Fractional distillation

How are the different hydrocarbons in crude oil separated?

D: Identify how a mixture of liquids could be separated

C: Describe and use the terms ‘volatility’, ‘viscosity’, ‘flammability’

B: Explain the steps involved in fractional distillation and uses of the products

A: Analyse the uses of the products from fractional distillation using their properties

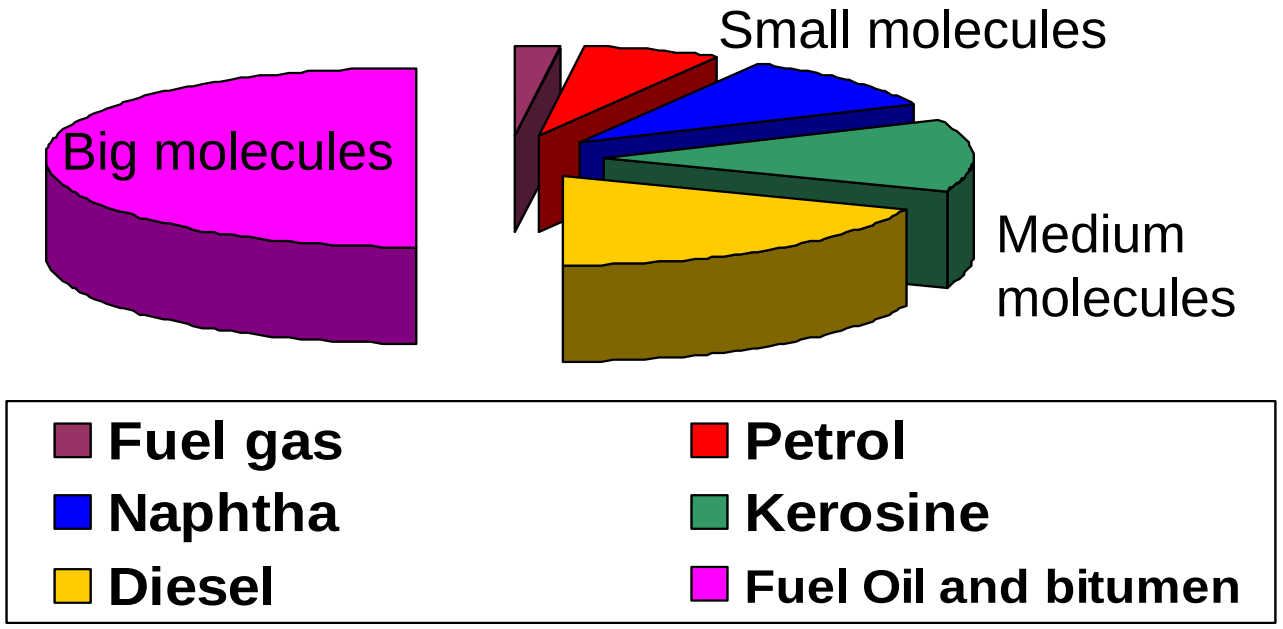
A*: Link chain length to properties of hydrocarbons

Starter

1. Copy title, date, and driving question – rate your starting grade
2. How could you separate the substance in front of you?
   Discuss.....

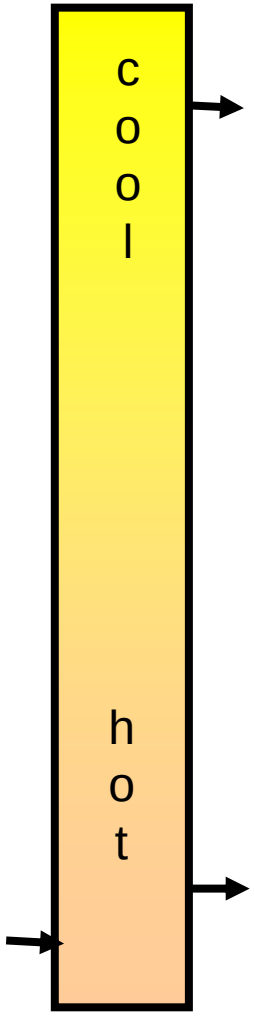
What is crude oil?

- Crude oil is a mixture of different sized hydrocarbons. The exact composition depends upon where the oil comes from but typically it contains a lot of big molecules.



Fractional Distillation

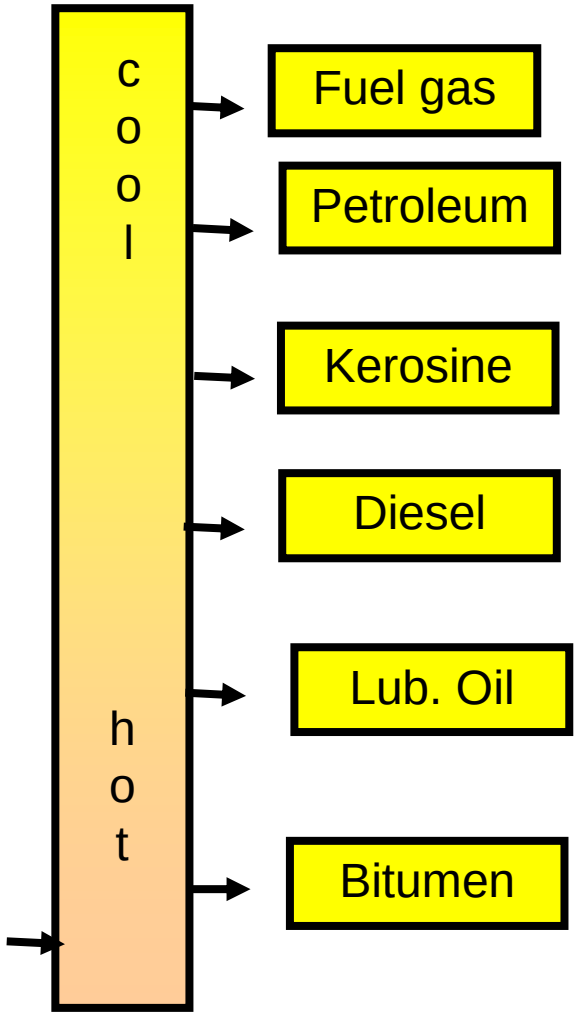
- Crude oil is split into fractions containing similar sized molecules using fractional distillation.
- The oil is heated until it vaporises.
- It then passes up a tall tower that is hot at the bottom but cool at the top.
- As the vapour passes up this tower the molecules cool and condense back to liquid.



Fractional Distillation

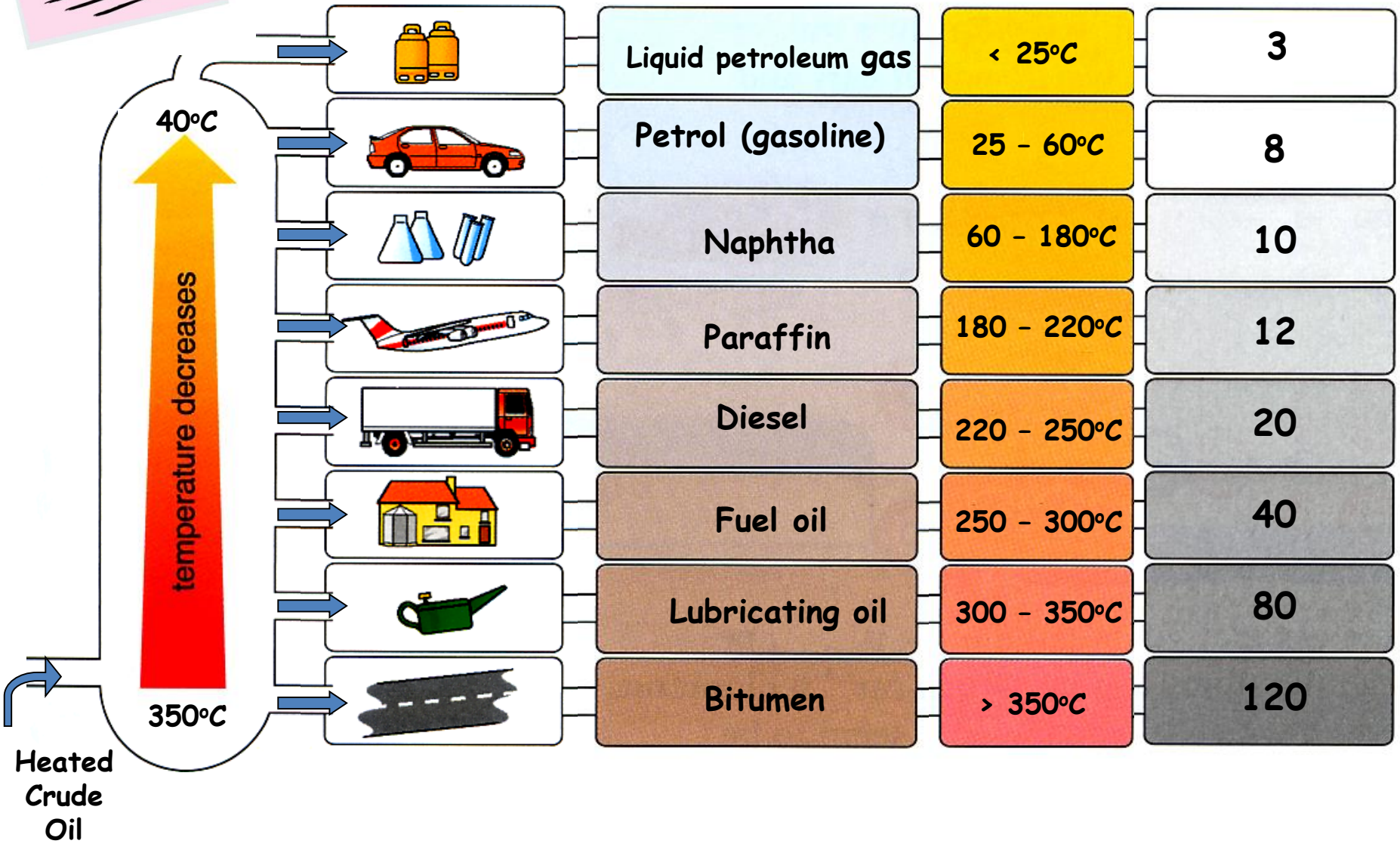
Copy the column and arrange the fractions in the right order next to the arrows.

Fraction	Boiling Range (°C)
Kerosine	150 - 240
Diesel	220 – 275
Petrol	40 - 175
Bitumen	>350
Fuel gas	Below 40
Lubricating oil	250-350

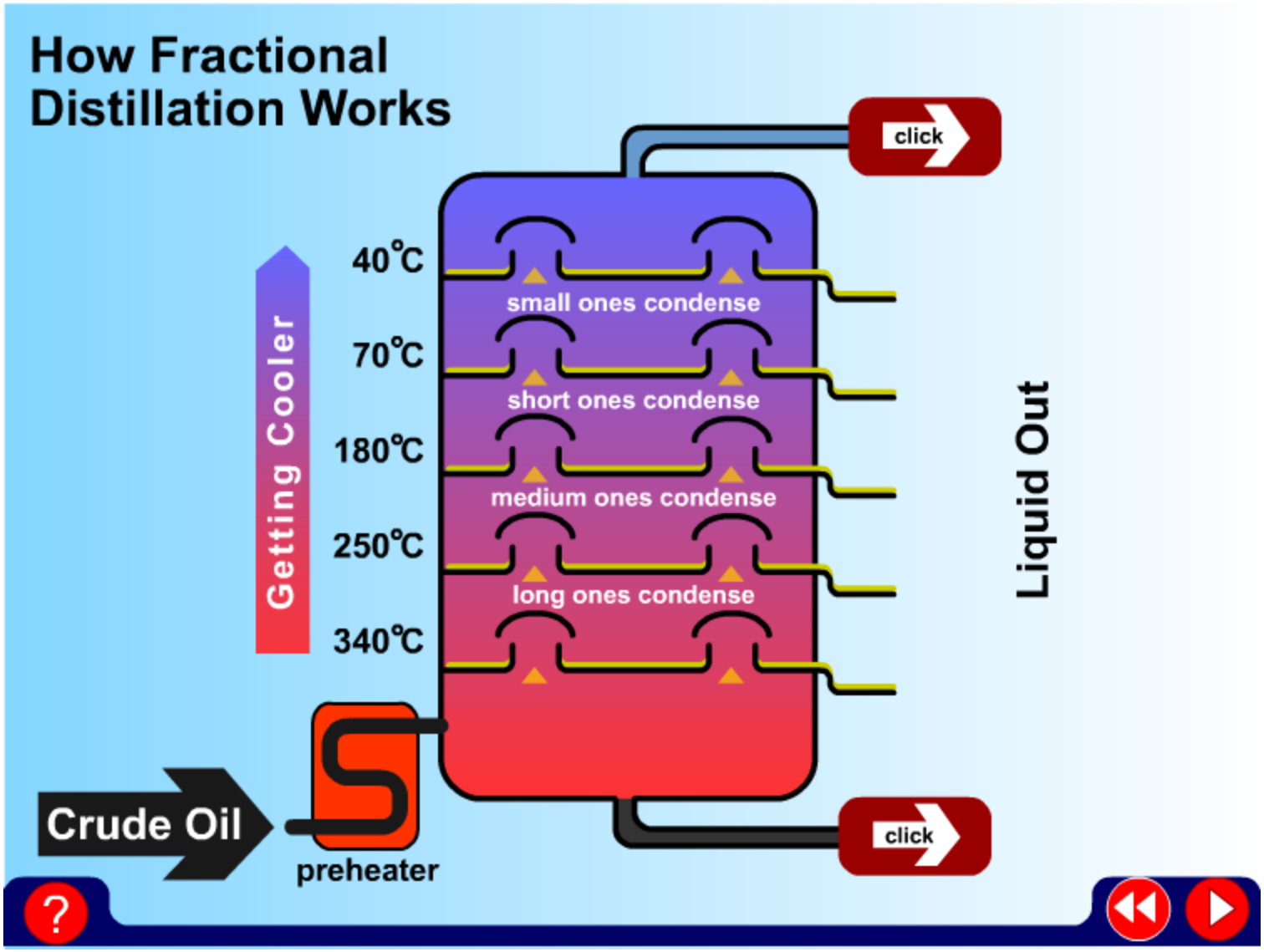


NEW

The Fractional Distillation of Crude Oil

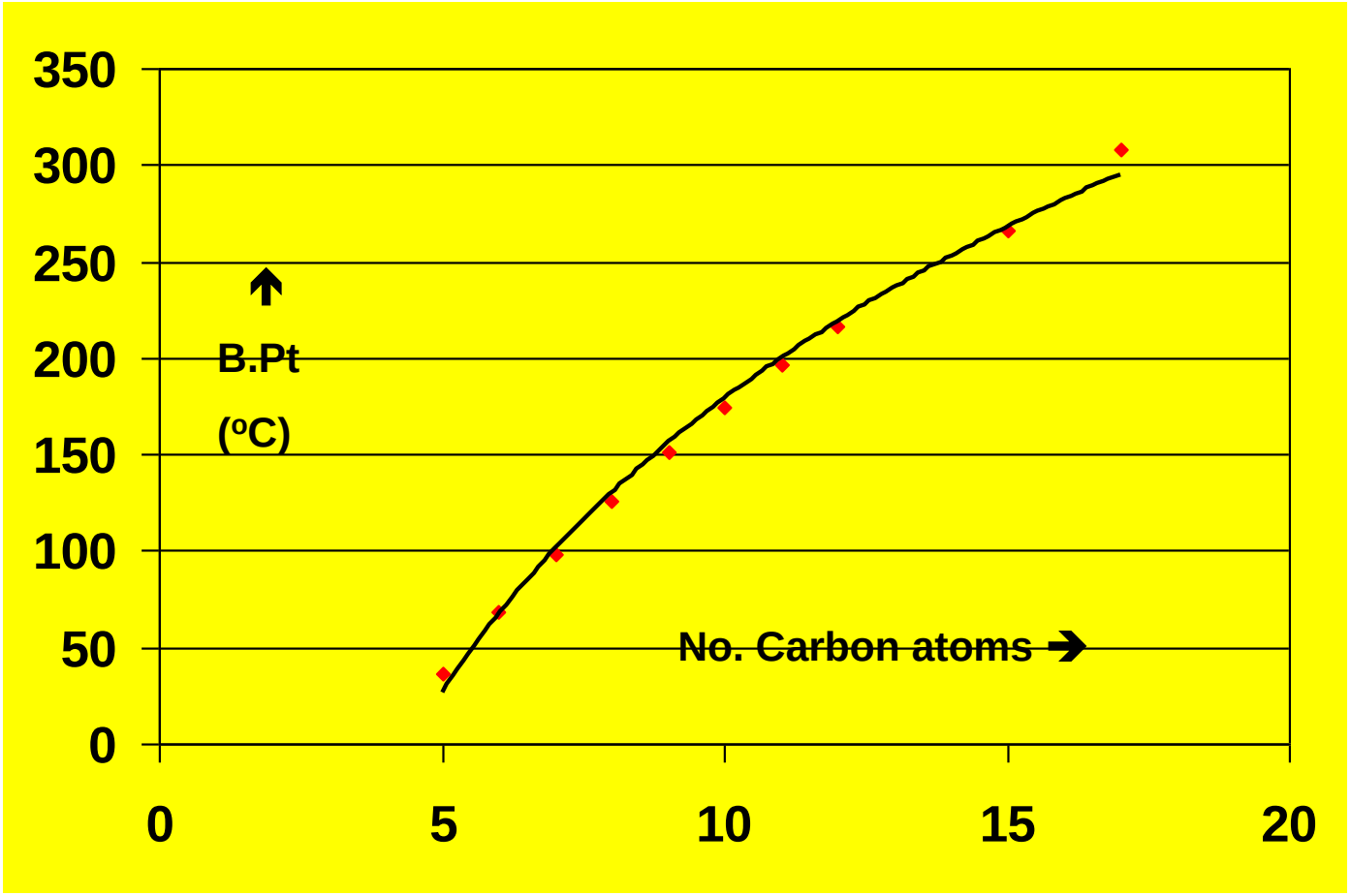


Fractional Distillation



The boiling points of molecules

We have already said that, in general, the bigger the molecule the higher the boiling point.



Here are the boiling ranges of some fractions obtained from distillation of petroleum.

1. Using the previous graph, estimate the size range of the molecules present in each fraction.

Fraction	**Boiling Range (°C)**	**Number of carbons**
Fuel gas	Below 40	**1-5**
Petrol	40 - 175	**5-10**
Kerosine	150 - 240	**9-14**
Diesel	220 - 275	**13-17**

The flammability of molecules

- When hydrocarbons burn they are reacting with oxygen in the air.
- In general, the smaller the molecule the better it will mix and then react with the air.

The viscosity of molecules

- When we pour a liquid the molecules have to pass each other. The easier they do this, the runnier the liquid is.
- The molecules in fuel oil and bitumen may contain up to 400 carbon atoms in long chain structures.
- These chains easily become entangled reducing the runniness of the liquid and so those made up of big molecules tend to be viscous (treacly) not runny.

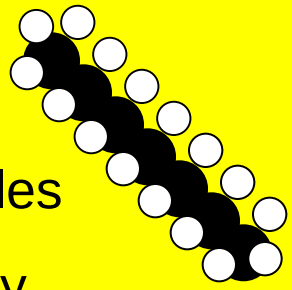
The viscosity of molecules

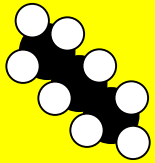
- In contrast, small molecules are more spherical and tend not to get tangled.
- They are therefore likely to have a low viscosity (be runny).

Bigger molecules

Higher viscosity

“Treacly”





Smaller molecules

Lower viscosity

“Runny”

The colour of molecules

- Small hydrocarbon molecules are gases or transparent liquids.
- As the molecules get larger the colour becomes increasingly yellow through to the brown/black colour of bitumen used on roads and roof repairs.

Increasing size of molecules ➔

Uses of each fraction

Fuel gas	Burned in the refinery to fuel the distillation process, sold as LPG, purified and sold as bottled camping gas
Petrol / gasoline	Fuel for cars and motorcycles, also used to make chemicals.
Naphtha	Used to make chemicals.
Paraffin / Kerosine	Fuel for greenhouse heaters and jet engines, manufacture of chemicals.
Diesel fuel	Fuel for lorries, trains.
Fuel and lubricating oil	Fuel for the heating systems of large buildings, fuel for ships, lubricating oil.
Bitumen	Roofing, and road surfaces.

This question is about fractional distillation of crude oil.

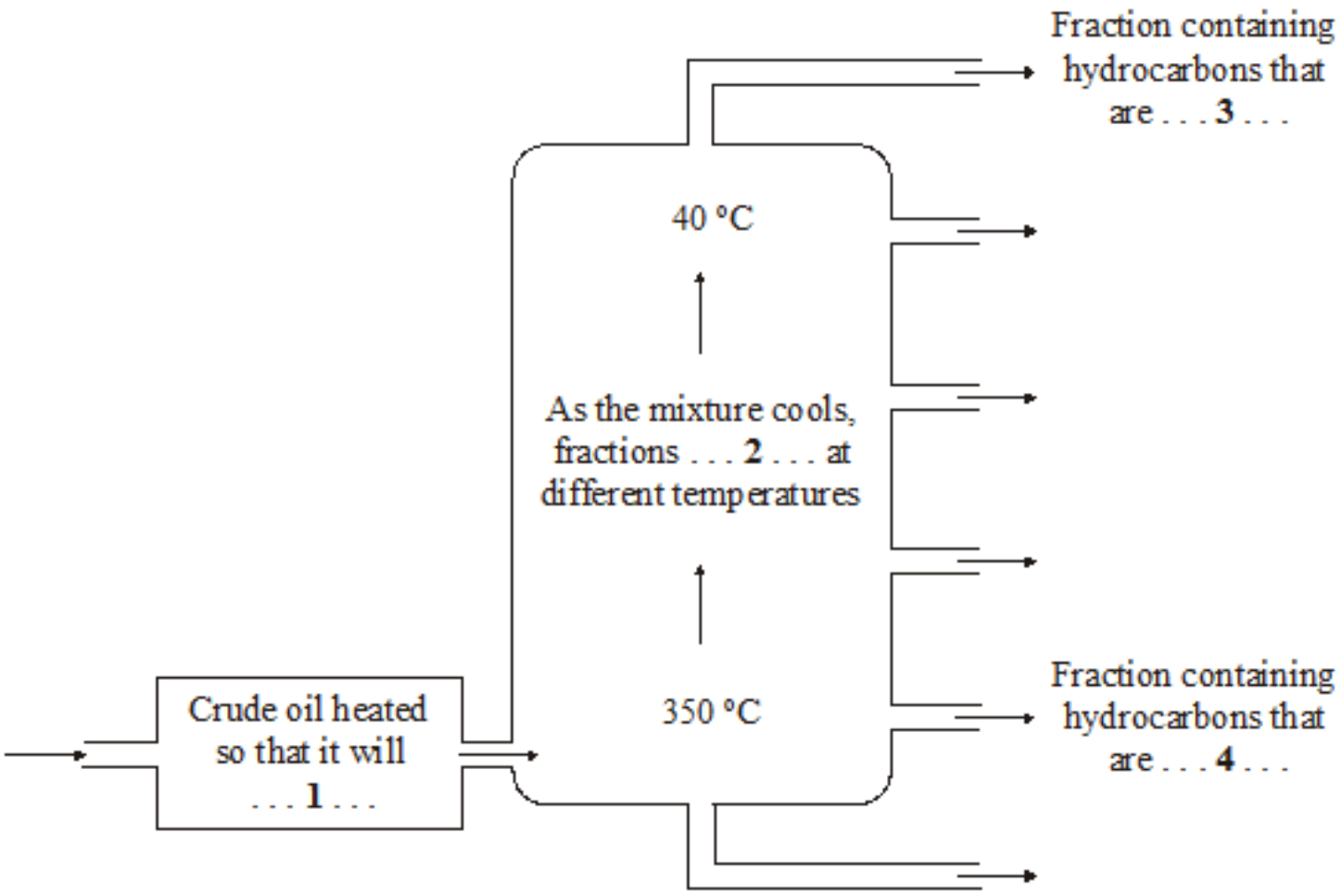
Match words, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences on the diagram.

A condense

B vaporise

C viscous

D volatile



Which is a correct statement about crude oil?

A. A mixture of carbohydrates.

B. Formed by the decay of dead sea creatures.

C. Consist of a mixture of very large molecules.

D. Is purified in an oil rig.

Which is a correct statement about fractional distillation?

A. Oil is separated into fractions with the same size molecule.

B. Oil is separated into fractions with the same density.

C. Oil is separated into fractions with similar size molecules.

D. Oil is separated into alkanes and alkenes.

Which is a correct order for these fractions working down from the top of the column?

A. Fuel gas, kerosine, petrol, diesel, bitumen.

B. Fuel gas, diesel, kerosine, petrol, bitumen.

C. Fuel gas, petrol, diesel, kerosine, bitumen.

D. Fuel gas, petrol, kerosine, diesel, bitumen.

Which of these is a true statement about the changes that occur as hydrocarbon molecules get larger?

A. Boiling point decreases.

B. Viscosity increases.

C. Flammability increases.

D. Transparency increases.

INFO SHEETS

Boiling point of fractions

Each fraction of crude oil contains a mixture of different compounds. This means that the boiling point of the fraction is not a fixed temperature but a range.

Fraction	Boiling point (°C)
LPG	< 0
gasoline	20-200
naphtha	20-180
kerosene	180-260
diesel	260-340
lubricating oil	370-600
fuel oil	>330
residue	N/A

Volatility and flammability

Fractions that have a low boiling point evaporate easily. The easier a fraction evaporates, the more **volatile** it is.

When fractions burn, they react with oxygen in the air.

The more volatile a fraction is, the easier it mixes with air. This means the fraction ignites and burns easily.

Fractions that ignite and burn easily are **flammable**.

Generally, the smaller the molecules in a fraction, the more volatile and flammable the fraction.

What is viscosity?

Some fractions of crude oil are thin and runny. Other fractions are thick and sticky. The runniness of a liquid is called **viscosity**.

For example, the residue from fractional distillation has a very high viscosity (it is **viscous**) and cannot be easily poured. Gasoline has a low viscosity and pours easily.

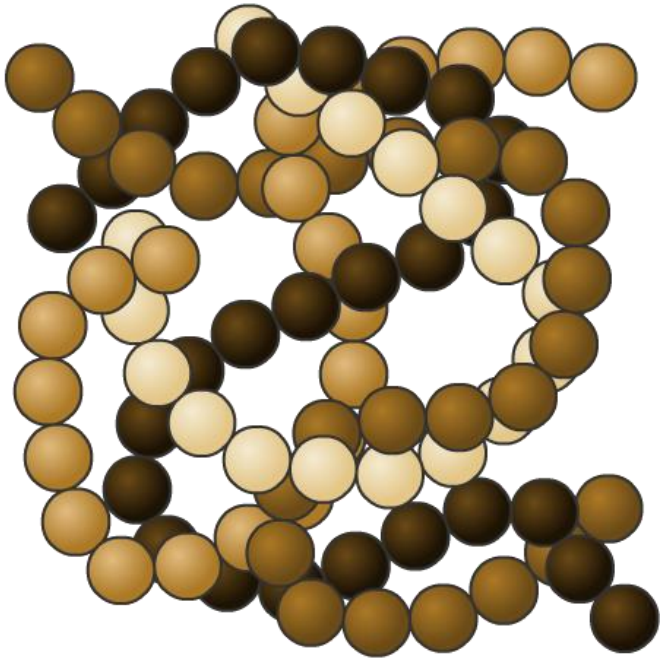
What is the relationship between the length of a hydrocarbon chain and the viscosity of a fraction?

The longer the hydrocarbon chains in a fraction, the more viscous the fraction will be.

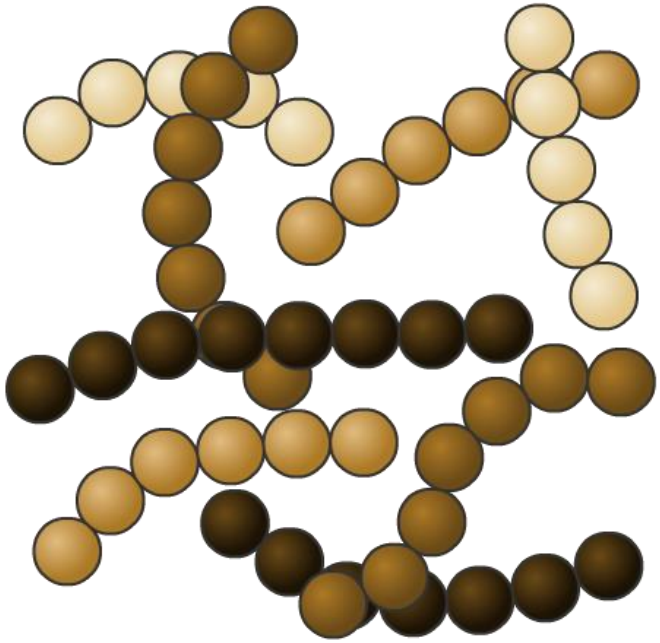
Molecule size and viscosity

Why are fractions with large hydrocarbon molecules more viscous than fractions with small hydrocarbon molecules?

The longer chains of large hydrocarbon molecules are easily entangled.



Smaller molecules have shorter chains and are less likely to become entangled.



Colour of fractions

The colour of a fraction depends on the size of the molecules it contains.

As the molecules get smaller, the colour of the fraction becomes lighter, from dark brown to light brown, orange/yellow and transparent.