O$ to relate 0.50 mol O_2 to H_2 required and water formed.

6. Correct: “one mole always weighs 12 g” and “the relative molecular mass has units g mol^{-1}”.