Researchers in Schools

# Take a Leaf of Faith

## How using plant waste can save the world

## Key Stage 4 Programme

| | |
|---|---|
| Pupil Name | |
| Coursebook Designed by | Dr Aksanoglu |

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# Timetable and Assignment Submission

## Timetable – Tutorials

| Tutorial | Date | Time | Location |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 (Feedback) | | | |
| 7 (Feedback) | | | |

## Timetable – Homework Assignments

| Homework Assignment | Description | Due Date |
|---|---|---|
| Tutorial 1 | The Importance of Catalysis in Green Chemistry | |
| Tutorial 2 | Evaluating Reaction Conditions | |
| Tutorial 3 | The Principles of Green Chemistry | |
| Tutorial 4 | Metal Catalysts | |
| Tutorial 5 | How Can We Be More Sustainable? | |

## Assignment Submission – Lateness and Plagiarism

| Lateness | |
|---|---|
| Submission after midnight on due date | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

## Course Rationale

Have you ever wondered what all the fuss about "going green" is about? You may have listened to the news or read articles of recent natural disasters occurring around the world, all of these attributed to the climate crisis. Have you overheard endless conversations about "reducing your carbon footprint" and wondered how? This course is designed to answer these questions. By the end of this course, you will have a good understanding of *the* problem with global warming and climate change. As this is a chemistry course, the focus will be on how we can make chemistry more sustainable.

In tutorial one, we will recap that a chemical reaction is simply the rearrangement of atoms and that chemical reactions can speed up if a catalyst is utilised. We will cover how a catalyst works and the term "activation energy" will be introduced in relation to catalysis.

In tutorial two, you will use the knowledge you acquired in tutorial one to explore the two different types of transition metal catalysts. These differ from one another due to their solubility in the reaction medium; therefore, we will revisit solubility.

You may be wondering how this all fits into "going green" and reducing your "carbon footprint". Tutorial three is where we will evaluate how we can be more sustainable. We will define some important terms such as finite, sustainable, and renewable resources and you will be introduced to using biomass as a renewable feedstock. Most importantly, in this tutorial we will look into the principles of green chemistry.

In tutorial four, we will shift our focus onto how we can calculate how successful a chemical reaction has been by measuring the atom economy, percentage yield, and percentage conversion. These are important tools chemists in academia or industry use every day.

Our final tutorial will be an overview of all our previous learning. You will evaluate the conditions of a chemical reaction and identify pros and cons of the chemical reactions you encounter. You will be able to suggest ways the reaction can be improved and made more sustainable.

# Uni Pathways Mark Scheme 2020 – Essay-based assignments

| | Subject Knowledge | Critical Thinking | Written Communication |
|---|---|---|---|
| 1st | The essay shows a breadth of knowledge and understanding of the key concepts and issues, through engaging with and interpreting a wide range of relevant sources.<br>Knowledge is used to build and support highly effective arguments. | Analyses, key ideas, information, and arguments. Interprets meaning and makes connections.<br>Identifies and critically evaluates key arguments and statements, deciding on their credibility, strength and relative significance, drawing convincing conclusions. | The essay has a clear and engaging structure, taking the reader on a journey from the introduction to the conclusion.<br>The writing style is appropriate; key terms are used with fluency.<br>There are no, or very few, errors in spelling or grammar.<br>Referencing is used consistently and matches the style taught in the course. |
| 2:1 | The essay shows an understanding of key concepts and issues, drawing on a range of relevant sources<br>Knowledge is used to build and support effective arguments | Analyses key ideas, information and arguments.<br>Identifies relevant arguments and statements, deciding on their credibility and strength, drawing reasonable conclusions.<br>Shows some understanding of the relative importance of arguments. | The essay has a clear structure and the arguments are easy to follow. The introduction outlines the essay effectively and the conclusion summarises the arguments.<br>The writing style is appropriate; key terms are used correctly.<br>There are few errors in spelling or grammar.<br>Referencing is mostly consistent and matches the style taught in the course. |
| 2:2 | The essay shows an understanding of key concepts and issues, with no major misconceptions.<br>Beginning to apply this knowledge to build and support arguments. | Begins to analyse ideas, information and arguments.<br>Identifies some arguments and statements and attempts to evaluate their quality.<br>Not yet showing understanding of the relative strengths and weaknesses of arguments. | The essay structure could be made clearer to better guide the reader through the arguments.<br>The writing style can sometimes be informal.<br>Occasionally key terms are not used when it would be appropriate to do so.<br>There are some errors in spelling or grammar, but they do not get in the way of communicating the content. |

| | | | |
|---|---|---|---|
| | | | There is some consistency to the referencing. |
| 3rd | Shows a developing understanding of key concepts and issues, with some misconceptions. Not yet applying this knowledge to build and support arguments. | Begins to analyse ideas and information.<br>Describes statements and arguments while not yet evaluating them. | The grammar, spelling, style, and structure of the work need improving in order to communicate ideas to the reader.<br>The essay has no or a limited introduction and conclusion.<br>Key terms and references are not always used correctly. |

# Baseline Assignment (essay based): Pupil Feedback Report

| | |
|---|---|
| Name of Pupil | |
| Name of School | |
| Name of RIS teacher | |
| Title of Assignment | |

How your assignment is graded:

| Grade | Marks | What this means |
|---|---|---|
| 1st | 70+ | Performing to an excellent standard at A-level |
| 2:1 | 60-69 | Performing to a good standard at A-level |
| 2:2 | 50-59 | Performing to an excellent standard at GCSE |
| 3rd | 40-49 | Performing to a good standard at GCSE |
| Working towards a pass | 0-39 | Performing below a good standard at GCSE |
| Did not submit | DNS | No assignment received by The Brilliant Club |

| Lateness | |
|---|---|
| Any lateness | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

Marks

| | | | |
|---|---|---|---|
| OVERALL MARK / 100 | | FINAL MARK / 100 (including any deductions) | |
| DEDUCTED MARKS | | FINAL GRADE | |

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

| Subject knowledge | |
|---|---|
| | *mark* |
| | |
| | |
| **Critical thinking** | |
| | *mark* |
| | |
| | |
| **Written communication** | |
| | *mark* |
| | |
| | |

# Baseline Assignment (problem-set): Pupil Feedback Report

| | |
|---|---|
| Name of Pupil | |
| Name of School | |
| Name of RIS teacher | |
| Title of Assignment | |

How your assignment is graded:

| Grade | Marks | What this means |
|---|---|---|
| 1st | 70+ | Performing to an excellent standard at A-level |
| 2:1 | 60-69 | Performing to a good standard at A-level |
| 2:2 | 50-59 | Performing to an excellent standard at GCSE |
| 3rd | 40-49 | Performing to a good standard at GCSE |
| Working towards a pass | 0-39 | Performing below a good standard at GCSE |
| Did not submit | DNS | No assignment received by The Brilliant Club |

| Lateness | |
|---|---|
| Any lateness | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

Marks

| | | | |
|---|---|---|---|
| OVERALL MARK / 100 | | FINAL MARK / 100 (including any deductions) | |
| DEDUCTED MARKS | | FINAL GRADE | |

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

| Subject knowledge | |
|---|---|
| | *mark* |
| | |
| | |
| **Critical thinking** | |
| | *mark* |
| | |
| | |
| **Written communication** | |
| | *mark* |
| | |
| | |

| Problem Set | |
|---|---|
| *Comment* | *mark* |
| | |

# Final Assignment (essay based): Pupil Feedback Report

| | |
|---|---|
| Name of Pupil | |
| Name of School | |
| Name of RIS teacher | |
| Title of Assignment | |

How your assignment is graded:

| Grade | Marks | What this means |
|---|---|---|
| 1st | 70+ | Performing to an excellent standard at A-level |
| 2:1 | 60-69 | Performing to a good standard at A-level |
| 2:2 | 50-59 | Performing to an excellent standard at GCSE |
| 3rd | 40-49 | Performing to a good standard at GCSE |
| Working towards a pass | 0-39 | Performing below a good standard at GCSE |
| Did not submit | DNS | No assignment received by The Brilliant Club |

| Lateness | |
|---|---|
| Any lateness | 10 marks deducted |
| **Plagiarism** | |
| Some plagiarism | 10 marks deducted |
| Moderate plagiarism | 20 marks deducted |
| Extreme plagiarism | Automatic fail |

Marks

| | | | |
|---|---|---|---|
| OVERALL MARK / 100 | | FINAL MARK / 100 (including any deductions) | |
| DEDUCTED MARKS | | FINAL GRADE | |

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

| Subject knowledge | |
|---|---|
| | *mark* |
| | |
| | |
| **Critical thinking** | |
| | *mark* |
| | |
| | |
| **Written communication** | |
| | *mark* |
| | |
| | |

## Launch Event

The launch event is your opportunity to learn more about this course and Uni Pathways. You will watch some videos, listen to your teacher and have some discussion. Below is some room to make notes for some of the videos you will watch during the event.

**Virtual Campus Tours**

Notes…

**The Scholars Programme Alumni**

Notes…

**Student Ambassadors**

Notes…

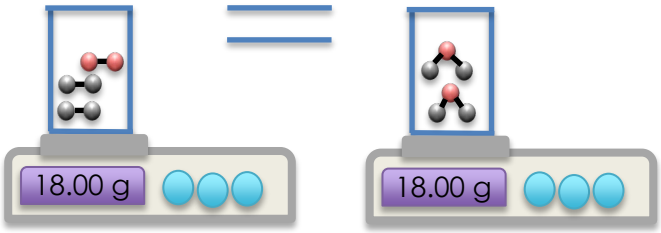
## Subject Vocabulary

| Word | Definition | In a sentence |
|---|---|---|
| **Catalyst** | A substance used to **increase** the **rate** of a reaction **without** being **consumed**. | Iron is a catalyst in the Haber process. |
| **Homogeneous Catalysis** | The **catalyst** is in the **same state** as the **reactant** i.e. the catalyst and the reactant are dissolved in the solvent. | Transition metal catalysis is a good example of homogeneous and heterogeneous catalysis. |
| **Heterogeneous Catalysis** | The **catalyst** is in a **different state** from the **reactant** i.e. the catalyst is not dissolved whereas the reactant is. | Transition metal catalysis is a good example of homogeneous and heterogeneous catalysis. |
| **Earth-abundant** | The **element** exists in **large quantities** in the **Earth's crust**. | Vanadium is an Earth-abundant metal. |
| **Sustainable** | Something which will **not** run out (the opposite of finite). | A strategy for building a sustainable future is conserving resources. |
| **Hazardous** | A **risky** and **dangerous** substance or process. | Breathing in the smoke from cigarettes is hazardous to human health. |
| **Pollution** | The presence of something which is **harmful** or **dangerous** in the **environment**. | Air pollution is hazardous to human health. |
| **Carcinogenic** | Something which can cause **cancer**. | Benzene is carcinogenic. |
| **Atom Economy** | A **measure** of how much of the **reactants** will end up as the **desirable product**. | A high atom economy is desirable. |
| **Yield** | The **amount of product** that has been **produced** in a **reaction** (expressed as a percentage). | The reaction had a low yield of 10% as little product was formed. |
| **Conversion** | The **amount of reactant** which has **reacted** to form something else in a reaction (expressed as a percentage). | The reaction had a high conversion of 99% (99% of the reactant underwent reaction). |
| **Solution** | A **solute** dissolved in a **solvent**. | Brine is a solution consisting of salt (solute) and water (solvent). |
| **Biomass** | **Matter** which comes from a **living organism**. | Biomass-derived fuels are sustainable. |

| | | |
|---|---|---|
| **Degradation** | The process of **breaking something down**. | It takes hundreds of years for plastic bottles to undergo degradation. |
| **Activation Energy** | The **minimum energy** required for a reaction to **proceed**. | A catalyst functions by lowering the activation energy of a reaction. |
| **Recycle** | **Using** something **again**. | It is important to recycle your waste cans and paper. |
| **Finite** | Something which **will** eventually **run out** (the opposite of sustainable). | Fossil fuels are finite. |

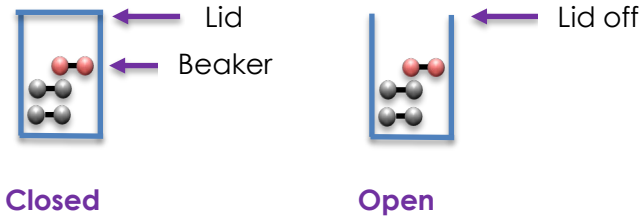
# Prior Knowledge Organiser

## Conservation of mass

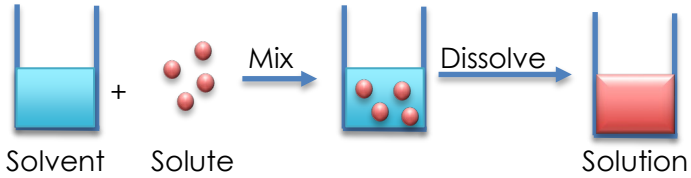



The **law of conservation of mass** states that no matter is **created** or **destroyed** in a chemical reaction.

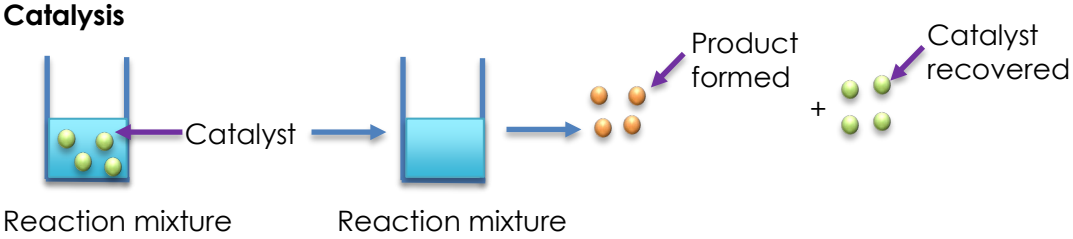
## Closed Systems



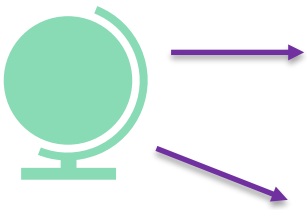

## Solutions




## Catalysis



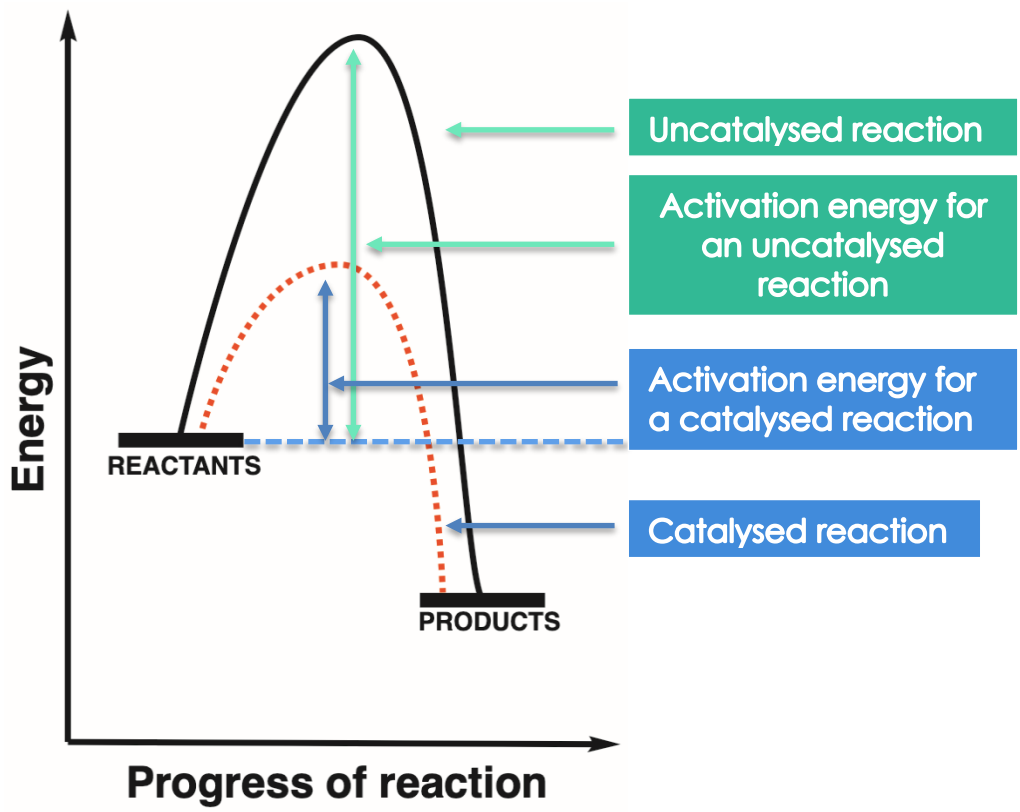

## Earth's Resources



**Finite resources:** such as fossil feedstock will eventually run out. The faster it is extracted, the sooner it will run out.

**Renewable resources:** such as biomass can be replenished i.e. by growing plants.

## Tutorial 1 – What is a catalyst?




### What is the Purpose of Tutorial 1?

This tutorial will give you an introduction to **what a catalyst is** and **why they are useful** in chemical reactions. We will begin to discuss how using a catalyst in your chemical reaction can make it "**greener**".

You will be able to:

- **Recall** that a chemical reaction is the rearrangement of atoms
- **Explain** how a catalyst mediates chemical reactions by its effect on the rate of chemical reactions
- **Define** activation energy in relation to a catalysts function

### Keywords

Reaction, atoms, conservation of mass, catalyst, activation energy, reactants, products.

## Activity 1 – Understanding Chemical Reactions

**Question 1.**

Reaction 1 is carried out in a **CLOSED SYSTEM**.

$$2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$$

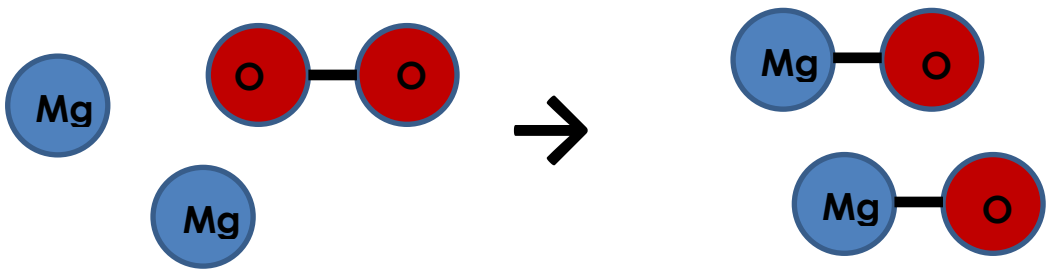
(a) Circle the number corresponding to the correct definition of a **closed system**.

A reaction where:
1. Reactants CAN escape but products CANNOT.
2. Both reactants and products CANNOT escape.
3. Both reactants and products CAN escape.
4. Products CAN escape but reactants CANNOT.

(b) Of the reactants, which is a **MOLECULE**? Circle the number corresponding to the molecule.
1. Mg
2. $O_2$

(c) What does the (s) in 2 Mg**(s)** stand for?
1. Solution
2. Solvent
3. Solid
4. Science

(d) The figure below represents Reaction 1.




(i) Label the bond/s which are **broken** (with a cross **X**)

(ii) Label the bond/s which are **formed** (with an arrow ↓).

(e) Have a look at the chemical symbol equation below.

$$2\ H_2(g)\ +\ O_2(g) \rightarrow H_2O(l)$$

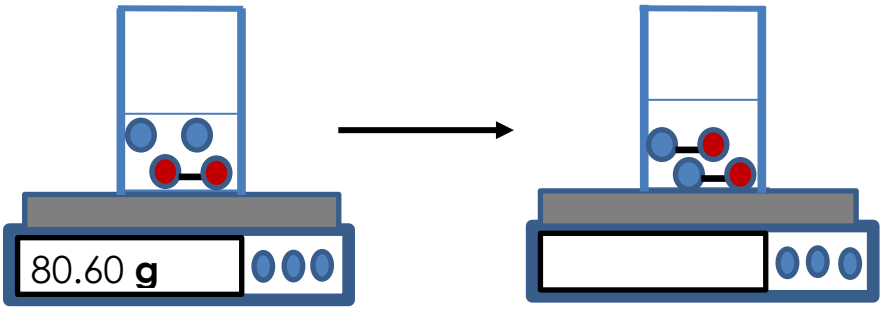
(i) Using the diagram in (d), draw a figure to represent this reaction.

(ii) On your figure in (e)(i), label the bonds which are broken and the bonds which are formed in the same way as the previous example.

**Question 2.**

The reaction you have discussed in Question 1 is shown in the Figure below. The **reactants** are present in the beaker on the **left-hand side**. They weigh **80.60 g** (shown on the screen of the balance).

(a) Fill in the blank screen of the balance, on the **right-hand side**, showing the **mass of the product**. Remember, this reaction is carried out in a **closed system**.




**Stretch and Challenge**

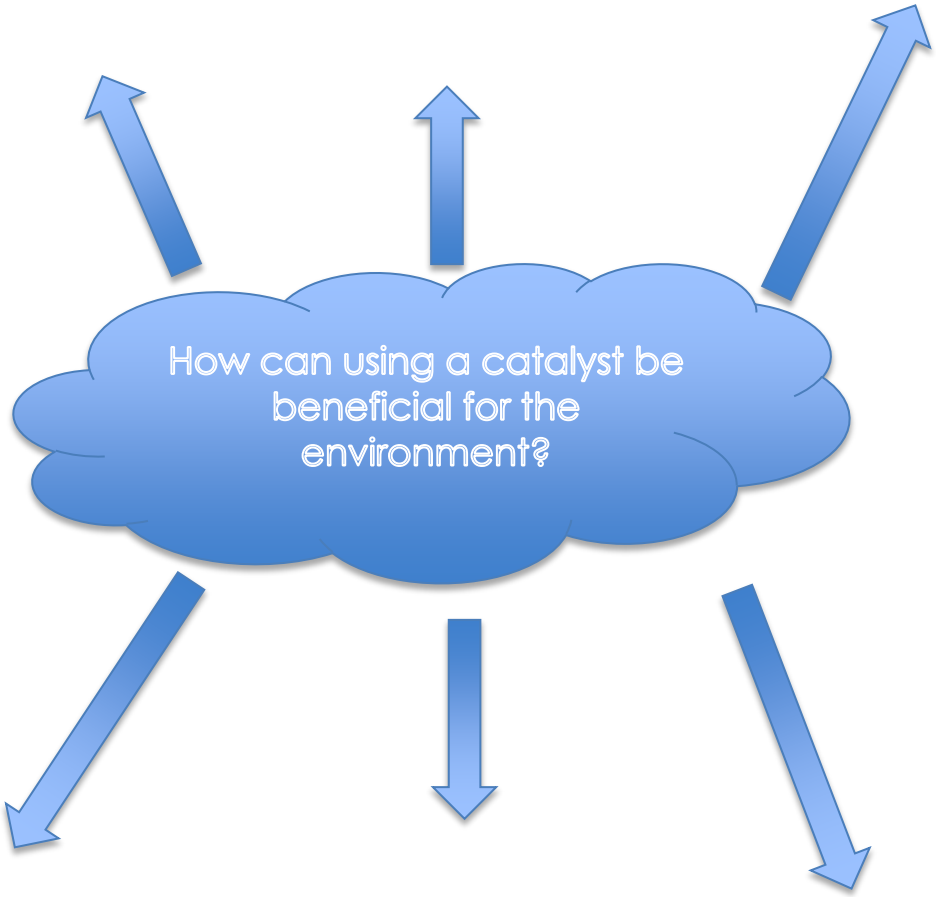
What do you think a catalyst is?

## Notes

Use this space to answer questions like:

- ⇒ What is a catalyst?
- ⇒ How does a catalyst speed up the rate of a reaction?
- ⇒ How else would you speed up the rate of a reaction?

**Activity 2 – How can using a catalyst be beneficial for the environment?**



## Homework 1 – The Importance of Catalysis in Green Chemistry (Baseline)

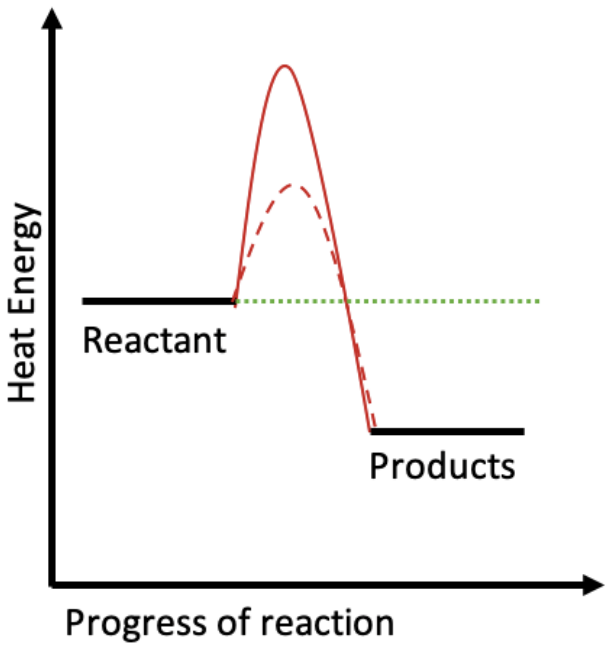
**Problem Set** - Answer the following questions in full sentences.

1. Define, using illustrations if necessary, the conservation of mass (2 marks).

2. Define a catalyst (2 marks).

3. Define the activation energy of a reaction (2 marks).

4. (a) On the Figure below, label which is a catalysed reaction, and which is an uncatalysed reaction (2 marks).



(b) On the Figure, draw an arrow and label it to illustrate the activation energy of a catalysed reaction (1 mark).

(c) Use this to explain how a catalyst increases the rate of a reaction (2 marks).

## Essay Question

Two students wish to carry out their reactions in your lab. They pitch their reaction conditions to you. Your task is to evaluate the chemical reactions and pick which student you will dedicate lab space to.

⇒ **Student A's** chemical reaction: The reaction **does NOT** use a catalyst. The reaction is carried out at **200 °C** and requires a time of **24 hours** to be complete.
⇒ **Student B's** chemical reaction: The reaction **does** use a catalyst. The reaction can be carried out at **room temperature** and requires a time of **30 minutes** to be complete.

In your answer include an evaluation of:

- Their use of a catalyst.
- The temperature they require for their reactions.
- The time the reaction takes.
- An overall evaluation of why you have picked one reaction over the other.
- The impact of human activity on the environment.
- The impact the chemical industry has had on the environment.
- How the use of a catalyst can alleviate the negative effect on the environment.

Conclude your mini-essay with why it is important to be more sustainable and pick three ways you can be more sustainable in your everyday life.

Hints: your answer can include a definition of the term "sustainable" and how it relates to this scenario. You can look up news articles to report on the human impact and chemical industry impact on the environment.

Use websites such as:

⇒ www.theguardian.com/uk or your choice of news websites.
⇒ www.rsc.org and use the search bar.
⇒ www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html

Or you can consult books you may find in the library or in the science or geography department!

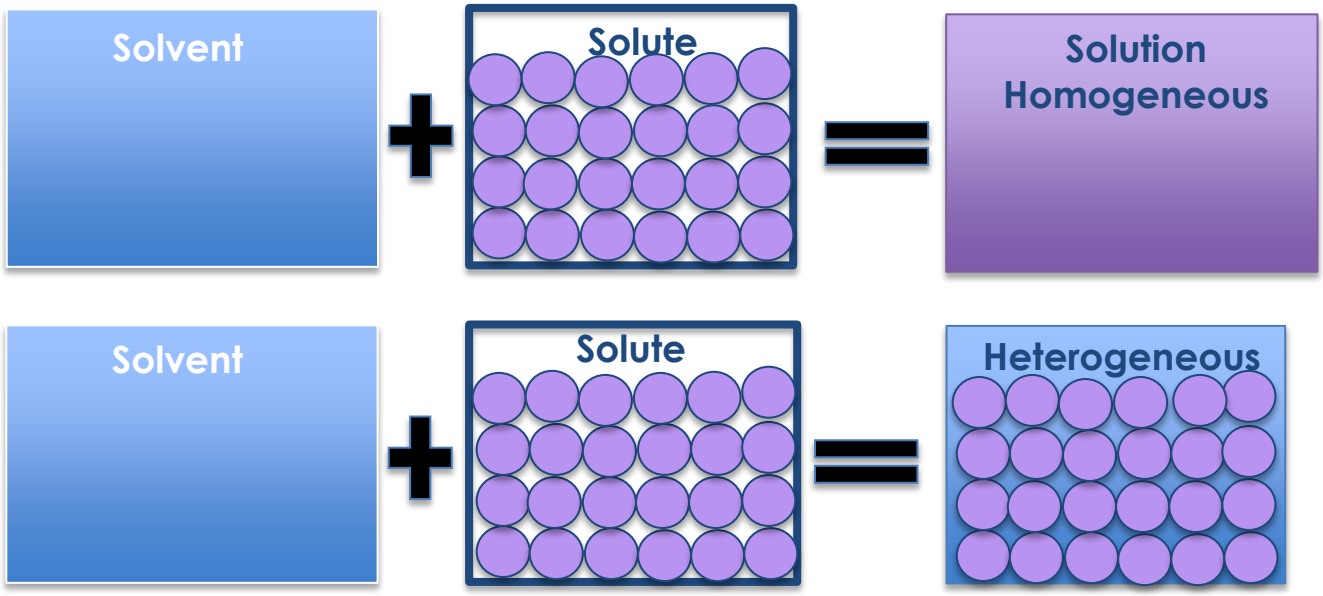
## Success criteria – how to structure your assignment and what to include:

- Your mini essay should be no longer than 1500 words (excluding references).
- You could include the terms: climate change, acid rain, pollution, toxic, energy, sustainable, finite, infinite.
- Remember, this is an open-book essay question. You can use your notes from Tutorial 1 and further research. Remember to cite your sources (see Appendix 1 for how to cite your sources).
- Use the definitions from your problem set to help you.

- Use appropriate headings and subheadings. Headings can be Introduction, discussion, conclusion, use your own subheadings.

| In this assignment, show me that you **understand**: | Show me that you are **able to**: |
|---|---|
| • What a **catalyst** is and how it **functions**.<br>• How a catalyst can be **beneficial** to the **chemical industry**.<br>• How to **evaluate** how **successful** a reaction is based on **reaction conditions**.<br>• How **humans** have impacted the environment. | • Structure your essay logically.<br>• Use scientific vocabulary correctly.<br>• Use your notes and independent research in order to write a clear and concise essay. |

# Tutorial 2 – Homogeneous and Heterogeneous Catalysis




## What is the Purpose of Tutorial 2?

This tutorial will remind you of the **states of matter** and the concept of **solubility**. Using this knowledge, you will be able to describe the difference between **homogeneous** and **heterogeneous catalysts**. We will begin to identify pros and cons for both.

You will be able to:

- **Identify** the three states of matter
- **Describe** the concept of solubility with regards to the solute and solvent
- **Define** homogeneous and heterogeneous catalysts using their knowledge of states of matter and solubility

**Keywords:** solid, liquid, gas, solute, solvent, dissolve, solubility, solution, homogeneous, heterogeneous, recyclability.

**Activity 1 - Do Now!**

Q1. What is a closed system?

Q2. Define a catalyst.

Q3. Define activation energy.

## Notes

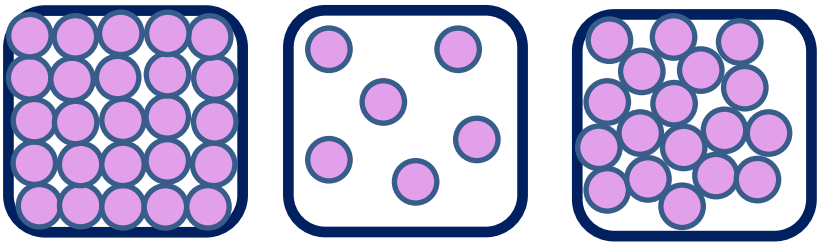
Use this space to answer questions like:

- ⇒ What differentiates a solid from a liquid from a gas?
- ⇒ What is the definition of a solute, a solvent, and a solution?
- ⇒ Give examples of "bad" solvents and "good" solvents.

## Activity 2 – Understanding Solubility

**Question 1**

In the boxes provided, please state whether the figure corresponds to the atomic distribution of a gas, liquid or solid.



_____ _____ _____

**Question 2**

Circle the letter which corresponds to the correct definition of a solution.

(a) A solvent dissolved in a solute.
(b) A solute dissolved in a solvent.

**Question 3**

(a) Below is a list of potential solutions. Can you identify which are correctly defined as solutions and which are incorrect? Correct = it is a solution. Incorrect = it is not a solution.

| Potential solution | Correct or incorrect |
|---|---|
| Salt in water forming saltwater | |
| Sugar in tea | |
| Oil in water | |
| Coffee beans in a cup of coffee | |
| Sodium hypochlorite and water in bleach | |

(b) For the potential solutions you chose as correct examples of solutions, can you identify which component is the solute and which is the solvent? If you identified it as not a correct example of a solution, leave the spaces blank.

| Potential solution | Solute | Solvent |
|---|---|---|
| Salt in water forming saltwater | | |
| Sugar in tea | | |
| Oil in water | | |
| Coffee beans in a cup of coffee | | |
| Sodium hypochlorite and water in bleach | | |

**Question 4.**

Place the following solvents into the following table of good (thumbs up!) or bad (cross) solvents.

Benzene

Ethanol

Chlorobenzene

Water

| | |
|---|---|
| | |
| | |

**Stretch and Challenge**

Explain why you placed each solvent in the "bad" or "good" category in the table.

- Benzene:
- Ethanol:
- Water:
- Chlorobenzene:

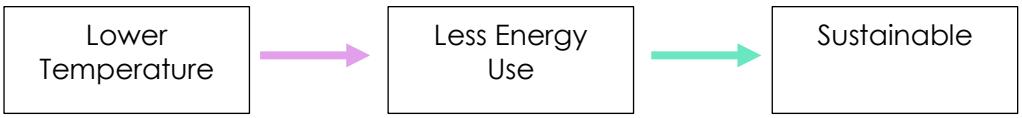
## Notes

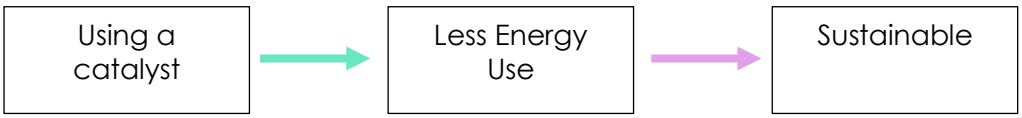
Use this space to answer questions such as:

- ⇒ What is a homogeneous catalyst?
- ⇒ What is a heterogeneous catalyst?
- ⇒ List two pros and two cons for each.

## Homework 2 - Evaluating Reaction Conditions

In our tutorials, we have started evaluating reaction conditions and categorising them as GOOD or BAD.
Examples of what we have studied so far can be expressed as flow diagrams.




**Question 1**

Using the blank flow diagram below, make your own flow diagram to describe what you have learnt in Tutorial 2 regarding "use of a solvent". For example, you can use "using an environmentally friendly solvent such as…" as your first box.

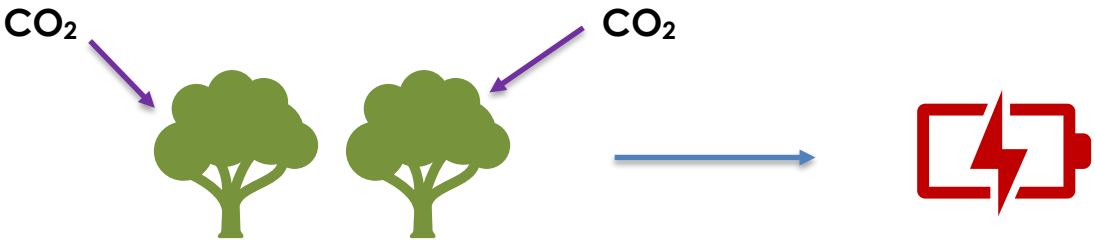
**Question 2**

Explain the link between your first two boxes in question 1 regarding "use of a solvent". i.e. using an environmentally friendly solvent such as butanol is beneficial to the environment as it is biomass derived.

**Question 3**

Explain why using a catalyst during a chemical reaction requires less energy than carrying out a reaction without a catalyst.

## Tutorial 3 – How can we be more sustainable?




### What is the Purpose of Tutorial 3?

This tutorial will further your understanding of the terms **finite** and **sustainable**. It will compare **fossil feedstock** to **biomass** derived reagents and the pros and cons of both. We will begin to look at the meaning of **green chemistry**.

You will be able to:

- **Discuss** the impact that chemical reactions could have on the environment and human health
- **Recognise** Earth's limited resources and **define** terms such as "finite" and "sustainable"
- **Define** "green chemistry" with respect to how it can limit the harmful effects of chemical reactions on the environment and human health

**Keywords:** Finite, sustainable, fossil feedstock, biomass, green chemistry.

**Activity 1 – Do Now!**

Q1. What is a homogeneous catalyst?

Q2. What is a heterogeneous catalyst?

Q3. How can catalysts help make reactions less energy intensive?

Q4. List one pro of each homogeneous catalysis and heterogeneous catalysis.

## Notes

Use this space to answer questions such as:

- ⇒ What negative impacts can chemistry have on the environment?
- ⇒ What positive impacts can chemistry have on the environment?

## Activity 2 – Understanding sustainability

### Question 1

Fill in the blanks in the following sentences.

(i) Fossil feedstock is an example of a _____ resource, as it will eventually run out.
(ii) Biomass is an example of a _____ resource, as it is virtually infinite.
(iii) The largest form of biomass are _____ and one example is _____.

### Question 2

List three pros and three cons to using biomass-derived material instead of fossil feedstock.

| Pros | Cons |
|---|---|
| | |
| | |
| | |

### Question 3

Using your knowledge from your previous tutorial and today's tutorial, how can catalysis be used to help switch from fossil feedstock to biomass-derived material for either fuels or high-value chemicals?

## Activity 3 – The Principles of Green Chemistry

Carefully read the background section and highlight or underline key parts.

**Background**

Practical chemistry has an enormous positive impact on society. Examples of this are:

- ⇒ Medicines are synthesised using practical chemistry.
- ⇒ Crops for food and fuels require chemicals such as pesticides and fungicides. These chemicals are synthesised using practical chemistry.
- ⇒ Everyday commercial products such as cosmetics, plastics, dyes and paints are synthesised using practical chemistry.

Life would be very different to how it is now without practical chemistry.
However, we have discussed how, in a mission to improve our quality of life, we have harmed the environment. Green chemistry is a strategy implemented to prevent or minimise further damage to the environment through practical chemistry.

In practice, green chemistry can be implemented by following the principles of green chemistry, designed by Anastas and Warner.[1] The headings for the 12 principles are listed below. In your own words, explain what each heading refers to.

1. Waste Prevention –

2. Atom Economy –

3. Less Hazardous Synthesis –

4. Designing Safer Chemicals –

[1] Anastas, P. T., & Warner, J. C. (1998). *Green chemistry: Theory and practice*. Oxford [England: Oxford University Press.

5. Safer Solvents

6. Energy Efficiency –

7. Use of Renewable Feedstocks (Biomass) –

8. Reduce Derivatives –

9. Catalysis –

10. Design for Degradation –

11. Real-time Analysis for Pollution Prevention –

12. Inherently Safer Chemistry –

## Homework 3 – The Principles of Green Chemistry

You can find the 12 principles of green chemistry on this website: www.acs.org/content/acs/en/greenchemistry/principles/12-principles-of-green-chemistry.html

1. Finish off your activity 3 worksheet using the explanations on the website.

2. Think of three things you will start doing from tomorrow onwards to lead a more sustainable lifestyle. Explain how these three things will have a positive effect on the environment. You can do this via the use of a mindmap or bullet points.

# Tutorial 4 – Atom Economy, Percentage Yield, & Conversion of Chemical Reactions

$$\text{Percentage Atom Economy} = \frac{\text{Total } M_r \text{ of the desired product}}{\text{Total } M_r \text{ or all reactants}} \times 100$$

$$\text{Percentage Yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$\text{Percentage Conversion} = \frac{\text{Mass of the reactant left after the reaction}}{\text{Mass of the reactant at the start of the reaction}} \times 100$$

## What is the Purpose of Tutorial 4?

In our previous tutorials, we have discussed ways to **qualitatively** determine whether a reaction is **sustainable** and **successful**. In this tutorial, we will discuss ways to measure the success of a reaction **quantitatively** through calculating the **percentage atom economy**, **percentage yield**, and **percentage conversion**.

You will be able to:

- **Define** atom economy, yield of a reaction, and the conversion of a reaction
- **Calculate** the atom economy, yield and conversion of reactions involving catalysts vs non-catalysed reactions
- **Identify** how atom economy, the yield and the conversion of a reaction determine the success of a reaction

**Keywords:** atom economy, yield, conversion, mass, relative formula mass, reactant, product.

## Activity 1 – Do Now!

Define the following terms:

Finite:

Renewable:

Sustainable:

**Stretch and Challenge**

What do you think atom economy means? Tip – break it into two individual words and think about their meaning.

## Notes

Use this space to make notes on how to solve calculations.

## Activity 2 – Important definitions

Atom Economy –

Why is it important to calculate atom economy?

Yield of a Reaction –

Why is it important to calculate percentage yield?

Conversion of a Reaction –

Why is it important to calculate percentage conversion?

## Activity 3 – Calculation Practise

Question 1

Using the information below, decide on which reaction you would rather carry out.

**Reaction 1:** $2\ Cu + O_2 \rightarrow 2\ CuO$
**Reaction 2:** $2\ Cu(NO_3)_2 \rightarrow 2\ CuO + 4\ NO_2 + O_2$

_____

_____

_____

_____

Reaction _____

Question 2

Using the information below, decide on which reaction you would rather carry out.

**Reaction 1:** $MgO + H_2O \rightarrow Mg(OH)_2$
**Reaction 2:** $MgCO_3 + 2\ NaOH \rightarrow Mg(OH)_2 + Na_2CO_3$

_____

_____

_____

_____

Reaction _____

Question 3

Calculate the percentage yield of the following reactions.

(i) $2\ Mg + O_2 \rightarrow 2\ MgO$
The theoretical yield of this reaction was 38 g. However, only 24 g was synthesised.

(ii) $2\ H_2 + O_2 \rightarrow 2\ H_2O$

The theoretical yield of this reaction was 18 g. However, only 11 g was synthesised.

Which reaction was more successful?

Question 4

Calculate the percentage conversion in the following reactions.

(i) $2\ CuO \rightarrow 2\ Cu + O_2$

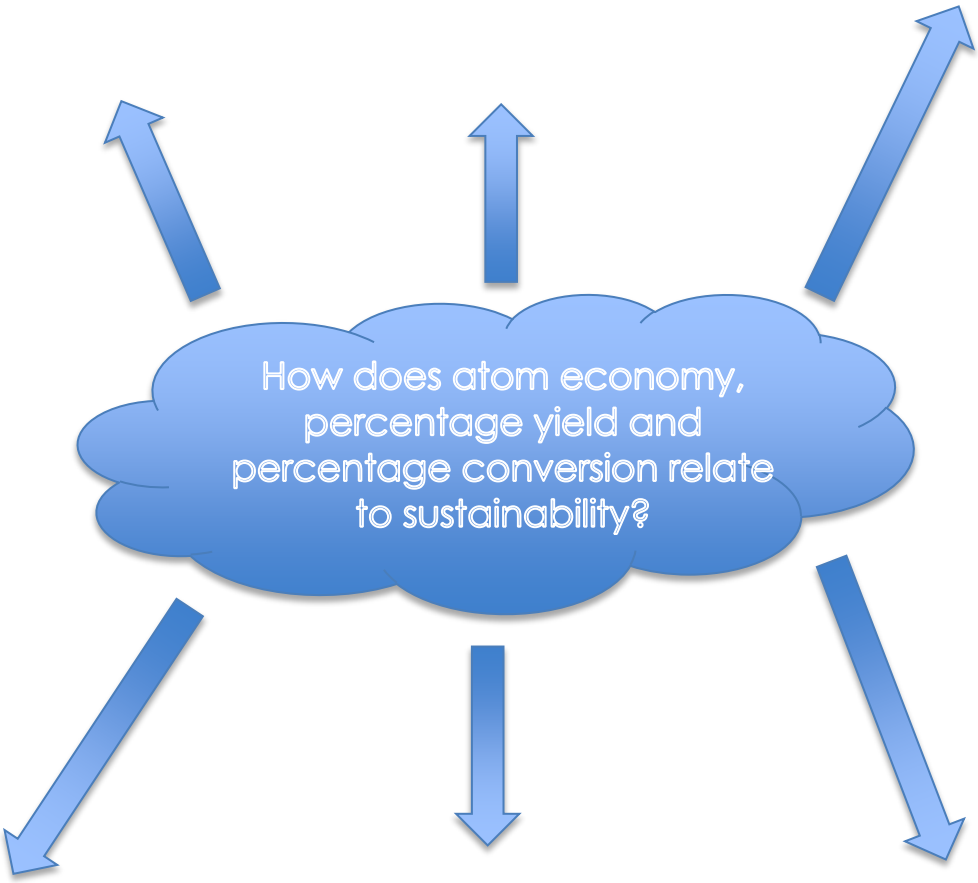
The scientist started with 27 g of copper oxide. The final reaction mixture contained 2 g.

(ii) $2\ H_2O \rightarrow 2\ H_2 + O_2$

The scientist started with 20 g of water. The final reaction mixture contained 0.5 g of water.

Using your answers to question 4, which reaction was more successful?

**Plenary – How does this all relate to green and sustainable chemistry?**



**Homework 4 – Metal Catalysts**

Read the article in the following link and answer the questions:

https://edu.rsc.org/feature/catalytic-metals-and-their-uses/3007558.article

Q1. Catalysts work by lowering the activation energy of chemical reactions. The article states that the effect of this is saving energy. Unrelated to saving energy, what else can a catalyst do?

_____

_____

_____

Q2. What are biological catalysts called?

_____

Q3. What type of metals are commonly used as catalysts?

_____

Q4. Give three examples of metal catalysts.

(i) _____

(ii) _____

(iii) _____

Q5. Why do these metals make good catalysts?

_____

_____

_____

Q6. Give three examples of industrial processes catalysts are used for.

(i) _____

_____

(ii) _____

_____

(iii) _____

_____

Q7. How can catalysts be used to reduce harmful emissions from cars?

_____

_____

Q8. Watch the video and state how you know that the catalyst is a heterogeneous catalyst.

_____

_____

_____

# Tutorial 5 – Defining Successful Reactions

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## What is the Purpose of Tutorial 5?

This tutorial will bring together the knowledge from prior tutorials in order to define a successful reaction. You will be able to determine the pros and cons of a reaction by analysing the reaction conditions and be able to suggest methods to make reactions greener.

By the end of this tutorial, you will be able to:

- **Evaluate** the success of catalysed reactions against the principles of green chemistry
- **Discuss** how catalysis makes chemistry greener

## Activity 1 – Post-It!



You have been given three post-it notes.

On these post-it notes, write three different ways you could tell if a reaction is successful.

Write one on each post-it note.

Once you are finished, stick your post-it note on the whiteboard.

## Notes

Use this space to take notes from the post-it note activity.
Did someone post something you did not think of? If so, write it down.

## Activity 2 – What is biomass really?

Whilst watching the video, answer the following questions:

1. What is biomass?

_____

_____

_____

_____

2. What are the three examples of biomass given?

   (i)

   (ii)

   (iii)

3. What are the three examples of fossil fuels given?

   (i)

   (ii)

   (iii)

4. Roughly, how long does it take for carbon to become compressed and form fossil feedstock?

5. Compare the $CO_2$ emissions of using fossil fuels and biomass. Why is the use of biomass near carbon neutral?

## Activity 3 – How green is this reaction?

Read the description of the reactions below and evaluate how "green" they already are and suggest ways in which they can improve. Use the highlighters provided to highlight the pros of the reaction in one colour and the cons in the other.

Reaction 1

This reaction converts glucose from cellulose (abundant form of biomass) into three products, one of which is the desirable product. The reaction is carried out at 300 °C in a high-pressure reactor. The solvent for the reaction is benzene. The reaction takes 24 hours to be complete. It uses a homogeneous catalyst which requires energy to extract from the reaction mixture after the reaction is complete. The conversion of the starting material is 100%, however, the yield of the product is 80%.

What is good about this reaction?

How can you improve it?

Reaction 2

This reaction converts glucose from cellulose (abundant form of biomass) into one product, which is the desirable product. This reaction is carried out in *n*-butanol, derived from biomass. The reaction is carried out at 100 °C and requires a reaction time of 10 hours. The reaction uses a heterogeneous catalyst which is simply filtered out of the reaction once the reaction is complete. The reaction is monitored during to ensure no derivatives are made.

What is good about this reaction?

How can you improve it?

**Notes**

## Homework 5 – How can we be more sustainable?

Write an essay, containing appropriate headings and subheadings, answering the question **"How can we be more sustainable?"**. As this is a chemistry course, pay particular attention to how the chemical industry is moving to a more sustainable model. In particular, discuss catalysis as a method to make chemistry greener.

Ensure that your essay answers the following questions:

- What does the term sustainable mean?
- Why do we need to be more sustainable?
- How can we change our lifestyle to become more sustainable?
- What is the difference between renewable and finite feedstock?
- What are the pros and cons of both?
- What is the chemical industry doing to become more sustainable?
- How can catalysis help make chemistry greener?

Within your essay evaluate these fictional chemical reactions presented against the principles of green chemistry and discuss whether you think the reactions adhere to these principles. Pick the reaction you would choose as a chemist and discuss why.

(a) The reactant is glucose obtained from cellulose. Vanadium is the transition metal in the catalyst. Solvent = *n*-butanol. Temperature = ambient, Pressure = ambient, Yield of alkene product = 90%, Conversion of diol reactant = 90%. Byproduct = water.

(b) The reactant is glucose obtained from cellulose. Rhenium is the transition metal in the catalyst. Solvent = chlorobenzene. Temperature = 200 °C. Pressure = in-build pressure reaches 5 bar. Yield of alkene product = 50%. Conversion of diol reactant = 100%. Byproduct = water.

If required, include labelled diagrams with a caption summarising the content of the figure. The captions should begin with "Figure 1" and the numbering should be continuous throughout the essay.

All quotes should be referenced correctly (please refer to page 47).

**Success criteria – how to structure your assignment and what to include:**

- Your essay should be no longer than 2500 words (excluding references).
- You could include the terms: climate change, acid rain, pollution, toxic, energy, sustainable, finite, infinite.
- Remember, this is an open-book essay question. You can use your notes from our tutorials and further research. Remember to cite your sources (see Appendix 1 for how to cite your sources).
- Use the definitions from the glossary and the knowledge organiser to remind you of key concepts.
- Use appropriate headings and subheadings. Headings can be Introduction, discussion, conclusion, use your own subheadings.

# Tutorial 6 – Feedback tutorial

## What is the Purpose of Tutorial 6?

- To receive feedback on your final assignment
- To respond to the feedback from your Uni Pathways teacher
- To write targets for improvement on your final assignment

## Final assignment feedback from your Uni Pathways Teacher

(Remember to look at the mark scheme to help you understand what you have done well so far, and how you can do even better in your final assignment)

| Here are three things that my Uni Pathways Teacher thought I did well in my draft assignment |
|---|
| • <br><br>• <br><br>• |

| Here are three things that my Uni Pathways Teacher thinks that I could do to get a higher mark in my final assignment |
|---|
| • <br><br>• <br><br>• |

| Tasks from my Uni Pathways Teacher to do during the feedback tutorial to help me improve |
| --- |
| • <br><br>• <br><br>• |
| My response: |

| Actions I will take to improve my final assignment after this tutorial… |
| --- |
| • <br><br>• <br><br>• |

| Hand in date for my final assignment: | |
| --- | --- |

# Tutorial 7 – Final tutorial

**What is the Purpose of Tutorial 7?**

- To receive feedback and a grade on your final assignment.
- To reflect on the programme including what you enjoyed and what was challenging.
- To ask any questions you may have about university.

**Final assignment feedback from my Uni Pathways Teacher**

| Final mark: | University style grade: |
|---|---|
| Feedback: Here are three things that my Uni Pathways teacher thought I did well in my final assignment<br>•<br>•<br>• | |

| Here are three things that my Uni Pathways teacher thinks I should remember for when I am doing this kind of study in the future |
|---|
| •<br>•<br>• |

**University**

| What questions do you still have about University after taking part in Uni Pathways? |
| --- |
| • <br> • <br> • |

**Reflecting on Uni Pathways**

| What did you most enjoy about Uni Pathways? |
| --- |
| • <br> • <br> • |

| What did you find challenging about the programme? | How did you overcome these challenges? |
| --- | --- |
| • <br> • <br> • | • <br> • <br> • |

## Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

**What is a reference?**

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

**Why should I reference?**

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

**When should you use a reference?**

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

## How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].

2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

## Notes

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