

Fractional distillation

This resource is from the **Johnstone's triangle** series, which can be viewed at: rsc.li/43jMfSn.

Learning objectives

LO	Objective	Where assessed
1	Explain why different fuels have different boiling point ranges	Q1
2	Explain how diesel and petrol are separated in a fractionating column	Q2
3	Explain why butane and bitumen are collected at the top and bottom of a fractionating column	Q3
4	Explain the order in which fractions are collected in a fractionating column	Q4

How to use this resource

This resource aims to develop learners' understanding of the idea of the separation of crude oil with a fractionating column.

When to use?	 Introduce	 Develop	 Revise	 Assess
	Use after initial teaching or discussion of this topic to develop ideas further. You can also use it as a revision activity.			
Group size?	 Independent	 Small group	 Whole class	 Homework
	Suitable for independent work either in class or at home. Or you can use the questions for group or class discussions.			
How long?			15–30 mins	

The questions encourage learners to think at the macroscopic and sub-microscopic levels about how a fractionating column works. As a result, learners should develop more secure mental models to support their thinking about this topic.

Johnstone's triangle

Johnstone's triangle is a model of the three different conceptual levels in chemistry: macroscopic, sub-microscopic and symbolic. You can use Johnstone's triangle to build a secure understanding of chemical ideas for your learners.

Find further reading about Johnstone's triangle and how to use it in your teaching at rsc.li/4fuR6Gv.

Johnstone's triangle and this resource

The icons in the margin indicate which level of understanding each question is developing so as to help prompt learners in their thinking.



Macroscopic: what we can see. Think about the properties that we can observe, measure and record.



Sub-microscopic: smaller than we can see. Think about the particle or atomic level.



Symbolic: representations. Think about how we represent chemical ideas using symbols and diagrams.

The levels are interrelated; for example, learners need visual representation of the sub-microscopic in order to develop mental models of the particle or atomic level. Our approach has been to apply icons to questions based on what the learners should be thinking about.

Questions may be marked with two or all three icons, indicating that learners will be thinking at more than one level. However, individual parts of the question may require learners to think about only one or two specific levels at a time.

Support

Additional support could be provided for some learners by sharing a video or animation of the fractional distillation process. This worksheet is ramped so that the earlier questions are more accessible. The activity becomes more challenging in the later questions, so you may want to give extra explanations for these. If completing the worksheet as an in-class activity, it is best to pause and check understanding at intervals, as often one question builds on the previous one.

Answers



1. **Guidance note:** This question develops learners' understanding of the boiling point ranges of two hydrocarbon fuels (macroscopic understanding).

- (a) A hydrocarbon is a substance made up of carbon and hydrogen atoms only.
- (b) Diesel does not have a single boiling point because it is a mixture of different substances/hydrocarbons.

- (c) The hydrocarbon molecules that make up petrol are shorter. (If learners are not confident in their understanding, see Developing understanding, Alkane boiling points: rsc.li/4wRGd8E).



2. *Guidance note:* This question develops learners' understanding that hydrocarbons move up the fractionating column when in the gas state but leave the column when they condense to the liquid state (macroscopic understanding).

- (a) Evaporation
- (b) They are in the gas state and so are able to spread up the column.
- (c) B
- (d) The molecules have reformed the liquid state and so have been drained out of the fractionating column.
- (e) Petrol is made up of shorter hydrocarbon molecules which condense higher up the column where the temperature is lower.



3. *Guidance note:* This question develops learners' understanding of what happens at the top and the bottom of the fractionating column (macroscopic understanding) and why (sub-microscopic understanding).

- (a) Hotter
- (b) Bitumen is made up of a mixture of very long hydrocarbon molecules. These have not left the liquid to form the gas state and so can be drained from the bottom of the column.
- (c) Butane has very short molecules compared with the other fractions of crude oil. Even at the coolest temperatures at the top of the column butane does not condense, so it cannot be collected in the liquid state.



4. *Guidance note:* This question develops learners' understanding of the order in which hydrocarbons are collected from the fractionating column (macroscopic understanding) in terms of the molecule length (sub-microscopic understanding).

- (a) Petrol, kerosene, fuel oil
- (b) Fuel oil, kerosene, petrol
- (c) The temperature gradually cools moving up the column. Fractions with longer molecules condense near the bottom because they have higher boiling points, whereas fractions with shorter molecules and lower boiling points rise further up to the cooler regions where they condense and are collected.