

Teacher Mole's Nightmare

Simulation: edtechsims.com/teacher-moles-nightmare

Name: _____ Class: _____ Date: _____



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Data

Useful data	
Ar: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, Al = 27, S = 32, Cl = 35.5, Ca = 40, Fe = 56, Cu = 64	
Avogadro constant $L = 6.02 \times 10^{23} / \text{mol}$	Molar gas volume = 24 dm^3 ($24\,000 \text{ cm}^3$) at r.t.p.

Part A: Escape the Nightmare

On the sim: Choose Solo or Team mode. Solve at least 5 of the 9 stations (3 questions each) to unlock the Final Vault, then sort the true statements from the traps to wake up.

A1 Record your progress in Table 1. For each station you solve, note one mistake (misconception) it warned you about.

Station	Solved (✓)	Misconception I learned about/ Step I must be careful carrying out
Asteroid Shower		
Seesaw of Moles		
Atom Accountant		
Formula Forensics		
Balloon Mania		
Toxic Brew		
Canteen Rush		
Gas Guesses		
Titration Terror		

Part B: Station Practice

Each station's questions change every time you play. Use these questions to practise the same skills.

B1 Asteroid Shower: relative molecular mass

Calculate the Mr of each substance.

[4]

Substance	Mr	Substance	Mr
Mg(NO ₃) ₂		CuSO ₄ ·5H ₂ O	
Al ₂ (SO ₄) ₃		Cl ₂	

B2 Seesaw of Moles: moles from mass

(a) Calculate the number of moles in 8.0 g of O₂ and in 11 g of CO₂.

[2]

.....

.....

(b) Do the two samples contain the same number of molecules? Explain.

[1]

.....

B3 Atom Accountant: atoms vs molecules

Sample	Number of molecules	Number of atoms
0.5 mol of H ₂ O		
2 mol of O ₂		
0.25 mol of CH ₄		

B4 Formula Forensics: empirical and molecular formulae

(a) A hydrocarbon contains 85.7% carbon and 14.3% hydrogen by mass. Find its empirical formula. [3]

(b) The Mr of the hydrocarbon is 56. Find its molecular formula. [2]

B5 Balloon Mania: molar gas volume

(a) Calculate the volume of 0.25 mol of CO₂ at r.t.p. [1]

volume = ... dm³

(b) Calculate the number of moles in 600 cm³ of H₂ at r.t.p. [1]

moles = ... mol

B6 Toxic Brew: concentration and standard solutions

(a) Calculate the mass of NaOH needed to make 250 cm³ of 0.200 mol/dm³ solution. [2]

mass = ... g

(b) Number the steps (1–4) for making this standard solution. [2]

Step	Order
Make up to the mark with distilled water, then invert to mix	
Weigh the NaOH accurately	
Transfer the solution and rinsings to a 250 cm ³ volumetric flask	
Dissolve the solid in a little distilled water in a beaker	

B7 Canteen Rush: limiting reactant

4.8 g of Mg is burned in 4.0 g of O₂: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

(a) Identify the limiting reactant. Show your working. [2]

.....

.....

.....

(b) Calculate the mass of MgO formed. [2]

mass = ... g

B8 Gas Guesses: volume of gas produced

$\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$

(a) Calculate the volume of H₂ produced when 0.12 g of Mg reacts with excess acid at r.t.p. [2]

volume = ... cm³

(b) In $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, what volume of O₂ reacts with 50 cm³ of H₂? [1]

volume = ... cm³

B9 Titration Terror: titres and concentration

A student records these titres: rough 24.10 cm³; 23.40 cm³; 23.45 cm³; 23.80 cm³.

(a) Which titres are concordant? Calculate the mean titre. [2]

.....

.....

(b) 25.0 cm³ of 0.100 mol/dm³ NaOH is neutralised by 12.50 cm³ of H₂SO₄. Calculate the concentration of the H₂SO₄. $\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ [3]

concentration = ... mol/dm³

Part C: The Final Vault

Like the Final Vault in the game, there are 8 statements. Circle True or False. If a statement is a trap, correct it.

1. The Mr of Cl_2 is 35.5.

True / False Correction:.....

2. 2 g of H_2 and 32 g of O_2 contain the same number of molecules.

True / False Correction:.....

3. 1 mol of O_2 contains 6.02×10^{23} atoms.

True / False Correction:.....

4. Glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, has the empirical formula CH_2O .

True / False Correction:.....

5. Diluting a solution decreases the number of moles of solute.

True / False Correction:.....

6. The reactant with the smaller mass is always the limiting reactant.

True / False Correction:.....

7. In $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, 40 cm^3 of H_2 reacts with 20 cm^3 of O_2 .

True / False Correction:.....

8. The rough titre should be included when calculating the mean titre.

True / False Correction:.....

Part D: Practice Questions

D1 5.0 g of calcium carbonate reacts with excess hydrochloric acid. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

(a) Calculate the number of moles of CaCO_3 used. [1]

moles = ... mol

(b) Calculate the volume of CO_2 produced at r.t.p. [2]

volume = ... dm^3

(c) Only 1.0 dm^3 of CO_2 was collected. Calculate the percentage yield. [2]

percentage yield = ... %

D2 3.2 g of sulfur burns completely in oxygen. $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$

(a) Calculate the mass of SO_2 formed. [2]

mass = ... g

(b) Calculate the volume of O_2 used at r.t.p. [1]

volume = ... dm^3

Answer Key: Teacher Mole's Nightmare

Data

Useful data	
Ar: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, Al = 27, S = 32, Cl = 35.5, Ca = 40, Fe = 56, Cu = 64	
Avogadro constant $L = 6.02 \times 10^{23} / \text{mol}$	Molar gas volume = 24 dm^3 ($24\,000 \text{ cm}^3$) at r.t.p.

Part A: Escape the Nightmare

On the sim: Choose Solo or Team mode. Solve at least 5 of the 9 stations (3 questions each) to unlock the Final Vault, then sort the true statements from the traps to wake up.

A1 Record your progress in Table 1. For each station you solve, note one mistake (misconception) it warned you about.

Misconceptions by station

Station	Misconceptions targeted
1. Asteroid Shower	Brackets not multiplied out; Water of crystallisation mishandled; Subscripts ignored or misapplied; Proton number used instead of Ar; Diatomic gases treated as single atoms
2. Seesaw of Moles	Thinking 1 mol of anything has the same mass; Assuming equal masses means equal moles; Moles and mass treated as the same number; Formula used upside down; Thinking gas volume depends on the type of gas; Avogadro constant misused
3. Atom Accountant	Brackets not multiplied out; Subscripts ignored or misapplied; Diatomic gases treated as single atoms; Assuming equal masses means equal moles; Moles and mass treated as the same number; Formula used upside down; Molecules and atoms confused; Avogadro constant misused
4. Formula Forensics	Subscripts ignored or misapplied; Diatomic gases treated as single atoms; Formula used upside down; Percentages used directly as the mole ratio; Ratio rounded instead of multiplied; Empirical and molecular formula confused
5. Balloon Mania	Diatomic gases treated as single atoms; Thinking 1 mol of anything has the same mass; Assuming equal masses means equal moles; Moles and mass treated as the same number; Formula used upside down; Thinking gas volume depends on the type of gas; 24 dm^3 applied to a solid or liquid; cm^3 and dm^3 mixed up
6. Toxic Brew	Water of crystallisation mishandled; Subscripts ignored or misapplied; Moles and mass treated as the same number; Formula used upside down; cm^3 and dm^3 mixed up; Solvent volume confused with solution volume; Thinking dilution changes the moles of solute; g/dm^3 and mol/dm^3 mixed up
7. Canteen Rush	Thinking 1 mol of anything has the same mass; Moles and mass treated as the same number; Formula used upside down; Equation coefficients used as mass ratios; Smaller amount assumed to be limiting; Mole ratio from the equation ignored

Station	Misconceptions targeted
8. Gas Syringe Guesses	Assuming equal masses means equal moles; Moles and mass treated as the same number; Formula used upside down; Mr of the wrong substance used; Thinking gas volume depends on the type of gas; cm^3 and dm^3 mixed up; Mole ratio from the equation ignored
9. Titration Terror	Formula used upside down; cm^3 and dm^3 mixed up; Mole ratio from the equation ignored; Burette read at the top of the meniscus; Burette scale read in the wrong direction; Rough titre included in the mean; Non-concordant titres used

Every station also uses a general "Calculation or reasoning slip" tag which is as follows:

What each misconception means (the game's fix text)

Misconception	Correct idea
Brackets not multiplied out	Everything inside a bracket is multiplied by the number after it: $\text{Ca}(\text{OH})_2$ has 2 O and 2 H.
Water of crystallisation mishandled	$\cdot 5\text{H}_2\text{O}$ means five whole water molecules: add $5 \times 18 = 90$ to the Mr.
Subscripts ignored or misapplied	A subscript multiplies only the atom (or bracket) directly before it.
Proton number used instead of Ar	Use the relative atomic mass, not the proton number.
Diatomic gases treated as single atoms	O_2 , N_2 , H_2 and Cl_2 exist as two-atom molecules: the Mr of O_2 is 32, not 16.
Thinking 1 mol of anything has the same mass	A mole is a fixed number of particles; its mass depends on the Mr.
Assuming equal masses means equal moles	Equal masses of different substances contain different numbers of moles. Always divide by Mr.
Moles and mass treated as the same number	$\text{moles} = \text{mass} \div \text{Mr}$.
Formula used upside down	$\text{moles} = \text{mass} \div \text{Mr}$ and $\text{moles} = \text{volume} \div 24 \text{ dm}^3$. Check that the units work out.
Mr of the wrong substance used	Find the moles of the substance whose mass you were given, using its own Mr.
Thinking gas volume depends on the type of gas	At r.t.p., 1 mol of any gas occupies 24 dm^3 , light or heavy.
24 dm^3 applied to a solid or liquid	Molar gas volume applies only to gases.
cm^3 and dm^3 mixed up	$1 \text{ dm}^3 = 1000 \text{ cm}^3$. Convert cm^3 to dm^3 before using mol/dm^3 or 24 dm^3 .
Solvent volume confused with solution volume	Concentration uses the final volume of solution: dissolve, then make up to the mark.

Misconception	Correct idea
Thinking dilution changes the moles of solute	Adding water spreads the same moles through a larger volume.
g/dm^3 and mol/dm^3 mixed up	$\text{g/dm}^3 = \text{mol/dm}^3 \times \text{Mr}$.
Molecules and atoms confused	1 mol of H_2O has 6.02×10^{23} molecules but $3 \times 6.02 \times 10^{23}$ atoms.
Avogadro constant misused	Number of particles = moles $\times 6.02 \times 10^{23}$.
Equation coefficients used as mass ratios	Coefficients are mole ratios. Convert masses to moles first.
Smaller amount assumed to be limiting	Compare what is available with the ratio needed.
Mole ratio from the equation ignored	Use the coefficients in the balanced equation to go between substances.
Burette read at the top of the meniscus	Read the bottom of the meniscus at eye level.
Burette scale read in the wrong direction	A burette reads 0.00 at the top and increases downwards.
Rough titre included in the mean	Leave the rough titre out of the mean titre.
Non-concordant titres used	Average only titres that agree within 0.10 cm^3 .
Percentages used directly as the mole ratio	Divide each percentage by its A_r to get moles, then find the simplest ratio.
Ratio rounded instead of multiplied	If a ratio ends in about .5 or .33, multiply by 2 or 3 instead of rounding.
Empirical and molecular formula confused	Molecular formula = empirical formula $\times n$, where $n = \text{Mr} \div \text{empirical formula mass}$.

Part B: Station Practice

Each station's questions change every time you play. Use these questions to practise the same skills.

B1 Asteroid Shower: relative molecular mass

Calculate the Mr of each substance.

[4]

Substance	Mr	Substance	Mr
$\text{Mg}(\text{NO}_3)_2$	148	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	250
$\text{Al}_2(\text{SO}_4)_3$	342	Cl_2	71

B2 Seesaw of Moles: moles from mass

(a) Calculate the number of moles in 8.0 g of O₂ and in 11 g of CO₂. [2]

O₂: $8.0 \div 32 = 0.25$ mol. CO₂: $11 \div 44 = 0.25$ mol.

(b) Do the two samples contain the same number of molecules? Explain. [1]

Yes. Equal numbers of moles contain equal numbers of molecules, even though their masses differ.

B3 Atom Accountant: atoms vs molecules

Sample	Number of molecules	Number of atoms
0.5 mol of H ₂ O	3.01×10^{23}	9.03×10^{23}
2 mol of O ₂	1.20×10^{24}	2.41×10^{24}
0.25 mol of CH ₄	1.51×10^{23}	7.53×10^{23}

B4 Formula Forensics: empirical and molecular formulae

(a) A hydrocarbon contains 85.7% carbon and 14.3% hydrogen by mass. Find its empirical formula. [3]

C: $85.7 \div 12 = 7.14$; H: $14.3 \div 1 = 14.3$. Ratio 7.14 : 14.3 = 1 : 2, so CH₂.

(b) The Mr of the hydrocarbon is 56. Find its molecular formula. [2]

Mr of CH₂ = 14; n = $56 \div 14 = 4$, so C₄H₈.

B5 Balloon Mania: molar gas volume

(a) Calculate the volume of 0.25 mol of CO₂ at r.t.p. [1]

$0.25 \times 24 = 6.0$ dm³

(b) Calculate the number of moles in 600 cm³ of H₂ at r.t.p. [1]

$600 \div 24\,000 = 0.025$ mol

B6 Toxic Brew: concentration and standard solutions

(a) Calculate the mass of NaOH needed to make 250 cm³ of 0.200 mol/dm³ solution. [2]

n = $0.200 \times 0.250 = 0.0500$ mol; mass = $0.0500 \times 40 = 2.00$ g

(b) Number the steps (1–4) for making this standard solution. [2]

Step	Order
Make up to the mark with distilled water, then invert to mix	4
Weigh the NaOH accurately	1
Transfer the solution and rinsings to a 250 cm ³ volumetric flask	3
Dissolve the solid in a little distilled water in a beaker	2

B7 Canteen Rush: limiting reactant

4.8 g of Mg is burned in 4.0 g of O₂: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

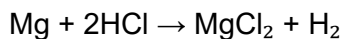
(a) Identify the limiting reactant. Show your working. [2]

Mg: $4.8 \div 24 = 0.20$ mol; O₂: $4.0 \div 32 = 0.125$ mol. 0.20 mol Mg needs only 0.10 mol O₂, so Mg is limiting.

(b) Calculate the mass of MgO formed. [2]

n(MgO) = 0.20 mol; mass = $0.20 \times 40 = 8.0$ g

B8 Gas Guesses: volume of gas produced



- (a) Calculate the volume of H_2 produced when 0.12 g of Mg reacts with excess acid at r.t.p. [2]
 $n(\text{Mg}) = 0.12 \div 24 = 0.0050 \text{ mol} = n(\text{H}_2)$; volume = $0.0050 \times 24\,000 = 120 \text{ cm}^3$
- (b) In $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, what volume of O_2 reacts with 50 cm^3 of H_2 ? [1]
25 cm^3 (volume ratio = mole ratio 2 : 1)

B9 Titration Terror: titres and concentration

A student records these titres: rough 24.10 cm^3 ; 23.40 cm^3 ; 23.45 cm^3 ; 23.80 cm^3 .

- (a) Which titres are concordant? Calculate the mean titre. [2]
23.40 and 23.45 cm^3 (within 0.10 cm^3). Mean = 23.43 cm^3 . The rough titre and 23.80 cm^3 are not used.
- (b) 25.0 cm^3 of 0.100 mol/dm^3 NaOH is neutralised by 12.50 cm^3 of H_2SO_4 . Calculate the concentration of the H_2SO_4 . $\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ [3]
 $n(\text{NaOH}) = 0.100 \times 0.0250 = 0.00250 \text{ mol}$; $n(\text{H}_2\text{SO}_4) = 0.00125 \text{ mol}$; $c = 0.00125 \div 0.01250 = 0.100 \text{ mol/dm}^3$

Part C: The Final Vault

Like the Final Vault in the game, there are 8 statements. Circle True or False. If a statement is a trap, correct it.

1. The Mr of Cl_2 is 35.5.
False. Chlorine gas is diatomic: $2 \times 35.5 = 71$.
2. 2 g of H_2 and 32 g of O_2 contain the same number of molecules.
True. Both are 1 mol.
3. 1 mol of O_2 contains 6.02×10^{23} atoms.
False. It contains 6.02×10^{23} molecules, so $2 \times 6.02 \times 10^{23}$ atoms.
4. Glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, has the empirical formula CH_2O .
True. Divide every subscript by 6.
5. Diluting a solution decreases the number of moles of solute.
False. The moles stay the same; only the concentration falls.
6. The reactant with the smaller mass is always the limiting reactant.
False. Compare moles with the equation ratio instead.
7. In $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, 40 cm^3 of H_2 reacts with 20 cm^3 of O_2 .
True. Volume ratio = mole ratio = 2 : 1.
8. The rough titre should be included when calculating the mean titre.
False. Use only the concordant accurate titres.

Part D: Practice Questions

D1 5.0 g of calcium carbonate reacts with excess hydrochloric acid. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

- (a) Calculate the number of moles of CaCO_3 used. [1]
Mr = 100; $n = 5.0 \div 100 = 0.050 \text{ mol}$
- (b) Calculate the volume of CO_2 produced at r.t.p. [2]
 $n(\text{CO}_2) = 0.050 \text{ mol}$; volume = $0.050 \times 24 = 1.2 \text{ dm}^3$

(c) Only 1.0 dm³ of CO₂ was collected. Calculate the percentage yield. [2]

$$(1.0 \div 1.2) \times 100 = 83.3\%$$

D2 3.2 g of sulfur burns completely in oxygen. $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$

(a) Calculate the mass of SO₂ formed. [2]

$$n(\text{S}) = 3.2 \div 32 = 0.10 \text{ mol} = n(\text{SO}_2); \text{mass} = 0.10 \times 64 = 6.4 \text{ g}$$

(b) Calculate the volume of O₂ used at r.t.p. [1]

$$0.10 \times 24 = 2.4 \text{ dm}^3$$