16 How much? The amount of chemical change

Teaching plan

Sub-chapter	Approximate number of learning hours	Learning content	Resources
16.1 The meaning of chemical equations	4–5	Chemical equations summarise the smallest ratio of reactants and products in a reaction. Deduction of chemical equations when reactants and products are specified. The mole ratio of an equation can be used to determine: **1** the masses and / or volumes of reactants and products **2** the concentrations of reactants and products for reactions occurring in aqueous solution. Calculation of reacting masses and / or volumes and concentrations of reactants and products.	**Coursebook** Section 16.1 Test your understanding Questions 1–21 **Workbook** Exercise 16.1 **Teacher's resource** PowerPoint 16, slides 3–4 Worksheet 16.1
16.2 Yield and atom economy of chemical reactions	2–3	The limiting reactant determines the theoretical yield. Identification of the limiting and excess reactants from given data. The percentage yield is calculated from the ratio of experimental yield to theoretical yield. Solution of problems relating to reacting quantities, limiting and excess reactants, theoretical, experimental and percentage yields.	**Coursebook** Section 16.2 **Workbook** Exercise 16.2

Sub-chapter	Approximate number of learning hours	Learning content	Resources
16.3 Titrations	1–2	The atom economy is a measure of efficiency applied in green chemistry. Calculation of the atom economy from the stoichiometry of a reaction.	**Coursebook** Section 16.3 Test your understanding questions 24–36 **Workbook** Exercises 16.3–16.4 **Teacher's resource** PowerPoint 16, slide 5 End of Chapter 16 Test

BACKGROUND KNOWLEDGE

- From previous learning, students should understand the concept of balanced symbol equations and be able to balance simple chemical equations.
- Most students will have seen stoichiometry before and will be able to do some simple calculations.
- Students will need to understand how to use the periodic table, knowledge they should have attained during the atomic structure topic.

Syllabus overview

- Students will learn how to balance equations and use the moles calculations to be able to work out the masses, volumes or concentrations of the different reactants and products involved in the chemical equations using the mole ratio from these balanced equations.
- Students will then learn how to work out which reactants are in excess and which ones will limit the reaction and use these data to calculate the amount of product formed. The students will then look at atom economy and link these to industry and environmental chemistry.

16.1 The meaning of chemical equations

LEARNING PLAN

Learning objectives	Success criteria
Understand how to write chemical equations	Students can write chemical equations.
Use the mole ratio from a chemical equation in calculations	Students can use the mole ratio from a chemical equation in calculations.

Common misconceptions

Misconceptions	How to identify	How to overcome
Students get the formulas the wrong way round.	A starter idea could be used to go through this and see which students are making mistakes.	Use a staggered approach to break the calculations down into steps, so the students know how to do each individual bit of the calculation.
Students include the coefficient when working out the A_r / M_r / relative formula mass (RFM) of molecules / compounds.	Give example questions to the students and go around the room checking their work.	Go through misconceptions with the students. Use questions where they must spot the mistake.
Students use the wrong equation when trying to work out the mass / volume / concentration of a compound.	Going through practice questions.	Plenty of practice. Students can write out the different equations and use this as a crib sheet.

Starter ideas

1 Coloured counters (20 minutes)

Resources: Coloured tokens.

Description and purpose: Students are asked to start with a certain number of coloured tokens and then make a compound out of them. They should get an understanding that they need a certain amount of each colour and that the tokens (atoms) are rearranged but not gained or lost.

What to do next: Students could be given an equation and asked to try and balance it.

2 Balancing equations (20 minutes)

Resources: A list of chemical equations that need to be balanced.

Description and purpose: The teacher explains how to balance equations using whole number ratios.

What to do next: The students practice balancing equations.

Main teaching ideas

1 Moles calculations (120–180 minutes)

Resources: Example calculations to go through with the class and question sheets on the different calculations.

Description and purpose: The teacher will go through moles calculations and explain how to calculate the masses, volumes and concentrations of different reactants and products using the moles triangles (Moles = Mass / Mass of 1 mole, Moles = Volume / Volume of 1 mole, moles = concentration × volume) and balanced equations. Students will then practice these calculations.

Differentiation ideas:

Support: There can be scaffolded questions that can lead the students from easier calculations to harder ones, to help with their understanding.

Stretch and challenge: Students are given harder calculations to test their understanding of the content covered.

2 Beat the teacher game (30 minutes)

Resources: Ten moles calculations.

Description and purpose: The students try to answer the 10 questions. If the students get the answer right, they get one point; if they get it wrong, the teacher gets one point. The first to five points wins. This is another way of engaging students with calculations.

Differentiation ideas:

Support: The questions can be staggered, with the easier questions first, to build the students confidence.

Stretch and challenge: Students could be given harder questions to really challenge themselves. Or the students could be challenged to get nine out of ten right to beat the teacher.

Plenary ideas

1 Spot the mistake (10 minutes)

Resources: A worked calculation with some deliberate mistakes in it.

Description and purpose: Students are given a worked calculation and are asked to spot the mistakes in it. This will help students to gain a better understanding of the content covered. This can be talked through with the class and is a good opportunity to highlight some misconceptions of the topic.

16.2 Yield and atom economy of a chemical reaction

LEARNING PLAN

Learning objectives	Success criteria
Understand how to work out what are the limiting reactants	Students can work out what are the limiting reactants.
Understand how to calculate theoretical and percentage yield	Students can calculate theoretical and percentage yield.

Common misconceptions

Misconceptions	How to identify	How to overcome
Students get confused about which reactant is the limiting reactant and which is in excess.	Through practice questions.	The teacher should go through the step-by-step method to work out the limiting reactant of a reaction.
Students don't understand what yield means and may use the masses of all of the products.	Tailored questions around limiting reactants.	Explain that the yield is the useful product in the reaction. Highlight this when going through questions.

Starter ideas

1 A recipe (15 minutes)

Resources: Recipe book.

Description and purpose: The teacher explains how a recipe works and gives the students a recipe to look at. On the board, there can be different quantities of the ingredients for the students work out which one there is too much of. This will help the students to think about how much of each reactant they will need from the equation and then think about which one is in excess.

What to do next: The students can be given some chemical equations with different amounts of reactants and work out which reactants are in excess and which ones are limiting.

2 What is a yield? (15 minutes)

Resources: What is a yield? Question on the board.

Description and purpose: The students talk in pairs and try to come up with an answer to the question what is a yield? The teacher then brings the discussion to the whole class, and they come up with a definition of yield.

What to do next: Students could be asked to think about how they could calculate the yield in a reaction.

Main teaching ideas

1 Practical to work out the percentage yield (40 minutes)

Resources: Chemicals and equipment for percentage yield practical.

Description and purpose: Students complete a practical to get an actual yield for the experiment (a variety of experiments could be chosen). They can then calculate the theoretical yield for the reaction and work out the percentage yield.

Safety: A risk assessment should be completed for any experimental work.

› Differentiation ideas:

Support: Students are given a structured method and step-by-step calculation to help with their understanding.

Stretch and challenge: Students could look at how they could improve the method to reduce the errors and produce a higher percentage yield.

2 Percentage yield questions (40 minutes)

Resources: Questions to calculate the percentage (%) yield.

Description and purpose: The teacher goes through an example calculation to show how to work out a percentage yield for a reaction. The students then have some questions to answer to help with their understanding of this topic.

› Differentiation ideas:

Support: The teacher leaves the method on the board for students to follow. The teacher can then go around and give individual support to students who need help.

Stretch and challenge: Students can be given more challenging questions to answer, where they have to work out the limiting reactant first.

Plenary ideas

1 Discussion on why percentage yield is important industrially and how the experiment could be improved (20 minutes)

Description and purpose: The students think about why a high percentage uncertainty is important and link it to industry. The teacher facilitates this discussion and could add some examples of different reactions that are used commercially. Students can also discuss how the method could be improved. This will help students to gain a greater understanding of the content.

16.3 Titrations

LEARNING PLAN

Learning objectives	Success criteria
Understand the term atom economy	Students can calculate the atom economy.

Common misconceptions

Misconception	How to identify	How to overcome
Students get confused between atom economy and yield.	Get students to define these two concepts.	The teacher goes through exact definitions and how you would calculate each one.

Starter ideas

1 What is atom economy? (10 minutes)

Description and purpose: The teacher explains what atom economy is and how it differs from the yield of a reaction.

› **Language focus:** The teacher explains the definitions for this topic using the appropriate scientific vocabulary.

What to do next: Go through an example in industry. An example could be comparing the fermentation of sugar to make ethanol versus the catalytic hydration of ethene to make ethanol.

Main teaching ideas

1 Why is atom economy important? (25 minutes)

Resources: Resources on atom economy and environmental issues and industrial processes. Ammonia production could be talked about.

Description and purpose: Students discuss atom economy and why it is important. The teacher can prepare resources for the students to look at and discuss, including environmental issues and industrial processes. Students can also think about how they could improve the atom economy of a reaction and go through an example in industry.

› **Differentiation ideas:**

Support: Students work in groups to solve the questions. This will help support the weaker students and also give an opportunity for the students to explain their thoughts, which will solidify their knowledge.

Stretch and challenge: Students can be given time limits to answer a certain number of questions; this will help them to prepare for the IB exams and allow them to get used to how much time they will have answering the questions.

› **Language focus:** Model answers could be used here to help the students understand what terminology they should be using when answering these types of questions.

2 Titration practical (45 minutes)

Resources: Chemicals and apparatus required for a titration practical.

Description and purpose: Students perform a titration to work out the concentration of an unmarked acid, using a known concentration of an alkali (for example, HCl and NaOH). Students can use the chemical equations and mole ratios to work this out.

Safety: Any practical work done needs to have an up-to-date risk assessment written.

› **Differentiation ideas:**

Support: Students can be guided through the practical and calculations with structured worksheets.

Stretch and challenge: Students could be given no instructions and asked to work out the concentration of the acid. Students can be given a diprotic acid and asked to work out the concentration of this. Students could also work out a back titration calculation.

Plenary ideas

1 Create a cheat sheet (20 minutes)

Description and purpose: Students create a cheat sheet, which puts all of the formulas they require for this topic onto one piece of paper. Once done, this will help them remember the formulas and help them to answer the questions correctly.

Assessment ideas

- Past paper questions on this topic.
- End of chapter questions.

Homework ideas

- Correct the mistakes – made up answer sheet where there are some deliberate mistakes; the students will have to correct these.
- Scaffolded questions on moles – can be separated out into smaller chunks to make them easier or harder, depending on the ability of the students.
- Watch videos on how to do the calculations for the topic.

  › **Language focus:** Students could design their own topic test to cover all the syllabus points in the topic, including a mark scheme for this. They could then swap with one of their friends and try each other's tests.
- The students go through the reflection checklist at the end of the chapter in the Coursebook to see if they understand everything fully.

Links to digital resources

- This page on the Royal Society of Chemistry website is an online resource that allows the student to do a titration on their own computer
- Website that goes through atom economy calculations

CROSS-CURRICULAR LINKS

- Maths: Manipulation of simple equations.