4 Counting particles by mass: the mole

Teaching plan

Sub-chapter	Approximate number of learning hours	Learning content	Resources
4.1 Relative masses 4.2 Moles 4.3 The mass of a molecule	1–2	Explain what the unit of mole represents. Know what an elementary entity means. Explain the definitions of relative atomic, molecular and formula masses and calculate the molar masses of atoms, ions, molecules and ionic formula units. Perform calculations involving molar masses, the number of moles of a substance and its mass. Know how to convert the number of moles of a substance into the number of particles and vice versa.	**Coursebook** Sections 4.1–4.3 Test your understanding Questions 1–5, 8–11 **Workbook** Exercises 4.1–4.3 **Teacher's resource** PowerPoint 4, slides 2–4 Worksheet 4.1 Questions 1–3 End of Chapter 4 test Questions 1–5
4.4 Empirical and molecular formulas	2	Define empirical formula and molecular formula. Calculate the percentage composition by mass of a compound. Deduce the empirical formula of a compound from the percentage composition by mass or reacting mass of the elements present. Interconvert empirical formula and molecular formula.	**Coursebook** Section 4.4 Test your understanding Questions 14, 21, 22, 24 Exam-style question 6 **Workbook** Exercise 4.4 **Teacher's resource** PowerPoint 4, slides 5–7 Worksheet 4.2 End of Chapter 4 test Questions 6–10

Sub-chapter	Approximate number of learning hours	Learning content	Resources
4.5 Solutions	3	Explain how the concentration of a solution is determined and how to convert its value between mol/dm^3 and g/dm^3.	**Coursebook** Section 4.5 Test your understanding Questions 27–30 **Workbook** Exercise 4.5 **Teacher's resource** Worksheet 4.1 Questions 1–2 and 4 PowerPoint 4, slides 8–9 End of Chapter 4 test Questions 11–13
4.6 Avogadro's law	1–2	State Avogadro's law. Explain the molar volume of a gas and state that it is the same for all ideal gases when measured under the same temperature and pressure. Use balanced chemical equations to calculate volumes of gases.	**Coursebook** Chapter 4.6 Test your understanding Question 37 Exam-style Questions 10–11 **Workbook** Exercise 4.6 **Teacher's resource** Section 4.6 PowerPoint 4, slide 10 End of Chapter 4 test Questions 14–15

BACKGROUND KNOWLEDGE

- Recall the definition of a mole, the Avogadro constant and relative atomic mass.
- Carry out calculations involving mass, M_r or A_r, and number of moles.
- Explain what empirical and molecular formulas are.
- Deduction of empirical and molecular formulas from reacting masses of elements or experimental data.

Syllabus overview

- The concept of the mole provides a link between the microscopic world of atoms, molecules, ions and electrons (Chapters 2 and 3) with the macroscopic properties of materials (masses and volumes) that we can work with in a laboratory. This chapter starts by defining the mole and the Avogadro constant, so students can grasp the idea that, as long as we are measuring a fixed and large number of particles, we can work out their masses meaningfully in grams or other more familiar units. Students should know how to represent large numbers using scientific notation and how to estimate physical quantities in calculations.
- The determination of empirical formula requires students to carry out experiments, analyse numerical data and solve percentage calculation problems. The differences between the experimental results and the expected literature value provide opportunities to evaluate experimental procedures. It is important for students to understand that experiments are very often not 'perfect', and scientists learn by understanding the errors in their methods and are constantly improving them.
- In this chapter, the empirical formula is mainly calculated from percentage composition by mass or reacting masses of elements. However, the more challenging calculations involve deduction from combustion data, which should be practised when the construction of balanced chemical equations is taught in Chapter 16.
- The solution calculations involving concentrations, volumes and amounts of solutes require students to manipulate equations and convert units. Students need to understand why there are different ways of working out the amounts of substances (from mass for a pure substance or from concentration/volume for a solute dissolved in a solution).
- The last part of this chapter would probably be better taught together with Chapters 5 and 16. Avogadro's law applies to an ideal gas, which is defined in Chapter 5. The application of Avogadro's law to work out volumes of gases using molar ratios requires the knowledge of balanced chemical equations, which are introduced in Chapter 16.

4.1 Relative masses; 4.2 Moles and 4.3 The mass of a molecule

LEARNING PLAN

Learning objectives	Success criteria
Understand the terms relative atomic mass and relative formula mass Understand what a mole is Calculate molar masses Calculate the amount of a substance in mol from masses and vice versa Carry out calculations involving the amounts of substances in moles, masses and numbers of particles	Students can define A_r, M_r and calculate relative molecular/formula mass from relative atomic masses. Students can explain what a mole is. Students know the unit of molar mass and can find molar masses from the relative atomic masses in the periodic table. Students can calculate the amount of a substance in mol from masses and vice versa. Students can calculate the number of elementary entities from the amount of substance in mol, or masses, and N_A value and vice versa.

Common misconceptions

Misconceptions	How to identify	How to overcome
Students confuse significant figures with decimal places	Give students a few calculations that are not divisible and ask them to express the answers to three significant figures or three decimal places.	The number of significant figures counts the number of digits from the first non-zero number. The number of decimal places counts the number of digits to the right of a decimal point. *Practise with rounding up numbers to a certain number of significant figures or decimal places.* *For example, 5.000 has 4 significant figures and 3 decimal places.*
Students confuse relative molecular mass and molar mass	Ask students to explain the difference between these two terms.	Relative molecular mass is the mass of a molecule compared to the mass of $\frac{1}{12}$th of a C-12 atom. It has no unit. Molar mass of a molecule has the same numerical value as the relative molecular mass with the unit g/mol, as it is mass per mole.
Students confuse relative molecular mass and relative formula mass	Ask students to explain the difference between these two terms.	Both are relative masses compared on a scale relative to a C-12 atom. Relative molecular mass refers to the mass of a covalent molecule, whereas relative formula mass can be used for any formula, including ionic compounds, metallic substances, covalent molecular compounds or covalent substances with giant lattice structures.

Starter ideas

1 Recap prior knowledge from Chapter 2 Atomic structure (10 minutes)

Resources: A periodic table.

Description and purpose: Filling the gaps in the definition of A_r (The relative atomic mass A_r of an element is the ________________ mass of the naturally occurring ________ of the element relative to the mass of ________ of an atom of carbon- ________). Then ask students to explain to each other in pairs what the difference is between mass number and relative atomic mass.

What to do next: Some students might need a reminder that mass number = number of protons + neutrons (always an integer), whereas the relative atomic mass has a value similar to the mass number but not exactly equal to it.

Main teaching ideas

1 Calculating M_r from A_r (15 minutes)

Resources: A periodic table and Test your understanding question 1 from the Coursebook.

Description and purpose: Many IB students would have had some knowledge of the mole from pre-IB study, and so, should be familiar with how to calculate M_r. To get to the correct answers, students need to know what the subscripts in chemical formulas represent.

Differentiation ideas

Support: Clearly explain the difference between relative molecular mass and relative formula mass. Relative formula mass is a general term and can be used for all compounds; relative molecular mass is strictly only suitable for covalent molecular substances. Some students might require help in working out the M_r of more complicated molecules by providing visual diagram, such as this:

$$Na_2SO_4$$

$$M_r = 2 \times 22.99 + 1 \times 32.07 + 4 \times 16.00 = 142.05$$

Stretch and challenge: Students can work out the M_r of more complicated molecules, for example, $CuSO_4{\cdot}5H_2O$ or from skeletal formulas of organic compounds.

Language focus: Application and correct use of terms.

2 Calculating the number of moles of specified elementary entities (an atom, a molecule, an ion or other specified group of particles) from their masses (15 minutes)

Resources: Easy: Test your understanding questions 2 and 3 from the Coursebook

More challenging: Test your understanding questions 4 and 5 from the Coursebook.

Description and purpose: This activity requires students to manipulate the equation relating the moles of substances, the mass in grams and the molar mass to solve problems.

Differentiation ideas

Support: Collaborative learning: students can be allocated to mixed-ability groups, so they can learn from their peers. Group work encourages more discussions and allows teachers to give verbal support accordingly.

Stretch and challenge: Students can attempt the more challenging questions to start with. To get to the correct answers, they need to write chemical formulas correctly and convert other mass units (kg and tonne) to g. They can then explain their working solutions to their peers.

3 Calculating the number of specified elementary entities (an atom, a molecule, an ion or other specified group of particles) from their masses (30 minutes)

Resources: Test your understanding questions 8–11 from the Coursebook.

Easy (from the moles of atoms to work out the number of atoms): Question 8

Medium (from the mass of atoms to work out the number of moles of atoms, then convert to the number of atoms): Question 9

Hard (from the mass of molecules to work out the number of moles of molecules, then convert to the number of molecules): Question 10

Challenging (from the number of moles of molecules to the number of atoms): Questions 11.

Description and purpose: This activity requires students to manipulate two equations (number of particles = number of moles × N_A and mass = number of moles × molar mass) to solve problems.

Differentiation ideas

Support: Some students struggle with the type of questions like Q11 when converting the number of moles of molecules into number of moles of atoms making up the molecules. Duplo/Lego or molecular models can be used for visualisation of the make-up of substances.

Teachers can also lay out the calculations: number of moles of the whole compound (× the number of the atoms or ions per compound unit) → number of moles of the individual entity (× the Avogadro constant) → number of the individual entity.

Stretch and challenge: Search the Royal Society of Chemistry website with the keywords 'Astounding numbers', or students can research into how the Avogadro constant was determined.

Plenary ideas

1 Complete the following calculations, giving the answers in standard form to three significant figures (15 minutes)

Resources:

1. $16.0 \times 6.0 \times 10^{23}$
2. $(3.66 \times 10^{24}) / (6.0 \times 10^{23})$
3. $1.25 \times 10^{-11} \times 5 \times 6.0 \times 10^{23}$
4. $12.5 / (64 + 32 + 16 \times 4) \times 2$
5. $3.14 / (40 + 12 + 16 \times 3) \times 6.0 \times 10^{23}$

Description and purpose: Students practise calculations under timed pressure, applying their knowledge of standard form and significant figures. To challenge, students can perform these calculations without a calculator.

2 Spot the mistakes in the following calculations (10 minutes)

Resources:

1. Calculate the number of moles of ions in 12.4 g of $(NH_4)_2SO_4$ when it dissolves in water:

$$\left(\frac{12.4}{14.01 + 1.01 \times 4 \times 2 + 32.07 + 16.00 \times 4}\right) \times 4$$

2. Calculate the mass of one molecule of hexane C_6H_{14}:

$$\frac{1}{12.01 \times 6 + 1.01 \times 14}\ \text{g}$$

Description and purpose: Students need to apply their knowledge and pay attention to details in the calculations.

4.4 Empirical and molecular formulas

LEARNING PLAN

Learning objectives	Success criteria
Understand what empirical and molecular formulas are Deduce empirical and molecular formulas from experimental data	Students should be able to explain the differences between empirical formulas and molecular formulas and give examples for each. Students can derive empirical and molecular formulas from percentage composition by mass or reacting mass data.

Starter ideas

1 Percentage composition calculations of elements in a compound (15 minutes)

Resources: A periodic table and Test your understanding question 14 from the Coursebook.

Description and purpose: Start by revising the concept of percentage composition and ask students to perform the calculations independently. Offer support if necessary.

What to do next: This is an exercise to recap students' pre-IB knowledge. If students are not familiar with the calculations, or have difficulty expressing numbers using percentages, teachers will need to re-teach this topic.

2 Identify the empirical formulas (5 minutes)

Resources: A list of formulas (mixture of molecular and empirical).

Description and purpose: Students need to distinguish between molecular and empirical formulas.

What to do next: If students are confused with which one is which, they should review the definitions of empirical and molecular formulas and try again.

Main teaching ideas

1 Calculating empirical and molecular formulas (30 minutes)

Resources: Test your understanding questions 21, 22 and 24 from the Coursebook. IB Chemistry SL/HL past paper 2021 November Paper 2 Question 1 (a) and (b).

Description and purpose: Students need to apply their knowledge from the previous lesson on converting mass into moles, then work out the simplest whole number ratio of the elements.

Differentiation ideas

Support: Start with Test your understanding questions, students may need clarification on the concept of percentage. Carry out the calculations in a table like the one shown in Coursebook Worked example 4.14.

Stretch and challenge: Combustion calculations for compounds with C, H and O. For example, IB Chemistry SL/HL past paper 2021 November Paper 2 Questions 1 (a) and (b). Students can self-assess their answers.

2 Practical experiment to determine the empirical formula of magnesium oxide (40 minutes)

Resources: Worksheet 4.2. The list of apparatus and chemicals, and a step-by-step method can be found by searching the Royal Society of Chemistry website with the keywords 'the change in mass when magnesium burns'.

Description and purpose: A practical for working out the empirical formula of magnesium oxide. Students should be encouraged to record data and uncertainties and make observations on what could affect their calculated results. Students complete Analysis of results and Evaluation of experiments sections of Worksheet 4.2.

Differentiation ideas

Support: Give a step-by-step method and ask students to consider the purpose of particular steps in the method. For example, the lid of the crucible should be lifted periodically to allow oxygen to enter. However, the lid should not be left off for long because the product, magnesium oxide, can escape as a white powder very easily. The mass of the final product should be weighed repeatedly until it is constant to ensure that the reaction is complete.

Stretch and challenge: Students can design their own experiment and carry it out. In addition, students should carry out an evaluation of errors and suggest how each systematic error can affect the result from their calculations. For example, if too much MgO escapes, the mass of oxygen measured would be too low and a ratio of more than 1 : 1 for Mg : O would be obtained in the final result.

3 Demonstration experiment to determine the water of crystallisation number in $MgSO_4 \cdot xH_2O$ (20 minutes)

Resources: Search the internet for 'water of crystallisation practical with hydrated magnesium sulfate'. Hydrated magnesium sulfate, a boiling tube, a test tube holder, and a balance.

Description and purpose: A demonstration or practical for working out the water of crystallisation in hydrated $MgSO_4$. Students should record data, uncertainties and observations.

› Differentiation ideas

Support: Going through the calculations in a tabulated format, like the one used for calculating empirical formulas.

Stretch and challenge: Students can propagate the random errors in their calculations and see how much that would affect their final answer.

Plenary ideas

1 Multiple-choice questions on empirical formulas (5 minutes)

Resources: Exam-style question 6 from the Coursebook.

Description and purpose: Students can self-assess their answers, and one student can explain the calculation in front of the class.

› Assessment idea: Check answers against the mark scheme.

2 Traffic light to rate confidence on the topic (5 minutes)

Resources: Red, yellow and green cards.

Description and purpose: Students can self-assess their understanding of the topic and show how confident they are with the calculations of empirical formulas from data and converting them into molecular formulas.

› Assessment idea: Students consider their confidence in their understanding.

4.5 Solutions

LEARNING PLAN

Learning objectives	Success criteria
Understand what is meant by the concentration of a solution Carry out calculations involving concentrations in mol dm^{-3} and g dm^{-3}	Students can define molar concentration. Students should be able to carry out calculations involving concentrations in mol dm^{-3} and g dm^{-3}.

Starter ideas

1 Converting the volumes into dm^3 (10 minutes)

Resources: Pen and paper.

Description and purpose: Students convert these volumes into dm^3:

1. 750 cm^3
2. 5 cm^3
3. 0.0345 m^3
4. 280 m^3
5. 35.8 millilitres
6. 1 litre

The exercise allows teachers to check students' mathematical skills and their knowledge of unit conversions.

What to do next: If students are not getting the correct answers, show 1 m^3 = 1000 dm^3 and 1 dm^3 = 1000 cm^3 (dm^3 = litre and cm^3 = millilitre). To convert cm^3 into dm^3, you need to divide by 1000, and to convert m^3 into dm^3, you need to multiply by 1000.

2 Deduction of the equation (or triangle) for working out solution concentrations (10 minutes)

Resources: Mini-whiteboard and pen.

Description and purpose: Give the definition of concentration of a solution as the amount of solute dissolved in a unit volume of solution and ask students which quantities they would need to work out the concentration.

What to do next: Emphasise that the mass or mole must be of that of the solute and the volume is usually expressed in dm^3, so the units of concentrations should be either g/dm^3 or mol/dm^3.

Main teaching ideas

1 Practice working out molar concentrations and those in g/dm^3 (20 minutes)

Resources: Test your understanding questions 27–30 from the Coursebook.

Description and purpose: Practise solving problems involving the concentration of a solute (in mol/dm^3 or g/dm^3), the number of moles of a solute and the volume of the solution.

› Differentiation ideas

Support: Start with Test your understanding questions 27–28 and give students both triangles ($n = C \times V$ and $m = n \times M_r$). Show one example on the board, so students can follow the method.

Stretch and challenge: No hints given and students should derive the interconversion between the two concentration units.

2 Practical to prepare a standard solution of 0.500 mol/dm^3 $NaHCO_3$ (45 minutes)

Resources: A weighing boat, a balance (measuring up to 3 decimal places if possible), solid $NaHCO_3$, a dry and clean 250 cm^3 beaker, a dry and clean 250 cm^3 volumetric flask, distilled water, a glass rod and a funnel.

Description and purpose: Preparation of a solution of a known and accurate concentration is very important in chemistry. For example, the standard solution can be used to find the concentrations of other solutions.

› Assessment idea: By doing this practical and considering the sources of errors, students can explore in pairs how to improve their methods to minimise errors.

› Differentiation ideas

Support: Give a step-by-step method and support while the experiment is being carried out. For example:

- Use a weighing boat and weigh out 10.501 g of solid $NaHCO_3$. Transfer the solid to a clean 250 cm^3 beaker. Add about 100 cm^3 of distilled water to dissolve the solid. Stir with a glass rod.
- Transfer the solution to a dry and clean 250 cm^3 volumetric flask using a funnel.
- Rinse the weighing boat, the glass rod, the beaker and the funnel with distilled water and add all the rinsings to the volumetric flask.
- Fill the volumetric flask up until the water level is just below the line on the neck of the flask. Insert the stopper. Invert the volumetric flask a few times to mix the solutions. Then add enough water so that the meniscus of the water level is on the line.

Stretch and challenge: Provide students with the apparatus and chemicals. Show them Figure **4.9** of the Coursebook and ask them to devise their own methods for making up the standard solution. Discuss the sources of errors in each step of their methods.

3 Plotting and analysing a calibration curve, and finding the concentration of a $CuSO_4$ solution (40 minutes)

Resources: A colorimeter, 0.5 mol/dm^3 $CuSO_4$ solution, cuvettes, a solution of $CuSO_4$ of unknown concentration (<0.5 mol/dm^3), measuring cylinders, test tubes, pen and graph paper.

Description and purpose: Prepare nine solutions with concentrations of 0.05, 0.1, 0.15, 0.2, 0.25, 0.3. 0.35, 0.4 and 0.45 in addition to the original 0.5 mol/dm^3 stock solution of $CuSO_4$. Blank the spectrophotometer with distilled water and then take the absorbance for each of the solutions at 635 nm. Plot a graph of absorbance against concentration–the calibration curve. The calibration curve should show that the absorbance is directly proportional to the concentration of the coloured solution. Take the absorbance of the unknown $CuSO_4$ solution, and its concentration can be read off from the calibration curve.

Safety: Dilute $CuSO_4$ solutions are skin irritants and can cause serious eye damage. Wear goggles and wash the skin with plenty of water if the solution is spilt on the skin.

Differentiation ideas

Support: Help students to work out the volumes of distilled water and the stock required to make up the diluted solutions. Students could use Excel/Google sheets to plot the calibration curve.

Stretch and challenge: Provide students with the apparatus, the stock $CuSO_4$ solution and distilled water. Students should work out and prepare their own dilution series, then plot a graph with their own axes.

Plenary ideas

1 Calculating the mass of a solute (10 minutes)

Resources: Students to work out how much solute is required to make 200 millilitres of 0.1 mol/dm^3 NaOH and 15 millilitres of 0.025 mol/dm^3 $KMnO_4$

Description and purpose: Students can self-assess their answers and explain their calculations in front of the class.

2 Writing a multiple-choice question on concentration calculation (15 minutes)

Resources: Pen and paper.

Description and purpose: Students can apply their knowledge and think about how they could ask relevant questions about the topic.

Assessment idea: They can question their peers and mark their work.

4.6 Avogadro's law

LEARNING PLAN

Learning objectives	Success criteria
Understand Avogadro's law	Students will be able to state Avogadro's law.
Solve problems involving gases using Avogadro's law	Students can solve problems involving volumes of gases using balanced equations and Avogadro's law.

Starter ideas

1 Balancing simple equations involving gases (10 minutes)

Resources: Some unbalanced symbol equations, for example, the ones in the Haber process, the reaction between H_2 and F_2 and the combustion of butane.

Description and purpose: Most students should have learned how to balance equations before IB, so this is an opportunity to recall their knowledge. Students can be asked to explain the thought process behind balancing an equation.

What to do next: If some students find this a challenge, draw out the molecules using a particle diagram or use molecular models to help them visualise the number of atoms of each element on the reactant and product sides. These must be balanced by using more reactants or making more products.

Main teaching ideas

1 Reacting volume calculations (50 minutes)

Resources: Easy: Test your understanding question 37 a-c from the Coursebook

Intermediate: Modify Test your understanding questions 37 a-c from the Coursebook so that students need to write their own balanced chemical equations

Hard: Limiting reactant calculations using Test your understanding question 37 d from the Coursebook; the question can be modified so that students need to write their own balanced chemical equations.

Description and purpose: Start by introducing Avogadro's law and a simulation can be shown (search the internet for 'Avogadro's law simulation'). By increasing the number of gas molecules, the volume of the gas increases proportionally (at constant temperature and pressure); this is irrespective of the identity of the gas. Once students have grasped this idea, they can move onto the calculations of reacting volumes of gases using molar ratios in balanced chemical equations.

Differentiation ideas

Support: Start from the easy level, provide students with balanced chemical equations, and give support by laying out steps in the calculations.

Stretch and challenge: Students should research into the concept of limiting and excess reactants before doing the calculations in question 37 d.

2 Demonstration using methane rockets (20 minutes)

Resources: Search the internet for 'methane rocket experiment'. Methane gas, oxygen gas, 250 cm^3 empty coke bottles with bungs, a delivery tube, a plastic tub for water displacement when filling the coke bottles with gas.

Description and purpose: Fill two 250 cm^3 empty coke bottles, one with 50% methane and 50% oxygen (1 : 1 ratio) and the other with 33% methane and 67% oxygen (1 : 2 ratio). Bung the bottles tightly. When ready, remove the bung and light the mixture of gas in the coke bottles. The one with the 1 : 2 ratio of methane to oxygen will fly further away than the one with the 1 : 1 ratio of methane to oxygen. This shows the importance of reacting substances according to their molar ratios in a balanced chemical equation and demonstrates Avogadro's law that the volumes of gases are proportional to their moles at the same temperature and pressure.

Differentiation ideas

Support: Give students the balanced chemical reaction for the combustion of methane.

Stretch and challenge: Ask students to give explanations on the different distances travelled by the two methane rockets.

Plenary ideas

1 Multiple-choice questions on Avogadro's law calculations (10 minutes)

Resources: Exam-style questions 10–11 from the Coursebook.

Description and purpose: Students should attempt these questions under timed conditions. Some students would want to convert the volumes into moles first before working out the moles or volumes of the required entity. There is no need to do that, as stated in Avogadro's law, and by using the mole ratio of volumes it will save a lot of time with much easier calculations involved.

Assessment ideas

- Test your understanding questions from the Coursebook.
- Give students wrong solutions for calculations of the number of particles or solution concentrations, ask them to identify and correct the mistakes.

- Give students the keywords from the topic to write a glossary. An example should be given at the beginning of this activity to show the level of detail required for the definitions.
- Calculation practice on
  1. molar mass
  2. conversion between mass, molar mass and the amount of substance
  3. conversion between the amount of substance, the Avogadro constant and the number of particles
  4. empirical formula and molecular formula
  5. the conversion between molar concentration, volume and the amount of solute in a solution
  6. dilution of a solution
  7. calibration curves
  8. using mole ratio to work out the volume of gases.

Homework ideas

- Exercises 4.1–4.6 from the Workbook.
- Exam-style questions from the Coursebook.
- Many past paper questions are available for practice, for example, search 'IB past paper by topics, moles' on the internet.
- Students can present a short 5-minute presentation explaining the concept of mole, addressing the following questions:
  1. What is the mole?
  2. How do we grasp the magnitude of the Avogadro constant?
  3. The importance of the concept of mole.
- Students can explain how to solve a number of particles question (for example, Exam-style question 1 from the Coursebook) to a partner, including how to work out the number of moles of an elementary entity and how to convert that into the number of particles.
- Students write up experiments on 1) finding the empirical formula of magnesium oxide and 2) finding the water of crystallisation number in magnesium sulfate. They should reflect on the systematic errors in the experimental method and suggest at least three specific improvements.

Links to digital resources

- Activity to look at some very large (the Avogadro constant) and some small numbers we use in chemistry (search the Royal Society of Chemistry website with keywords 'astounding numbers')
- Experimental method on determining the empirical formula of magnesium oxide (search the Royal Society of Chemistry with keywords 'the change in mass when magnesium burns').
- Simulation on Avogadro's law (search the internet for 'Avogadro's law simulation')
- Past paper questions on moles calculations (search 'IB past paper by topics, moles' on the internet)
- Revision notes on stoichiometry from the 2016 syllabus (search on ibchem.com with keyword 'stoichiometry')

CROSS-CURRICULAR LINKS

- Maths: Solve unfamiliar problems by the application of knowledge and select/manipulate formulas; algebraic calculations, including simplification of equations and arithmetic involving decimals, fractions, percentages, ratios, powers, standard notations and using approximations; plot graphs, draw lines of best fit on a scatter plot and interpret graphs.
- Biology: Serial dilution calculations.
- Physics: Estimate quantities, use of significant figures.
- TOK: How do we understand/describe a number (the Avogadro constant) that is uncommon in our everyday experience? What is the role of imagination in the sciences?