Worksheet: Alkanes & Crude Oil

ChemistrySheets

Specification: GCSE Chemistry (AQA 5.7.1 / Edexcel SC20)

Core Concepts: Alkanes are saturated hydrocarbons (C_nH_{2n+2}). Crude oil is a finite mixture of hydrocarbons. Fractional distillation separates crude oil into fractions based on boiling points. Properties of fractions (boiling point, viscosity, flammability) vary with chain length and determine their uses.

Section A: Key Terms & Concepts

1. The diagram below shows a fractional distillation column used to separate crude oil. Label the parts indicated by the arrows, including the temperature gradient and the names of the fractions collected at different levels.

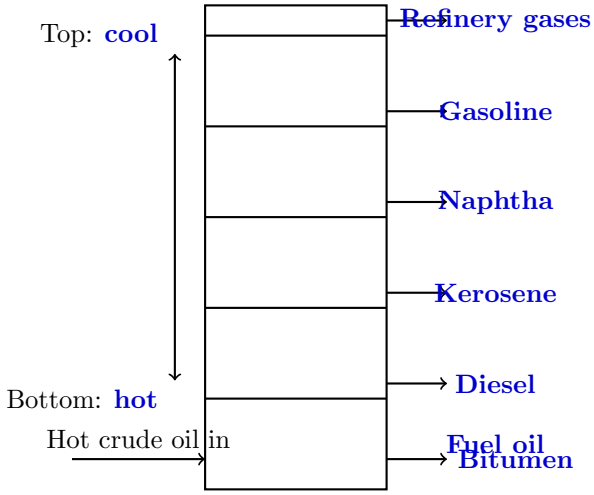

Figure 1: Fractional Distillation Column

2. Complete the following sentences using the most appropriate scientific terms.

a) Alkanes are **saturated** hydrocarbons, meaning they only contain **single** carbon-carbon bonds.

b) Crude oil is a **finite** resource and a **mixture** of many different hydrocarbons.

c) As the chain length of an alkane increases, its boiling point **increases**, its viscosity **increases**, and its flammability **decreases**.

Section B: Core Concepts & Explanations

1.

a) What is an alkane? State the general formula for alkanes.

Model Answer:
Alkanes are saturated hydrocarbons, meaning they are compounds made only of carbon and hydrogen atoms, and contain only single carbon-carbon bonds. Their general formula is C_nH_{2n+2}.

b) Describe the trend in boiling points of alkanes as their carbon chain length increases, and explain why this trend occurs.

Model Answer:
As the carbon chain length of alkanes increases, their boiling points increase. This is because larger molecules have more electrons, leading to stronger intermolecular forces (specifically, London dispersion forces) between molecules. More energy is required to overcome these stronger forces, resulting in a higher boiling point.

c) Explain why crude oil needs to be separated by fractional distillation before it can be used.

Model Answer:
Crude oil is a mixture of many different hydrocarbons, each with different boiling points. These individual hydrocarbons, or groups of hydrocarbons (fractions), are useful for different purposes. Fractional distillation separates crude oil into these useful fractions based on their boiling points, making them suitable for various applications.

d) Describe the process of fractional distillation of crude oil within the fractionating column.

Model Answer:
Crude oil is heated and vaporised before entering the bottom of the fractionating column. The column has a temperature gradient, being hottest at the bottom and coolest at the top. Vapours rise up the column and cool. Hydrocarbons condense at different levels (trays) according to their boiling points: longer chain hydrocarbons with higher boiling points condense lower down, while shorter chain hydrocarbons with lower boiling points continue to rise higher before condensing or remaining as gases at the top.

Section C: Exam Application & Extended Writing

1. The table below shows some fractions obtained from crude oil and their typical uses.

Fraction	Boiling Point Range (°C)	Typical Uses
Refinery gases	< 25	LPG, chemical feedstock
Gasoline (petrol)	25 – 100	Fuel for cars
Naphtha	100 – 150	Chemical feedstock
Kerosene (paraffin)	150 – 200	Jet fuel, heating oil
Diesel (gas oil)	200 – 300	Fuel for diesel engines
Fuel oil	300 – 370	Fuel for ships, power stations
Bitumen	> 370	Road surfacing, roofing

a) Using the information in the table, identify the fraction with the lowest boiling point and explain why it is collected at the top of the fractionating column.

Model Answer:
Refinery gases have the lowest boiling point (below 25 °C). They are collected at the top of the column because they have the shortest carbon chains, resulting in the weakest intermolecular forces. This means they require the least energy to remain as a gas and will only condense at the coolest temperatures found at the very top of the column, or not condense at all.

b) Explain how the properties of different fractions obtained from crude oil relate to their uses. Refer to boiling point, viscosity, and flammability in your answer. (6 marks)

Model Answer:
The properties of crude oil fractions, which vary with hydrocarbon chain length, directly determine their uses. **Boiling Point:** Fractions with short carbon chains (e.g., refinery gases, gasoline) have low boiling points, making them volatile and easily vaporised. This makes them suitable as fuels for internal combustion engines (gasoline) or as bottled gas (LPG). Fractions with long carbon chains (e.g., fuel oil, bitumen) have high boiling points, making them less volatile and suitable for uses requiring high temperatures or as residual products. **Viscosity:** Short-chain fractions are less viscous (runny), which is ideal for fuels that need to flow easily through pipes and atomise efficiently in engines. Long-chain fractions are very viscous (thick), making them suitable for road surfacing (bitumen) or as heavy fuel oils. **Flammability:** Short-chain fractions are highly flammable, which is a key property for fuels like gasoline and refinery gases, as they ignite easily to release energy. Longer-chain fractions are less flammable, making them safer for uses like heating oil (kerosene) or as lubricants, where controlled combustion or non-combustible properties are desired.