Teaching Activity: Demonstrating Fractional Distillation

Introduction: Fossil fuels, in particular, petroleum, are exceedingly complicated mixtures of organic compounds, the main components of which are *hydrocarbons*. In oil, these are chiefly *alkanes*, the simplest hydrocarbons, but it also has varying proportions of sulfur-, nitrogen-, and oxygen- containing compounds. While coal is primarily of plant origin, recent evidence indicates that petroleum is of animal origin. Most likely it is formed from the fats of ocean-dwelling, microscopic animals, for it is always found in rocks of oceanic origin (sedimentary rocks). Fats are made up mainly of carbon and hydrogen, with a little oxygen (for example, $C_{57}H_{110}O_6$). The removal of the oxygen and the slight rearrangement of the carbon and hydrogen atoms in these fats produce typical hydrocarbon molecules as they occur in petroleum.

TYPICAL PETROLEUM FRACTIONS:

FRACTION	RANGE OF BOILING POINTS	TYPICAL USES
GAS	LESS THAN 40 ° C	Fuel, plastics;
GASOLINE	40 - 200° C	Fuels, solvents;
KEROSENE	175 - 275 ° C	Diesel/jet fuels, home heating oil;
HEATING OIL	250 - 400 ° C	Industrial heating;
RESIDUE	Above 350° C	Paraffin, asphalt, tar;

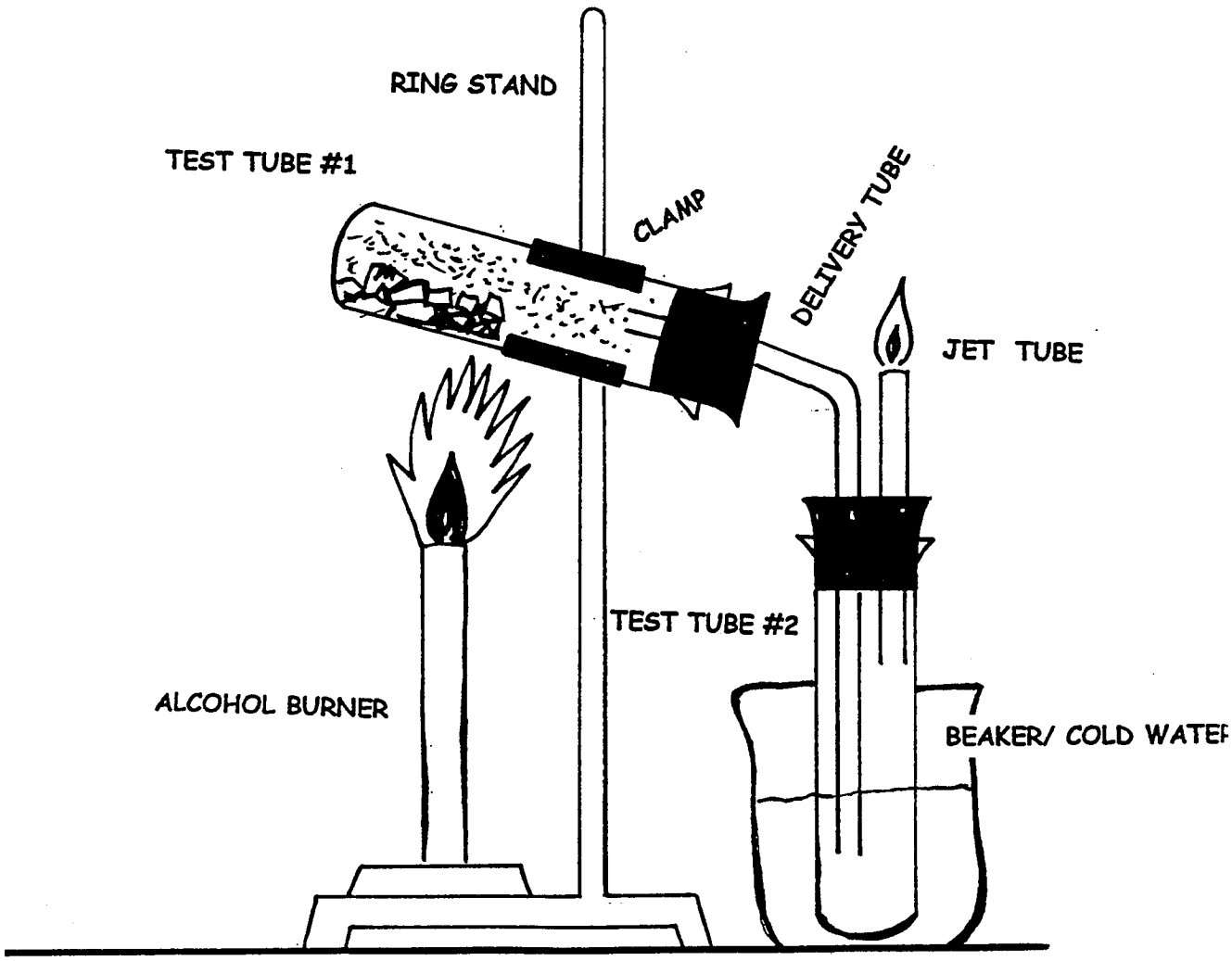
Petroleum as it comes from the ground is of limited use. To make it better suit our needs, it is separated into its *fractions* or parts by boiling it in a *distillation column*. The boiling points of each of the different fractions are relied upon in this method. The lighter molecules, with lower boiling points, come off at the top of the column, the heavier substances, with the higher boiling points, at the bottom. This process is a relatively crude, yet illustrative, example of how chemists modify nature's materials to meet human needs, and desires. Starting with petroleum, a chemist can create a dazzling array of substances with a wide variety of properties. A few of these substances are plastics, pesticides, herbicides, perfume, preservatives, pain killers, antibiotics, stimulants, depressants and detergents.

Efficiently burned, fossil fuels are relatively clean fuels. Petroleum is largely a mixture of hydrocarbons, which burn readily. Complete combustion yields mainly carbon dioxide and water, but it can also lead to the formation and release of nitrogen oxides, carbon monoxide and soot. In addition, petroleum also contains small amounts of sulfur compounds that produce sulfur dioxide(SO_2) when burned. Generally, when fossil fuels are burned they release all the chemical energy which had been stored within the original organisms over millions of years within a relatively short period of time. As a result of their increased use since the Industrial Revolution, the amount of carbon dioxide in the atmosphere has increase by more than 20 percent. Some scientists think that this increase in CO_2 could eventually raise the average global temperature of the Earth through a process called the *enhanced greenhouse effect.*

- If the flame goes out, there is water vapor present in the gas.
  making a diagram of the procedure.

8. Students should be taking notes and creating and labeling diagrams throughout this activity.
   - Observations and drawings should be included on the **OBSERVATIONS SHEET.**
   - Discuss the procedure and the outcomes at the end of the demonstration.
   - Instruct students to answer the **ANALYSIS/COMPREHENSION** questions.

DIAGRAM OF DEMONSTRATION SET-UP



Objectives:

- To discuss how fossil fuels are formed and why they are considered an environmental problem;
- To demonstrate how fossil fuels are broken down through the process of fractional distillation;

Important Terms: Fossil fuel, fuel, natural gas, petroleum, coal, methane, compound, hydrocarbons, fractional distillation, boiling point, sulfur, nitrogen, oxygen, carbon dioxide, sulfur dioxide;

Materials: Alcohol burner, test tubes, one-hole stopper #1, two-hole stopper #2, ring stand and clamp, wood splints OR small pieces of coal, delivery tube, small piece of glass tubing;

Procedure:

****NOTE: This is a demonstration activity to be done for the class by the instructor.**

1. Place six or eight small broken wood splints into a Pyrex test tube.

2. Clamp the test tube to the ring stand so that its mouth tips down at a slight angle.

3. Connect the one-hole stopper and delivery tube to the test tube containing the wood or coal.

4. Connect the other end of the delivery tube to a two- hole stopper in the second test tube. The delivery tube should extend well down into the second test tube.

5. Insert a piece of glass tubing into the other hole of the stopper.

6. The second test tube should be placed into the beaker half-filled with cold water.
   - This will allow condensation of some of the gas entering through the tube.
   - Some gas will escape through the venting tube into the air.

6. Heat the test tube containing the wood splints with the alcohol burner.
   - Water vapor will collect on the inside of the test tube.
   - A sticky brown liquid will collect along the walls of the test tube.
   - Gas will pass down the delivery tube into the second test tube.

7. With a lighted match, ignite the gas which comes out of the open glass tube.
   - If the flame surges, it is due to a hydrocarbon mixture in the gas.

STUDENT ACTIVITY SHEET #1:

DEMONSTRATING FRACTIONAL DISTILLATION

PART I: PROCEDURE: Write down each step of the demonstration.

PART II; DIAGRAM OF DEMO SETUP;

STUDENT ACTIVITY SHEET #2

PART III: ANALYSIS/ COMPREHENSION

1. What compounds are the main components of fossil fuels? _____

_____

2. In addition to alkanes, what other substances are found in hydrocarbons? _____

_____

3. What has recent evidence revealed about the origin of petroleum? _____

_____

4. Give an example of a chemical formula for a fat molecule._____

5. Is petroleum right out of the ground of any use? _____

6. What process is used to make it usable? _____

8. Which physical property of petroleum fractions is relied upon in this process?

_____

9.Where would in a fractioning column would you expect to find gasoline? _____
Heating Oil? _____

10. Name 4 substances created from petroleum. _____

_____

11. What are the main by-products of fossil fuel burning? _____

_____

_____

12. Why is fossil fuel burning such a big problem for the environment? _____

_____

_____

13. When did the levels of CO2 in the atmosphere begin to rise? _____

14. What type of problem could result from increased CO_2 concentrations in the atmosphere? _____

15. What needs to be done to eliminate the pollution problem caused by fossil fuel burning?

_____

_____