

Taking it Further: Producing Ethanol from Ethene

Answer the questions below.

1. State the chemical formula of ethanol.

$\text{C}_2\text{H}_5\text{OH}$

2. Explain why fermentation is an anaerobic process.

It takes place in the absence of oxygen.

3. Describe the conditions needed for fermentation.

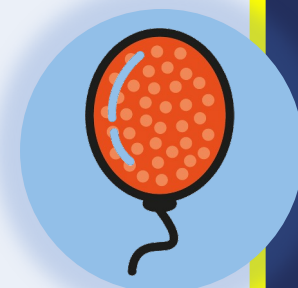
No oxygen, a sugar solution mixed with yeast, temperature of 25-35 °C

4. State the general formula of the alkenes.

C_nH_{2n}

5. Describe how bromine water can be used to tell the difference between an alkane and an alkene.

Using bromine water, which would turn from orange to colourless when added to an alkene but remain orange when added to an alkane.



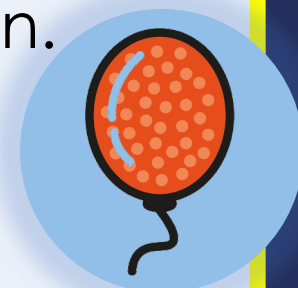
Taking it Further: Producing Ethanol from Ethene

Do Now:

1. State the chemical formula of ethanol.
2. Explain why fermentation is an anaerobic process.
3. Describe the conditions needed for fermentation.
4. State the general formula of the alkenes.
5. Describe how bromine water can be used to tell the difference between an alkane and an alkene.

Drill:

1. Draw the structural formula for ethene.
2. Name the product formed when ethene reacts with hydrogen.
3. Describe a condition needed for ethene to react with hydrogen.



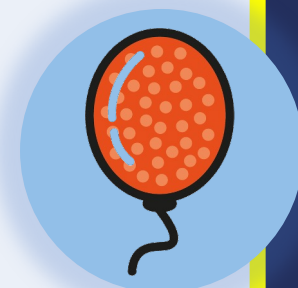
Taking it Further: Producing Ethanol from Ethene



Read Now:

Ethanol can be added to petrol for use as fuel for vehicles. This has become much more common since the 1990s, but particularly since 2005. Most petrol that you find at petrol stations is labelled 'E10', which means that it contains at least 10% ethanol. This is thought to slightly reduce the effects of burning fossil fuels on global warming, but only if the ethanol is produced through fermentation. This is when crops are grown as biofuels and therefore absorb carbon dioxide while they are growing. However, often ethanol is made from ethene, which is not a renewable resource as it is obtained from crude oil through fractional distillation and cracking.

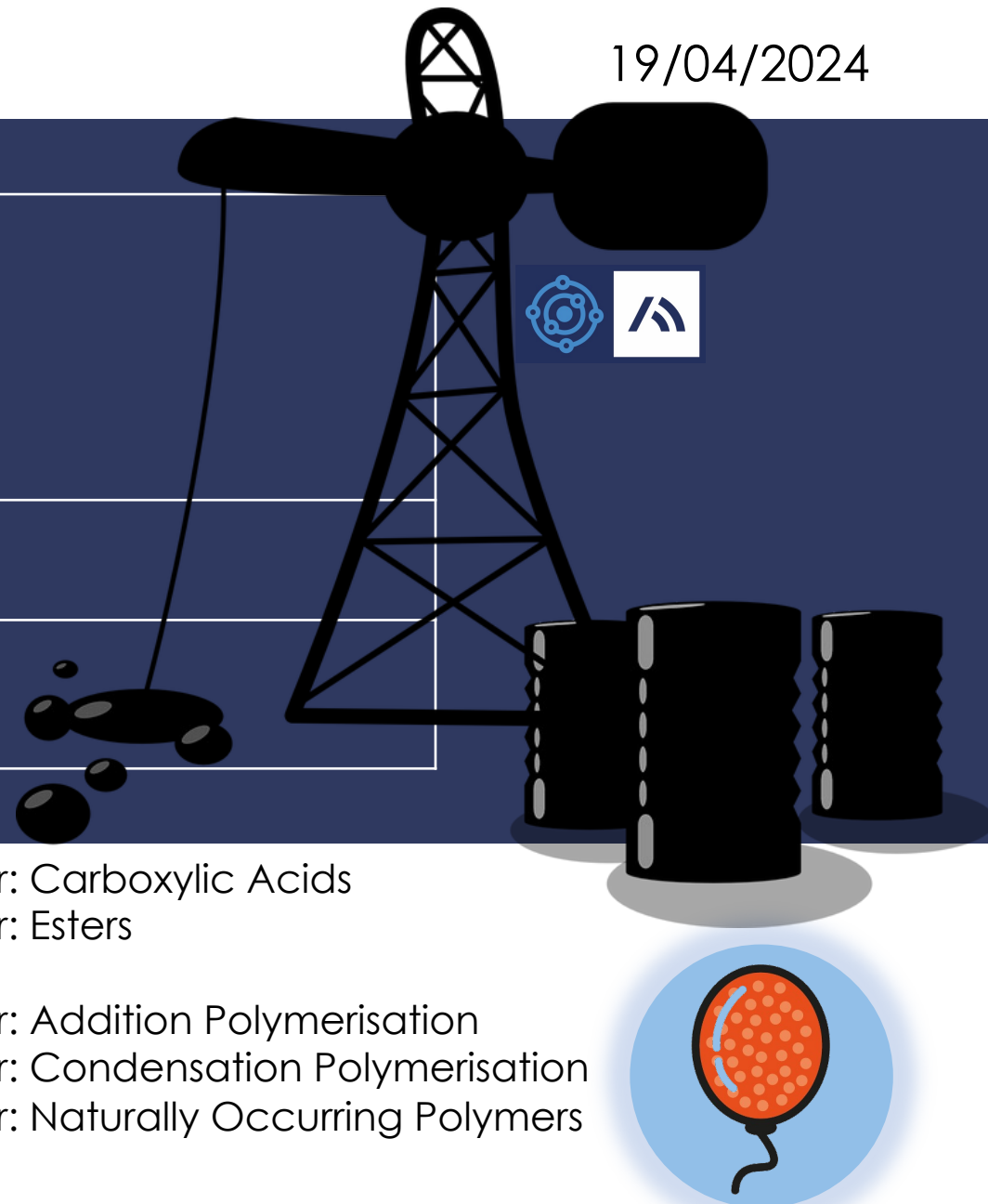
1. Give a use of ethanol other than in alcoholic drinks.
2. Explain what is meant by E10 petrol.
3. Explain why ethanol obtained from fermentation is a renewable resource.
4. Explain why ethanol obtained from ethene is not a renewable resource.



Taking it Further: Producing Ethanol from Ethene

C5.1.9

Science
Mastery



C5.1.1 Prior Knowledge Review
C5.1.2 Crude Oil and Hydrocarbons
C5.1.3 Fractional Distillation
C5.1.4 Combustion of Hydrocarbons
C5.1.5 Cracking
C5.1.6 Taking it Further: Alkenes
C5.1.7 Taking it Further: Alcohols
C5.1.8 Taking it Further: Producing Ethanol by Fermentation

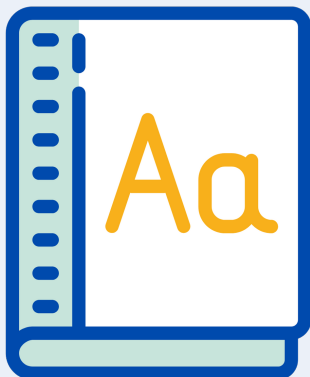
C5.1.10 Taking it Further: Carboxylic Acids
C5.1.11 Taking it Further: Esters
C5.1.12 Polymers
C5.1.13 Taking it Further: Addition Polymerisation
C5.1.14 Taking it Further: Condensation Polymerisation
C5.1.15 Taking it Further: Naturally Occurring Polymers

➤ **C5.1.9 Taking it Further: Producing Ethanol from Ethene**

Following this lesson, students will be able to:

- Describe how ethanol can be made from ethene
- Describe the conditions required for hydration of ethene
- Evaluate the advantages and disadvantages of different methods of ethanol production

Key Words:



ethanol

ethene

hydration

catalyst

continuous

This is the fix-it portion of the lesson

The **fix-it** is an opportunity to respond to gaps in knowledge, especially those identified by the **pre-unit quiz**.

- The teacher should customise this slide as needed, to facilitate
 - **reteach, explanation, demonstration** or **modelling** of ideas and concepts that students have not yet grasped or have misunderstood.
 - **practise** answering specific questions or of key skills.
 - **redrafting** or **improving** previous work.

Answer the questions below.

1. Choose the word equation for fermentation.
 - ☐ A. Glucose → lactic acid
 - ☒ B. Glucose → ethanol + carbon dioxide
 - ☐ C. Glucose + ethanol → carbon dioxide
2. Why should fermentation take place at a warm temperature?
 - ☐ A. So the reaction does not happen too quickly
 - ☒ B. So the enzymes in yeast are not denatured
 - ☐ C. So the ethanol can be evaporated
3. What is a disadvantage of producing ethanol by fermentation?
 - ☐ A. It is a very quick process
 - ☒ B. It can take days or weeks
 - ☐ C. It does not require much energy

Ethanol

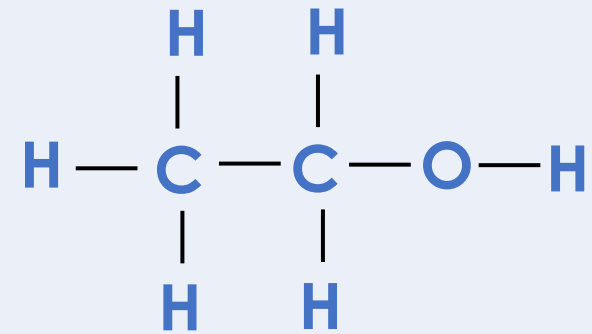
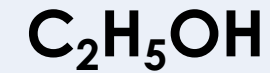
Ethanol is an **alcohol**.

It is useful as a solvent, a fuel or in alcoholic drinks.

It can be made in different ways:

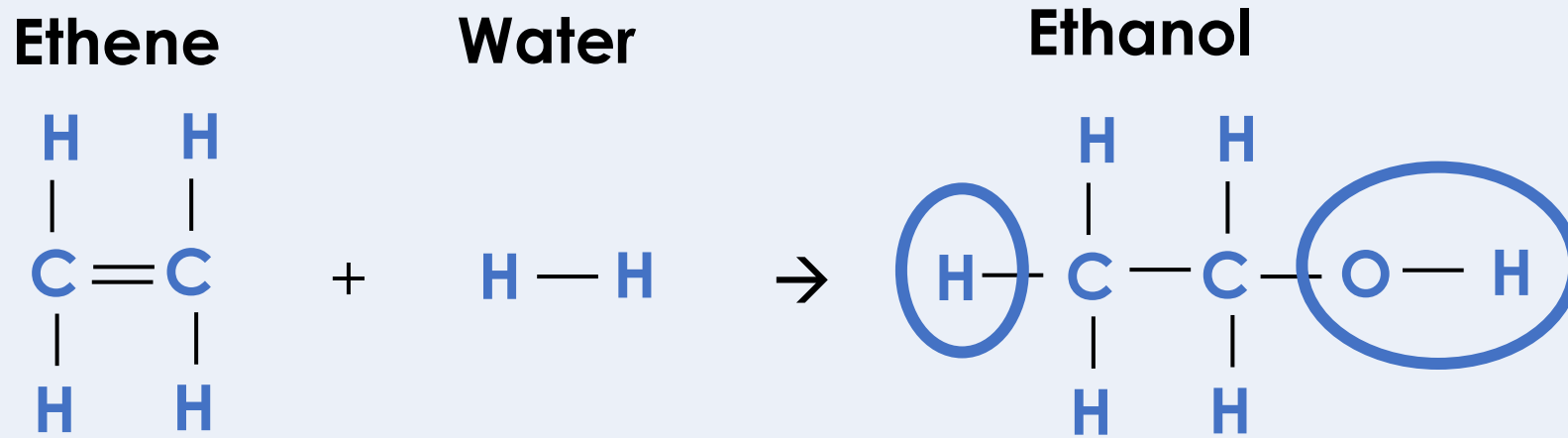
- **Fermentation**
- **Hydration of ethene**

Ethanol



Producing Ethanol

Alkenes can react with water through **hydration**.



Ethene for this reaction is obtained from **crude oil**, through **fractional distillation** and **cracking**.

Conditions for Hydration

There are several **conditions** required for alkenes, such as ethene, to be hydrated.

- The reaction requires a **high temperature** (approximately 300 °C)
- There needs to be a **catalyst**, for ethene → ethanol it is phosphoric acid
- The **pressure** needs to be 60-70 atmospheres

As the temperature is high, the alkene actually reacts with water vapour (steam):

Ethene + **steam** → ethanol



Reverse Reaction

The reaction can also be reversed.

This means that ethanol can be converted back to ethene:

Ethanol → ethene + steam



The rate of this reaction can be increased using aluminium oxide as a **catalyst**.

Which statements do you agree with?

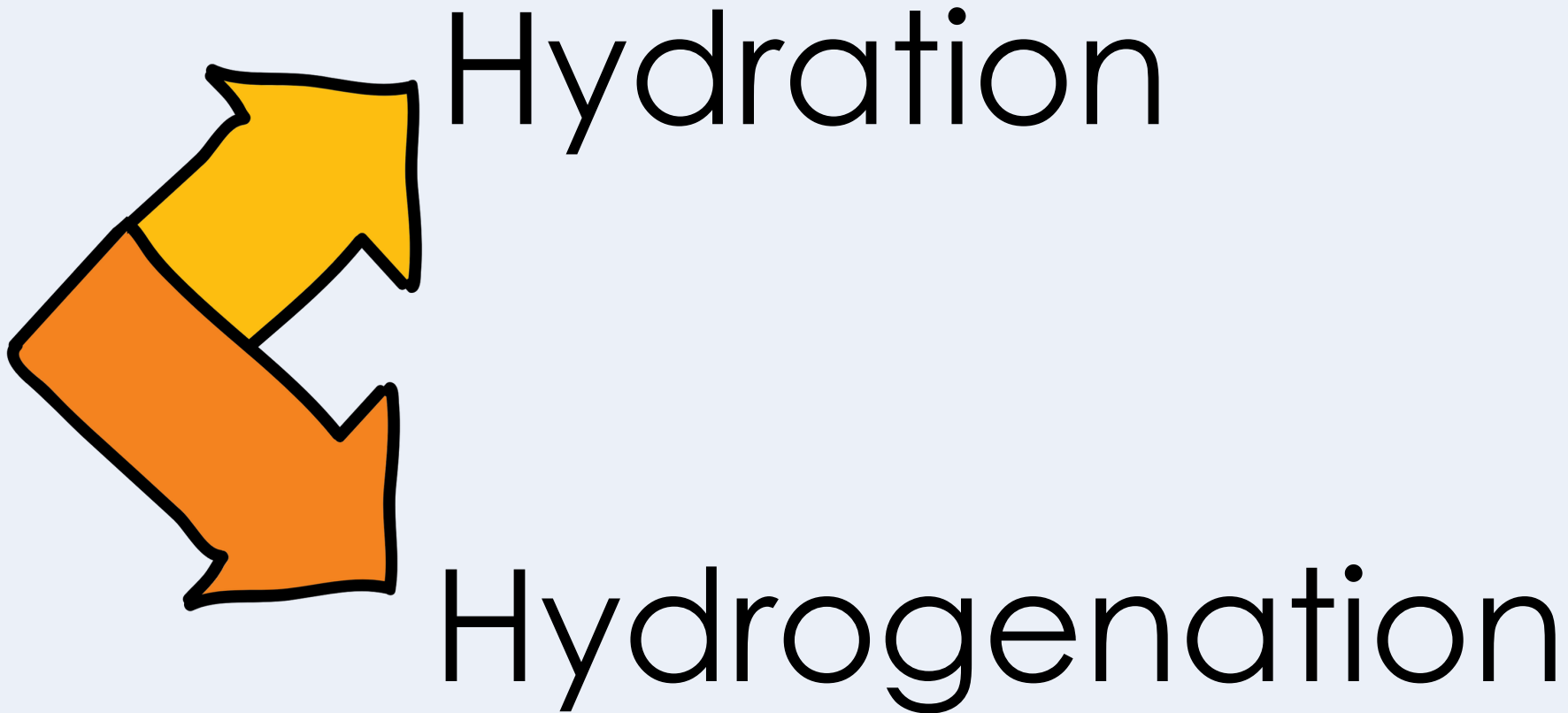
Producing ethanol from ethene uses a renewable raw material

Producing ethanol from ethene uses a non-renewable raw material

Producing ethanol from ethene requires a lot of energy

Producing ethanol from ethene does not require a lot of energy

Can you explain the difference between these two processes?



What are the reactants of each?

What are the products of each?

What conditions are needed for each?

Determine whether each of these statements is true or false

1. Ethene can be made by hydrating ethanol **False**
2. Hydration involves the addition of water **True**
3. Hydration of ethene requires a high temperature and pressure **True**
4. The reaction can be continuous if steam and ethene are continually added **True**
5. Hydration takes longer than fermentation **False**
6. Ethene comes from crude oil **True**

Drill

1. State the chemical formula of ethanol.
2. State the chemical formula of ethene.
3. Describe two methods of producing ethanol.
4. Describe how ethene is obtained from crude oil.
5. Explain whether ethene is a renewable or non-renewable resource.
6. Describe the conditions required for hydration of ethene.
7. State the word equation for the hydration of ethene.
8. State the chemical equation for the hydration of ethene.
9. State the general equation for the hydration of alkenes.
10. Describe the conditions required for the hydration of alkenes.
11. Explain why the alkenes are unsaturated.

Drill answers

1. $\text{C}_2\text{H}_5\text{OH}$
2. C_2H_4
3. Hydration of ethene and fermentation
4. Through fractional distillation of crude oil then cracking
5. Non-renewable, as it is obtained from crude oil, which is not replenished at the same rate that it is used
6. A high temperature (around $300\text{ }^\circ\text{C}$), 60-70 atm of pressure and a catalyst (phosphoric acid)
7. Ethene + steam \rightarrow ethanol
8. $\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH}$
9. Alkene + water (steam) \rightarrow alcohol
10. High temperature and a catalyst
11. They contain a $\text{C}=\text{C}$ double bond

I: Evaluating Methods of Ethanol Production

Describe the advantages of producing ethanol by hydration of ethene.

Hydration has a higher rate of reaction than fermentation so ethanol can be produced faster

Hydration produces ethanol with higher purity than fermentation, which means it is less likely to need to be distilled

| Method | Fermentation | Hydration of ethene |
|----------------------------|--------------|---------------------|
| Rate of reaction | Low | High |
| Purity of ethanol produced | 10-15% | >95% |
| Energy usage | Low | High |
| Raw material used | Sugar | Crude oil |

We: Evaluating Methods of Ethanol Production

Describe the disadvantages of producing ethanol by hydration of ethene.

Hydration uses more energy than fermentation, which means it is more expensive.

Hydration uses crude oil as a raw material which is non-renewable, whereas fermentation uses sugar, which is renewable.

| Method | Fermentation | Hydration of ethene |
|----------------------------|--------------|---------------------|
| Rate of reaction | Low | High |
| Purity of ethanol produced | 10-15% | >95% |
| Energy usage | Low | High |
| Raw material used | Sugar | Crude oil |

You: Evaluating Methods of Ethanol Production

Evaluate which method of ethanol production is better for a company.

Hydration has a higher rate of reaction than fermentation so ethanol can be produced faster. However, hydration uses more energy so is a more expensive process.

Hydration produces ethanol with higher purity than fermentation, which means it is less likely to need to be distilled. However, hydration uses crude oil, which is a non-renewable resource, unlike fermentation, which uses a renewable resource.

Overall, I think that hydration would be better for a company because although it uses non-renewable resources, it allows ethanol to be produced more quickly.

| Method | Fermentation | Hydration of ethene |
|----------------------------|--------------|---------------------|
| Rate of reaction | Low | High |
| Purity of ethanol produced | 10-15% | >95% |
| Energy usage | Low | High |
| Raw material used | Sugar | Crude oil |

Answer the questions below.

1. Choose the term for what happens when ethanol is made from ethene.
 - ☒ A. Hydration
 - ☐ B. Hydrogenation
 - ☐ C. Fermentation
2. What is a disadvantage of making ethanol from ethene?
 - ☐ A. Ethene is obtained from sugar cane so is renewable
 - ☒ B. Ethene is obtained from crude oil so is non-renewable
 - ☐ C. Ethene is obtained from biofuels so is renewable
3. What is an advantage of producing ethanol from ethene?
 - ☒ A. It produces ethanol much more quickly than fermentation
 - ☐ B. It is an energy intensive process
 - ☐ C. It requires high temperatures and a catalyst

Lesson C5.1.9

What was good about this lesson?

What can we do to improve this lesson?

[Send us your feedback by clicking this link](#)
or by emailing sciencemastery@arkonline.org
Thank you!