14–16 years

The fractional distillation of crude oil



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Introduction: crude oil

Crude oil is a **mixture** of chemical **compounds**, mostly **hydrocarbons**, which are molecules consisting of **carbon** and **hydrogen** only.

It is an incredibly useful **resource**. The molecules within the mixture have different physical and chemical properties which can be used in a wide variety of ways.



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Introduction: fractional distillation

To separate the **mixture** into its separate parts (or **fractions**), a process known as **fractional distillation** must be used.

In this experiment, you will use a crude oil substitute to **model** the fractional distillation process.

After collecting four fractions at different temperatures, you will test each one for **viscosity**, colour, smell and **flammability**.



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Learning objectives

1. Distil a crude oil substitute to simulate industrial fractional distillation of crude oil.
2. Observe and record the different properties of the fractions produced.
3. Describe how the different fractions are formed and link this to their physical properties.
4. Explain why different fractions have different properties.

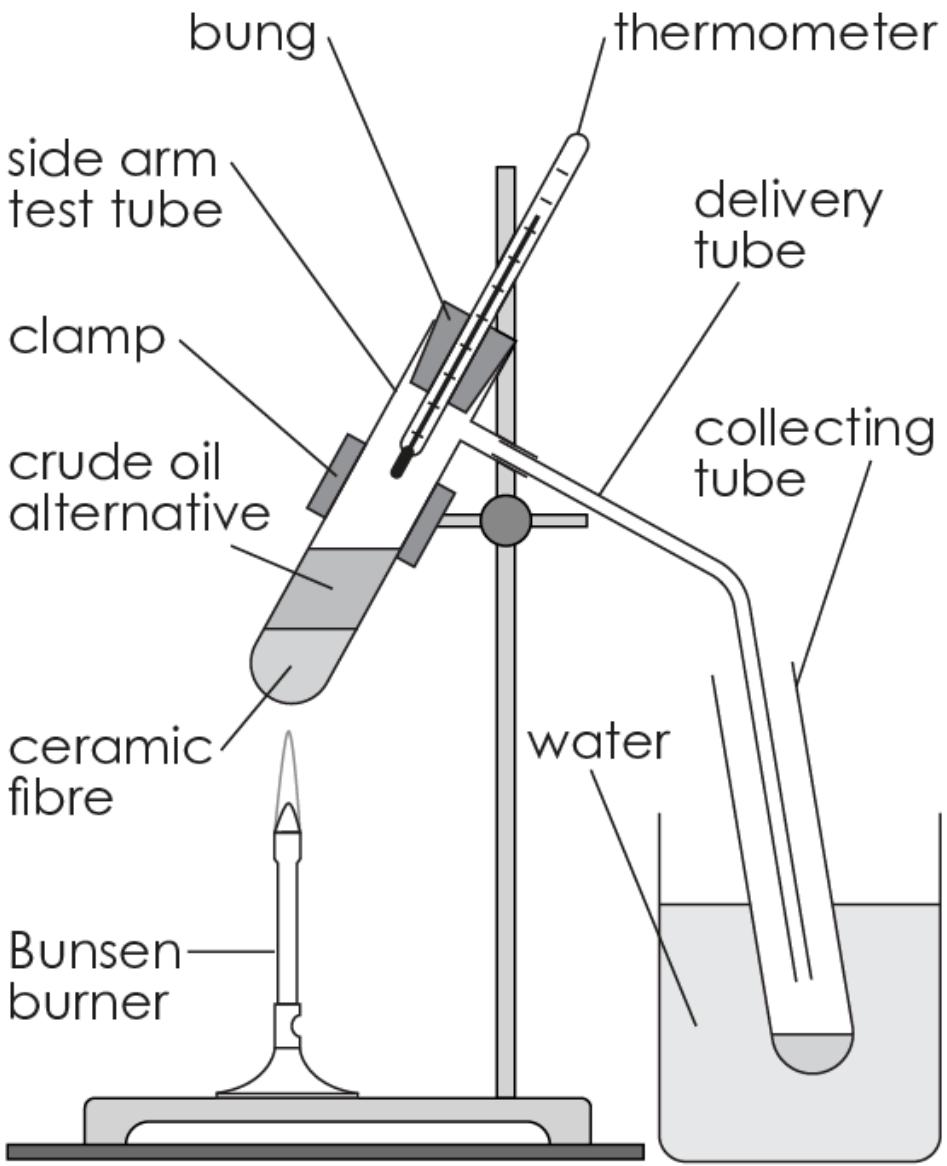
Equipment

- Safety glasses
- Bunsen burner
- Heat resistant mat
- Side-arm hard glass test tube
- Bent delivery tube and rubber connection tubing
- Small sample tubes, at least 20 mm x 5 mm (or small test tubes), x 4
- Thermometer, 0–360°C, with cork to fit side-arm test tube
- Teat pipette
- Beaker, 100 cm^3
- Hard glass (borosilicate) watch glass
- Mineral or ceramic fibre
- Wooden splints

Chemicals (per group)

- Crude oil substitute (HIGHLY FLAMMABLE and HARMFUL), about 2 cm^3

Diagram


bung
thermometer
side arm test tube
delivery tube
clamp
collecting tube
crude oil alternative
ceramic fibre
water
Bunsen burner

Method

1. Place about a 2 cm^3 depth of ceramic fibre in the bottom of the side-arm test tube. Add about 2 cm^3 of crude oil substitute to this, using the teat pipette.
2. Set up the apparatus as shown in the diagram. For the first fraction only, make sure that you place a beaker of cold water around the collecting tube. The bulb of the thermometer should be level with, or just below the side-arm. Heat the bottom of the side-arm test tube **gently**, with the **lowest Bunsen flame**. Watch the thermometer.
3. When the temperature reaches 100°C, replace the collection tube with another empty one. The beaker of water is no longer necessary.
4. Collect three further fractions at the following temperatures:
   - Room temperature to 100°C
   - 100–150°C
   - 150–200°C
   - 200–250°C

Method

5. A black residue will remain in the side-arm test tube. Test the four fractions for viscosity (how easily do they pour?), colour, smell and flammability, and record what you observe in your results table.
    - To test the smell, gently waft the smell towards you with your hand.
    - To test for flammability, pour the fraction onto a hard glass watch glass and light the fraction with a burning splint.

6. Keep one set of fractions and combine them to show that they form a mixture very like the original sample.

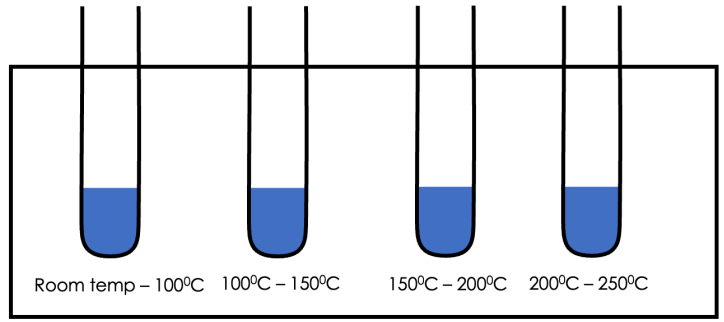
❶ 2 cm^3 ceramic fibre. ❑

❷ 2 cm^3 of crude oil ❑

❸ Heat gently. ❑

❹ Watch the thermometer.
At 100°C, swap the collection tube with an empty one. ❑

❺ Collect three further fractions:
100–150°C ❑
150–200°C ❑
200–250°C ❑



RSC Nuffield practical collection
The fractional distillation of crude oil
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Results

Results table

Fraction temperature range (°C)	Viscosity	Colour	Smell	Flammability
Room temperature to 100				
100–150				
150–200				
200–250				

Results

Fraction temperature range (°C)	Viscosity (how easily does it flow?) 1 = least viscous, 4 = most viscous	Colour	Smell	Flammability (how easily does it set on fire?) 1 = least flammable, 4 = most flammable
Room temperature to 100	1	Least colour/colourless	Paint solvent/petrol	4
100–150	2		Paraffin/jet fuel/paint thinner	3
150–200	3		Lamp/heating oil	2
200–250	4	Darkest in colour	Oils	1

Results table

Questions

1. Describe what crude oil is.
2. Explain why crude oil is a valuable resource.
3. State the order of viscosity as the boiling point range increases.
4. State the order of flammability as the boiling point range increases.
5. Describe what type of resource crude oil is. Explain why this is.
6. Explain the process of distillation.
7. Explain why the flammability of the fractions changes in this way.
8. Explain why the viscosity of the fractions changes in this way.

Unscaffolded questions

Questions

Scaffolded questions

Complete the following sentences using the words provided in bold:

1. Describe what crude oil is.

hydrogen **mixture** **hydrocarbons** **carbon**

Crude oil is a _____ of compounds called _____. These contain _____ and _____ only.

2. Explain why crude oil is a valuable resource.

lubricants **mixture** **heating** **feedstock**

plastics **fuels** **transport**

Crude oil is a valuable resource as it contains a _____ of compounds including _____ that we can use for _____ and _____ as well as chemicals that act as a _____ to manufacture solvents, _____ and _____.

3. State the order of viscosity as the boiling point range increases.

4. State the order of flammability as the boiling point range increases.

Questions

Complete the following sentences by deleting the wrong word from the brackets:

5. Describe what type of resource crude oil is and why.

Crude oil is an example of a **[renewable/non-renewable (finite)]** resource. This is because it is being used **[more quickly/more slowly]** than it is being replaced.

6. Explain the process of distillation.

During distillation, the liquid is first **[heated/cooled]**. It then turns into a **[gas/solid]**. This process is known as **[freezing/evaporation]**. When it **[cools/heats]** it begins to **[melt/condense]** back into a **[liquid/solid]**.

Questions

7. Explain why the flammability of the fractions changes in the way you observed.

Fractions with **[higher/lower]** boiling points contain larger molecules. Larger molecules are **[more/less]** volatile (they do not evaporate easily into a gas at room temperature), making it much **[harder/easier]** for them to catch fire compared with light, highly volatile molecules.

8. Explain why the viscosity of the fractions changes in the way you observed.

Fractions with **[higher/lower]** boiling points contain longer hydrocarbon chains. These longer chain molecules easily tangle together and have **[weaker/stronger]** intermolecular forces between them, making the liquid thicker and **[easier/harder]** to pour.

Scaffolded questions

Answers

1. Crude oil is a **mixture** of compounds called **hydrocarbons**. These contain **hydrogen** and **carbon** only.
2. Crude oil is a valuable resource as it contains a **mixture** of compounds including **fuels** that we can use for **heating** and **transport** as well as chemicals that act as a **feedstock** to manufacture solvents, **plastics** and **lubricants**.
3. The viscosity increases as the boiling point range increases.
4. The flammability decreases as the boiling point range increases.

Answers

5. Crude oil is an example of **non-renewable (finite)** resource. This is because it is being used **more quickly** than it is being replaced.
6. During distillation, the liquid is first **heated**. It then turns into a **gas**. This process is known as **evaporation**. When it then **cools** it begins to **condense** back into **a liquid**.
7. Fractions with **higher** boiling points contain larger molecules. Larger molecules are **less** volatile (they do not evaporate easily into a gas at room temperature), making it much **harder** for them to catch fire compared with light, highly volatile molecules.
8. Fractions with **higher** boiling points contain longer hydrocarbon chains. These longer chain molecules easily tangle together and have **stronger** intermolecular forces between them, making the liquid thicker and **harder** to pour.