Petroleum

Teacher's Guide

Sr. High

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www.insideeducation.ca/Surveys/Petroleum_Kit.html

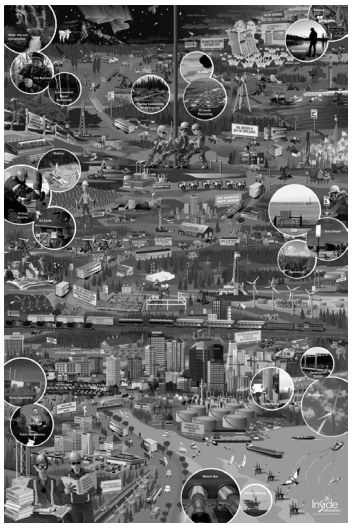
About the poster kit

Poster

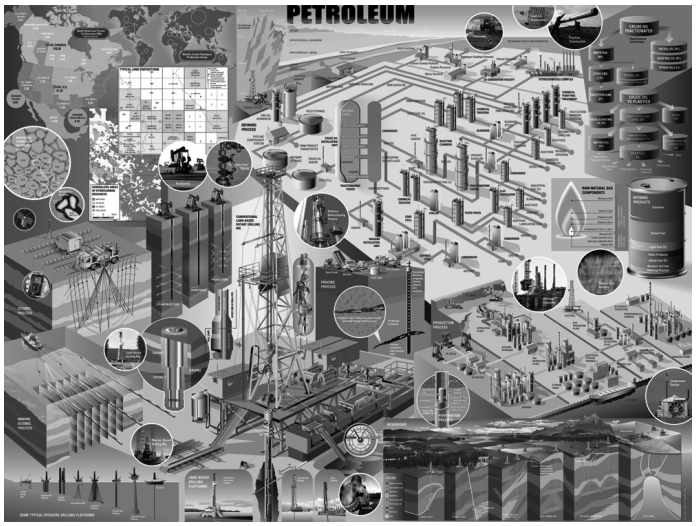
The kit contains five *Petroleum* posters to allow for small group activities. Digital copies of the poster are also available on the resource CD included in the kit. Because of the amount of material visually presented on the poster, it is recommended that teachers review the poster description on the following page.

Poster views are as follows:

FRONT (split-panel)



INSIDE



BACK

Student Worksheets

Student worksheets can be found throughout this teacher's guide as well as on the resource CD. Answer keys are in this guide as part of the activity outline or following the student worksheets.

Background Information

The book *Our Petroleum Challenge* contained in the kit is a valuable source of background information on petroleum. The glossary terms and websites listed at the back of this guide and on the resource CD provide additional information.

About the poster

On the front split-panels, the poster features a conglomeration of some of the direct and indirect effects of the political, social, economic and environmental impacts of the petroleum industry on the general population and their environment. With the poster flaps closed, the top quarter of the poster shows multiple land use. Activities such as forestry, trapping, mining, agriculture and recreation all take place in the area, sometimes on Alberta government or Crown land.

The next quarter of the poster goes into a little more detail on petroleum exploration and development – from the rig workers in the centre, to the oil sands and coal mines below, to the seismic exploration and land reclamation on the left, all are activities that have direct impact on our quality of life.

The bottom half of the poster transitions between petroleum exploration and production to processing and transport of the product. To the right are examples of renewable energy sources (solar, wind, biofuels) which are helping us reduce our consumption of fossil fuels. The bottom left of the poster demonstrates the process behind petroleum exploration: consultation and regulation. The regulatory process is a vital part of the petroleum story – any company or group performing activities on the land must follow government guidelines and they must have the proper plans in place (see the list on the binders, bottom left). The bottom right demonstrates the refining and transportation of the final product – in this case, from an ocean port. Given the absence of sea ports in Alberta, all of our refineries are located near major rail lines, highways or pipeline hubs to help distribute the petroleum product to consumers throughout our country and across North America.

On the inside of the poster, starting under the PETROLEUM banner, a cross-section of the main source of petroleum in Canada – the Western Canadian Sedimentary Basin – is highlighted. Grouped to the left are maps illustrating typical hydrocarbon locations and field activity sectors based on geological surveys and industrial data. The adjacent map of the world displays the world's major oil producers and North America's proven oil reserves. Grouped with the maps are graphics of porous rock and oil sands details. Underneath, the main rig illustration is surrounded by examples of seismic survey, stimulation, fracturing (commonly referred to as fracing, pronounced FRAK-ing), perforation, casing, some rig component details and a variety of rig platform profiles – all tied to drilling. At the bottom right we see drilling for the petroleum reserves in a variety of geological formations. Grouped directly above are several components: first, a simplified flow chart of oil and gas production processes, and above that, a simplified product flow chart of the complex refining/fractionization process of by-products and their subsequent uses. Tied to that, on the right, there is a schematic of the fractionization/processing of crude oil for refining and for the petrochemical industry, which feeds the manufacturing sector for the creation of a wide variety of commercial and consumer goods. Below that, a simple diagram shows a breakdown of natural gas to its raw components and various uses.

Scattered throughout the poster are photo bubbles that highlight some of the petroleum industry's activities to provide a more realistic perspective of the subject matter. The back of the poster features the "Petroleum Story" and "Did You Know?" facts. The graphics there are included for general information to show pipeline construction – the main transportation vehicle for oil and gas – and a simplified flow chart following the product to market and the steps required to make that happen (similar to the 3D process on the inside of the poster). Also included is a breakaway diagram of a house to illustrate products used in the home and/or in the manufacturing of materials for consumer goods.

Alberta Curriculum Connections

SCIENCE 14 - Unit D: Investigating Matter and Energy in the Environment

Students will:

1. Describe how the flow of matter in the biosphere is cyclical along characteristic pathways and can be disrupted by human activity
   - identify and assess the needs and interests of society that have led to technologies with unforeseen environmental consequences (e.g., fishing technologies that result in harvesting more than the rate of reproduction, use of pesticides such as DDT, impact of driving a car on atmospheric compositions)
   - describe the relationship between land use practices and altering ecosystems (e.g., swamp drainage, slash and burn forestry, agriculture
   - trace the development of a technological application that has altered an ecosystem (e.g., power generation, fishing, logging, oil and gas exploration, agricultural practices)

CHEMISTRY 20 – Unit D: Quantitative Relationships in Chemical Changes

General Outcome 1: Students will explain how balanced chemical equations indicate the quantitative relationships between reactants and products involved in chemical changes.

20–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

SCIENCE 20 – Unit A: Chemical Changes

General Outcome 3: Students will describe the properties of simple hydrocarbons and describe hydrocarbon-based industrial processes that are important in Alberta.

20–A3.3k provide International Union of Pure and Applied Chemistry (IUPAC) names and structural formulas for simple and non-cyclic hydrocarbons in the homologous series of alkanes, alkenes and alkynes that contain up to eight carbon atoms in the parent chain

20–A3.4k identify hydrocarbons as a source of fossil fuels and explain the processes of fractional distillation to refine petroleum and catalytic cracking to produce ethene (ethylene)

SCIENCE 24 – Unit A: Applications of Matter and Chemical Change

2. Investigate and classify chemical reactions
   - name simple compounds from chemical formulas, and recognize the chemical names of substances that are used every day
   - infer the relationship among chemical formulas, composition and name (e.g., simple acids, bases, salts)
   - investigate, describe and compare the changes to reactants and products in fossil fuel combustion and rusting reactions
   - investigate and describe simple composition and decomposition reactions (e.g., tarnishing of silver, electrolysis of water)
   - describe, using observation, the chemical properties of reactants and products in chemical reactions (e.g., neutralization, combustion, simple composition, decomposition)

3. Explain the law of conservation of mass when balancing chemical reactions
   - relate the concept of the atom to the conservation of mass; i.e., the number of atoms stays the same as they are rearranged in a chemical reaction; therefore, the total mass before and after the reaction remains the same (e.g., analyze the chemical equation $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$ to illustrate the law of conservation of mass by counting the number of atoms of each element)
   - represent simple chemical reactions (e.g., neutralization, combustion, simple composition, decomposition) using word and/or balanced chemical equations

4. Analyze common technological products and processes encountered in everyday life and careers, and analyze their potential effects on the environment
   - investigate and describe simple chemical processes occurring in everyday life (e.g., acid–base reactions in cleaning and food processing, dyeing of hair, washing of clothes, burning of gasoline in a car engine, swimming pool maintenance, rusting of metal)

Unit B: Understanding Common Energy Conversion Systems

4. Analyze and describe the impact of fossil fuel based technologies and their importance in meeting human needs
   - explain the importance of the fossil fuel industry in Alberta in meeting energy requirements
   - describe the sources of fossil fuels; and describe, in general terms, the extraction and refining processes used to provide people with fossil fuels
   - assess the impact of fossil fuel-based technologies on the environment
   - describe the importance of combustion reactions to a modern industrial society, and describe the implications of depleting fossil fuel

BIOLOGY 20 – Unit A: Energy and Matter Exchange in the Biosphere

General Outcome 2: Students will explain the cycling of matter through the biosphere.

20–A3.2sts explain that science and technology have both intended and unintended consequences for humans and the environment
   - describe how human activities can have a disrupting influence on the balance in the biosphere of photosynthetic and cellular respiratory activities:
   – fossil fuel combustion – depletion of stratospheric ozone – forest destruction.

ICHEMISTRY 30 – Unit C: Chemical Changes of Organic Compounds

General Outcome 2: Students will describe chemical reactions of organic compounds.

30–C2.1k define, illustrate and provide examples of simple addition, substitution, elimination, esterification and combustion reactions

30–C2.2k predict products and write and interpret balanced equations for the above reactions

30–C2.4k relate the reactions described above to major reactions that produce thermal energy and economically important compounds from fossil fuels

30–C2.1sts explain how science and technology are developed to meet societal needs and expand human capability

30–C2.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs

CAREER AND LIFE MANAGEMENT (Sr. High)

General Outcome 3: Career and Life Choices

Students will: develop and apply processes for managing personal, lifelong career development.

C2. update and expand a personal profile related to potential career choices

C3. examine the relationship among career planning, career decisions and lifestyles

C7. analyze variations in employment and the implications in the life career process

CAREER & TECHNOLOGY STUDIES – CAREER TRANSITIONS 1010: Job Preparation

The student will: identify and develop knowledge, skills and attitudes appropriate for conducting successful employment searches

The student should (Employability Skills):
   - identify personal reasons for exploring career options
   - show a self-assessment profile based on personal interests, values, aptitudes and abilities
   - define the terms: job, occupation, career

Paths in Petroleum: Careers in the Oil & Gas Industry

Time: 70 minutes

Curriculum Connections

Career and Life Management – Career and Life Choices

CTS: Energy and Mines, Career Transitions

Objectives

Students will identify and research careers in the petroleum industry and create a job tree outlining required skills and training.

Rationale

This activity allows students to assess the similarities and differences between careers in terms of education, training, skills, etc. by discovering how their daily activities and interests can be translated into job-related skills. This activity provides an overview of the possible careers in the petroleum industry and can be used in any lesson that involves discussion of career possibilities in the oil and gas field.

Background Information

Rich in natural gas, oil sands and conventional oil, Alberta's petroleum industry produces 70% of Canada's crude oil and 80% of its natural gas[1]. The energy sector employs over 275 000 Albertans (1 in every 6 people who live in the province)[1]. Qualified, skilled workers are vital to the petroleum industry's ability to function in a safe and sustainable manner.

Materials

Petroleum posters

Access to a computer lab

Transparencies (or flip-chart paper) and markers, or PowerPoint access

Paths in Petroleum student worksheet

Paths in Petroleum career cards, cut out and mixed together (see following pages or *resource* CD)

Activity

Part 1: (10 minutes)

1. Divide students into groups
2. Hand out the *Petroleum* poster to each group
3. Ask students to come up with a list of all the possible jobs and careers they can identify from the poster. Write their ideas on the board at the front of the room.

Part 2: (30 minutes)

Have each student choose one of the petroleum career cards. Students will research their career in the computer lab and complete the *Paths in Petroleum* worksheet.

Suggested websites and search tips are listed below and are available as hyperlinks on the electronic copy of the student worksheet (found on the *resource* CD).

1. Human Resources and Development Canada
   Careers in Oil & Gas:
   www.careersinoilandgas.com
2. Centre for Energy
   www.centreforenergy.com
   Click Careers in Energy, then select "oil and natural gas" as search options
3. Alberta Learning Information Services
   Alberta Occupational Profiles (search by industry)
   www.alis.alberta.ca/occinfo
4. Search job postings by using "oil and gas" as keywords at:
   www.monster.ca
   www.workopolis.com

References

1. The information is from the Canadian Association of Petroleum Producers website www.capp.ca/default.asp?V_DOC_ID=675. Accessed January 8, 2007.

Part 3: (30 minutes)

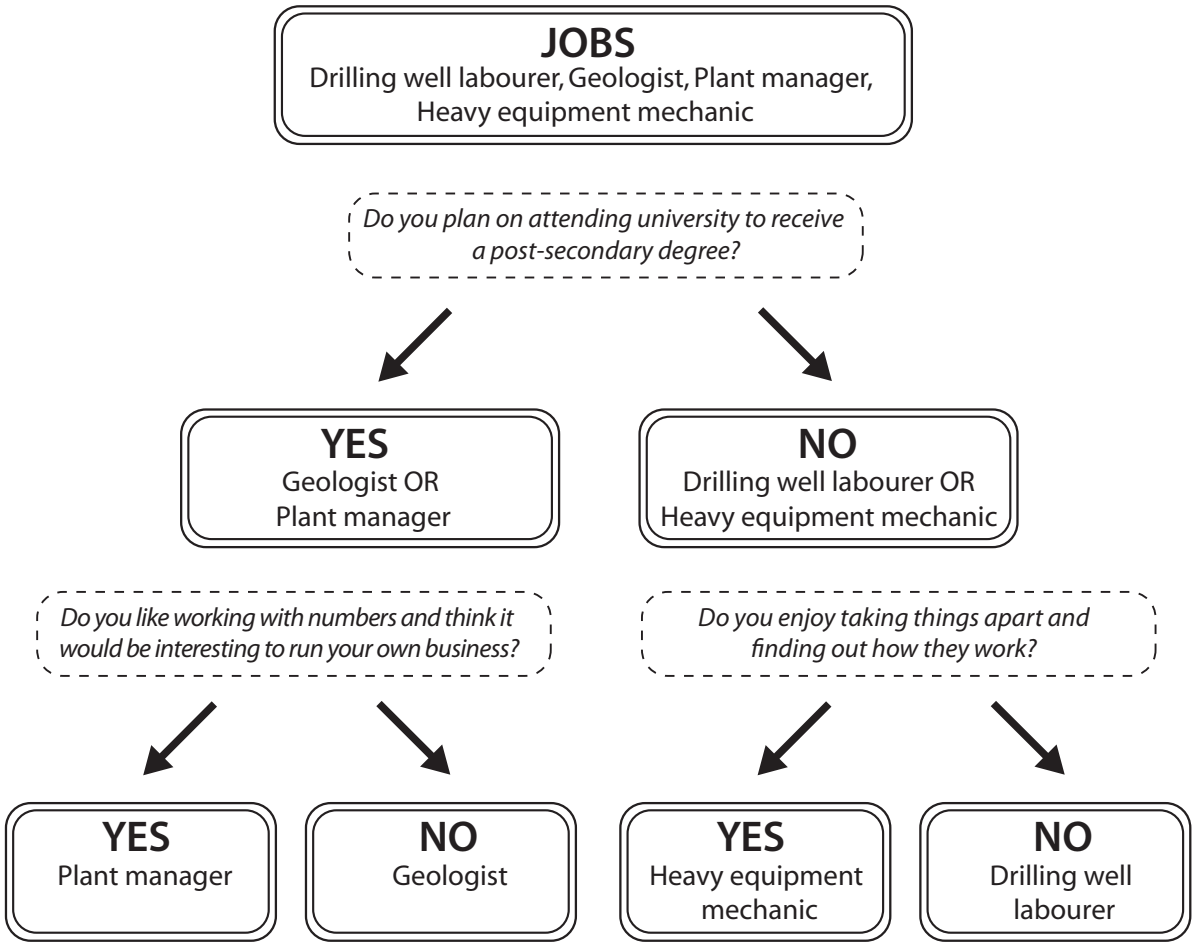
Students return to their groups to create a job tree. By using the skills and training requirements they researched along the way with the, similarities and differences between the careers, they create questions that can be used to navigate through the tree. (A sample job tree is below and on the resource CD) Each group presents the job tree they have developed to the class using a flip chart, transparency or PowerPoint.

Students will be exposed to the wide variety of jobs available in the oil and gas industry and will get an idea of the skills and training required for each. If time permits groups could also get together to expand and combine their career trees to include more possibilities.

Extension

Students create a job ad for their career highlighting the skills and requirements for the position. Ask students to write a paragraph about why they would or would not like to apply for the position.

Students find a job ad for their career using online job sites (See Monster or Workopolis). You may take this opportunity to review resumé-writing skills by having students draft a resumé for their chosen career. Then have students switch job ads with a partner and take turns holding mock interviews for their desired jobs. You may wish to demonstrate the basic format of a job interview beforehand, as this may be the student's first exposure to the process.



Paths in Petroleum: Careers in the Oil & Gas Industry

Plant Manager	Mining Engineer
Field Engineer	Site Safety Manager
Bed Truck Operator	Geological Engineer
District Manager	Petroleum Engineer
Well Testing Operator	Land Surveyor
Rig Operator	Gasfitter
Swamper	Chemical Technologist
Seismic Acquisition Manager	Environmental Consultant/Advisor
Seismic Worker	Geological and Mineral Technologist or Technician
Geologist	Industrial Instrument Technician or Mechanic
Chemical Engineer	Land Survey Technologist or Technician
Metallurgical and Materials Engineer	Nondestructive Tester or Inspector
Oil and Gas External Affairs Manager	Oil and Gas Media Relations (Communications)

Paths in Petroleum: Careers in the Oil & Gas Industry

Truck Driver	Construction Inspector
Natural and Applied Science Policy Researcher	Supervisor, Mining and Quarrying
Oil and Gas Sales Representative	Pipeline Operator
Quality Assurance Manager	Computer Technician / Programmer
Helicopter Pilot	Underground Production and Development Miner
Heavy Equipment Operator	Oil and Gas Well Servicer
Oil and Gas Well Driller	Underground Mine Service and Support Worker
Oil And Gas Chief Executive Officer	Mine Labourer
Blaster	Oil And Gas Drilling, Servicing Labourer
Welder	Petroleum, Gas And Chemical Processing, and Utilities Supervisor
Reclamation Specialist	Petroleum, Gas and Chemical Process Operator
Commercial Diver	Geographic Information System (GIS) Technician

Paths in Petroleum: Student Worksheet

Name _____ Class _____

Your career title:

What level of education do you require (secondary, post-secondary, technical degree or diploma)?

List a minimum of five skills you require to do your job (e.g. problem-solving, team player, typing etc.)

Are there any additional training requirements (safety, WHMIS, ATV training etc.)?

What is your average salary?

Do you work primarily indoors or outdoors?

What additional information can you tell people about your job? (What are the highlights / drawbacks of your job? Does the job involve travel, shift work or long hours? Is the job dangerous?)

Are you interested in this career path? Why or why not?

Fractional Distillation Activity

Time: 75 minutes

Curriculum Connections

Science 20 – Unit A: Chemical Changes

Science 24 – Unit B: Understanding Common Energy Conversion Systems

Chemistry 30 – Unit C: Chemical Changes of Organic Compounds

Objectives

Through a demonstration and lab activity, students will examine how hydrocarbons are separated based on their boiling points through the process of fractional distillation. Students will also develop an understanding of how the petroleum industry develops a wide variety of products from crude oil.

Rationale

This activity links the organic chemistry units highlighted in the curriculum and the industrial process students see operating in refineries everyday. Students explore the process of fractional distillation using visuals, demonstrations and lab techniques. This activity can be used to introduce or complete the study of any organic chemistry unit.

Background Information

Fractional distillation is an important first step in the refining process of crude oil, a mixture of several thousand hydrocarbons. A large, steel fractionating tower, containing a series of perforated trays, separates the hydrocarbons into fractions based on their boiling points. The heavier, longer chain hydrocarbons have the highest boiling points and turn to liquid near the base of the tower. The lighter, shorter hydrocarbons rise up through the tower and condense at various levels where they are collected.

Prior Knowledge

Chemistry lab safety

Materials

Petroleum posters

Fractional Distillation Activity student worksheet (see following pages or *resource* CD)

Pre-Lab Demonstration Materials:

Synthetic oil (25 mL)
Mineral oil (25 mL)
Grapeseed oil (25 mL)
Canola oil (25 mL)
Butter – melted (25 mL)
Beaker (500 mL)
Large test tube

Lab Materials: (one set per group)

Safety goggles
Lab apron
Lab gloves
Bunsen burner
Ring stand & clamp
1 graduated cylinder
3 medium test tubes
Test tube rack
Boiling chips
Metal pan
Paper strips – approx. 5 cm x 1 cm
2-hole stopper
Glass tubing with 90° bend
Rubber tubing (60 cm)
Thermometer
alcohol + water mixture (20 mL):
- 10 mL isopropyl (rubbing) alcohol (or 2-propanol)
- 10 mL distilled water

Stirring rod
Grease pencil/marker
Stop watch
Matches
Sugar
Graph paper
Scoopula

Fractional Distillation Activity

Activity

Part 1

Pre-lab demonstration and introduction (20 minutes)

1. Post a copy of the *Petroleum* poster at front of class. Alternatively, project the image of the poster from the CD. Focus in on *Refining Process* (located inside, top centre, under the poster heading).
2. Divide students into groups and hand out posters. Students can answer pre-lab questions on the worksheet as you perform the demonstration and work through the pre-lab.
3. In a large beaker, mix equal portions of the oils listed on page 9. Mix thoroughly until the oils are combined while explaining that the mixture represents crude oil, which is a complex mixture of hydrocarbons.

   Humans create many different products by refining crude oil. Direct students to list of products on right hand side of poster
4. Pour the "crude oil" into a large test tube.

   The test tube represents the fractionating tower that separates the hydrocarbon components under intense heat and pressure. Direct students to fractionating tower on poster.

   The components at the top of the test tube represent the small chain hydrocarbons that have relatively low boiling points. The components that fall to the bottom represent long chain hydrocarbons with high boiling points.

   Hydrocarbons that are gases are released and collected from the top of the tower and the heavy sludges are collected from the bottom. These along with the light, middle and heavy distillates are the building blocks for the variety of products we create from our petroleum resource.
5. Set up the distillation apparatus and outline the lab techniques that will be used as students perform their own distillation to separate a water-alcohol mixture.

Part 2

Fractional Distillation Lab Activity (40 minutes)

See the lab and worksheet questions section on the *Fractional Distillation Activity* student worksheet for materials and procedures.

References

"The Chemistry of Refining Crude Oil" *School Power...Naturally*. Research Foundation of the State University of New York with funding from the New York State Energy Research and Development Authority (NYSERDA). Accessed July 24, 2007. www.powernaturally.org/Programs/pdfs_docs/12_Oil_Refining_Chemistry.pdf

Our Petroleum Challenge– Exploring Canada's oil and gas industry. 6th ed. Bott, Robert D. Petroleum Communication Foundation, 1999

Fractional Distillation Activity: Student Worksheet

Name _____ Class _____

**Use the* Petroleum *poster to answer the questions below. Focus on the section titled "Refining Process"* (located inside, top centre, under the poster heading).

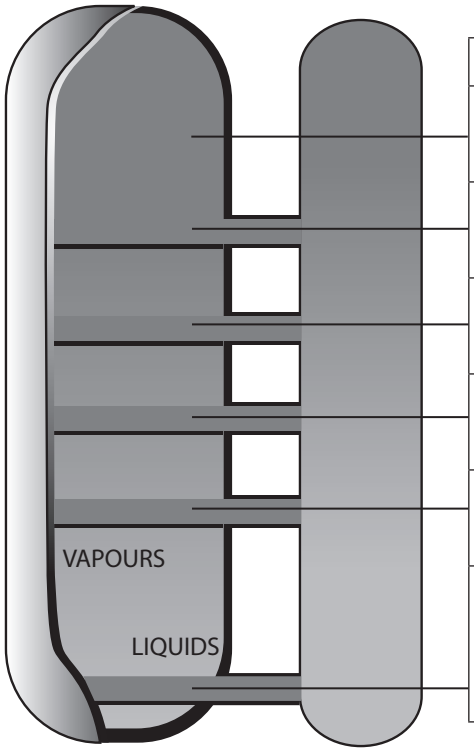
1. What is crude oil?

2. What are some products that the petroleum industry manufactures from crude oil?

3. What is the name of the piece of equipment used in the oil and gas industry to separate the hydrocarbon components of crude oil?

4. The list below shows common crude oil fractions that result from fractional distillation. Place the hydrocarbons in order in the distillation tower and match them to their boiling points.

Crude Oil Fractions:	*Boiling Points:*
Gas (C_1- C_3)	*300-370°C*
Lubricating oil (C_{17}- C_{25})	*<40°C*
Kerosene (C_{12}- C_{16})	*200-250°C*
Naptha & Gasoline (C_4- C_{11})	*>375°C*
Residuals & Asphalt (>C_{25})	*40-200°C*
Gas oil & Diesel (C_{16}- C_{18})	*250-300°C*

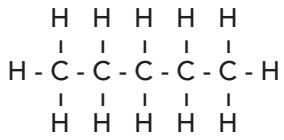


FRACTIONATING TOWER

Hydrocarbon	Boiling Point

Fractional Distillation Activity: Student Worksheet

5. Choose two crude oil fractions from the tower on the previous page. Choose a precise number of carbons within the range, write the chemical formula and draw the structure of your compound.

Crude Oil Fraction	# of Carbons	Chemical Formula	Structural Diagram
Example: naptha & gasoline	5	C_5H_{12}	
1)			
2)			

6. Refinery gases have the (highest/lowest) boiling points. An example is _____ _____, and is removed from the distillation tower. These gases undergo _____ _____ _____ to create these two products: _____ _____ and _____ _____ .

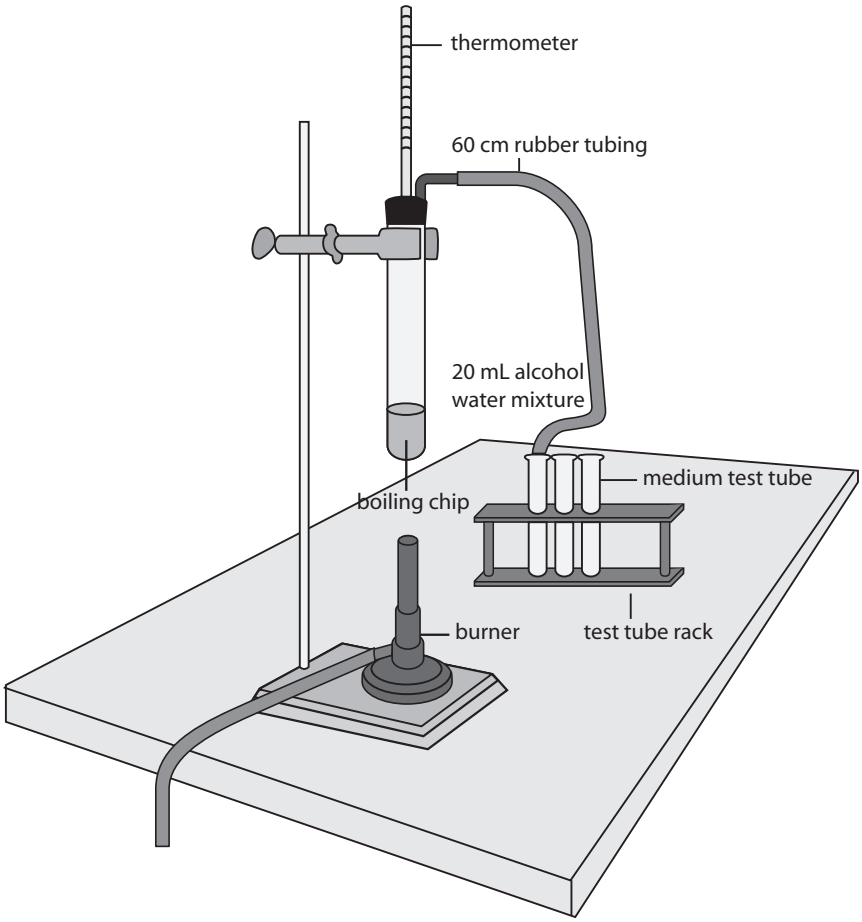
7. Refinery sludges have the (highest/lowest) boiling points. They are typically referred to as the _____ _____ . These fractions are refined to create products such as _____ .

Fractional Distillation Activity: Student Worksheet

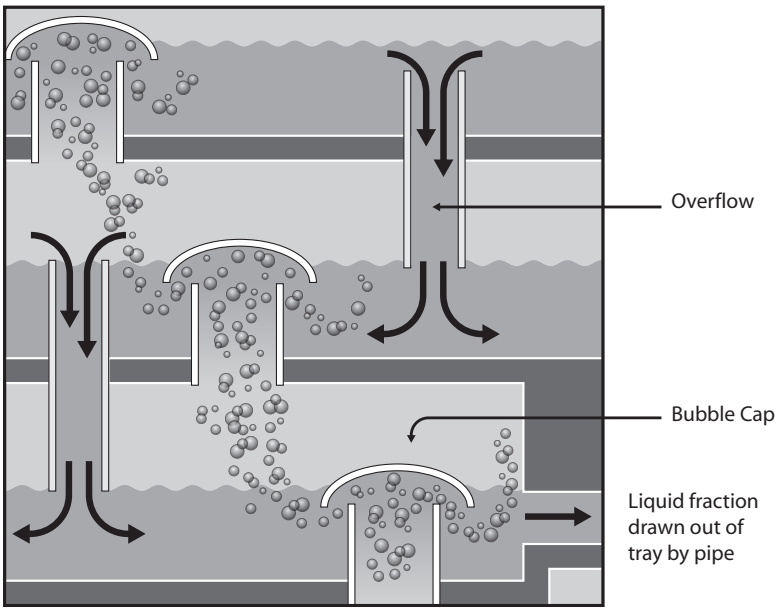
Lab Worksheet & Questions:
Perform fractional distillation using a mixture of alcohol and water.

Materials:
Safety goggles
Lab apron
Lab gloves
Bunsen burner
Ring stand & clamp
1 graduated cylinder
3 medium test tubes
Test tube rack
Boiling chips
Metal pan
Paper strips – approx. 5 cm x 1 cm
2-hole stopper
Glass tubing with 90° bend
Rubber tubing (60 cm)
Thermometer
alcohol + water mixture (20 mL):
- 10 mL isopropyl (rubbing) alcohol (or 2-propanol)
- 10 mL distilled water

Stirring rod
Grease pencil/marker
Stop watch
Matches
Sugar
Graph paper
Scoopula



Inside Fractionating Tower



Procedure:

1. Put on safety equipment and gather lab materials.
2. Set up a modified distillation apparatus as shown in the image above.
3. Label the 3 test tubes (1, 2, & 3) using the grease pencil.
4. Place the rubber tubing into test tube 1.
5. Add 20 mL of alcohol-water mixture and 1 boiling chip to the graduated cylinder.
6. Record initial temperature of the mixture. Assign a group member to record temperatures every minute in the time-temperature table.

Fractional Distillation Activity: Student Worksheet

7. Carefully light the Bunsen burner. (Ensure rubber tubing and test tube stand are not too close to the heat as they will melt/burn.) Set to low flame height.
8. Heat the mixture.
9. Record the temperature at which the mixture begins to boil. Place a mark (e.g. B or *) on the time-temperature table to represent this state change.
10. Watch for a sudden rise in temperature then use gloves to switch the tubing into test tube 2.
11. Continue heating. When temperature reaches 98°C, use gloves to move the tubing into test tube 3.
12. Continue heating until you have distilled the majority of the fluid and only a few mL of the initial mixture remains in the graduated cylinder.
13. Turn off Bunsen burner.
14. You have completed the fractional distillation of the alcohol-water mixture and should have three fractions of the original mixture to analyze.
15. Analyze the fractions on the basis of odour, flammability, & solubility.

    Odour:
    a) Use wafting technique to determine if there is any difference in the odour of your fractions. Record observations in observation table.

    Flammability:
    a) Dip a paper strip halfway into first test tube.
    b) Place the moistened strip in metal pan.
    c) Ignite the moist end with the match.
    d) Describe how easily it ignites. Record in observation table. Repeat for each test tube.

    Solubility:
    a) Place a small scoopula of sugar into each test tube. (The amount will vary depending on the quantity of liquid collected)
    b) Swirl.
    c) Does the sugar dissolve? Record observations in the observation table.
16. Clean up lab bench and complete analysis questions.

Time-Temperature Table

Time (minutes)	Temperature (°C)
0 (Initial Temperature)	
1	
2	
3	
4	
5	
6	
7	
8	
9	

10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Fractional Distillation Activity: Student Worksheet

Observation Table:

	Fraction 1	Fraction 2	Fraction 3
Odour			
Flammability			
Solubility			

Analysis:

1. What property of the liquids allowed you to separate the fractions?

_____

_____

_____

2. Which component of crude oil separated in the fractional distillation tower are represented by your fractions?

_____

_____

_____

3. Given that your initial mixture was a combination of 50% alcohol and 50% water, what fraction did each test tube contain?

   i. Test tube 1 _____

   ii. Test tube 2 _____

   iii. Test tube 3_____

   iv. On a separate piece of graph paper, graph the changes in temperature over time. Explain any rapid rises in temperature and/or periods where temperatures remained constant.

4. What are some methods that could be used to further refine and separate the contents of test tube 2?

_____

_____

_____

Fractional Distillation Activity: Answer Key

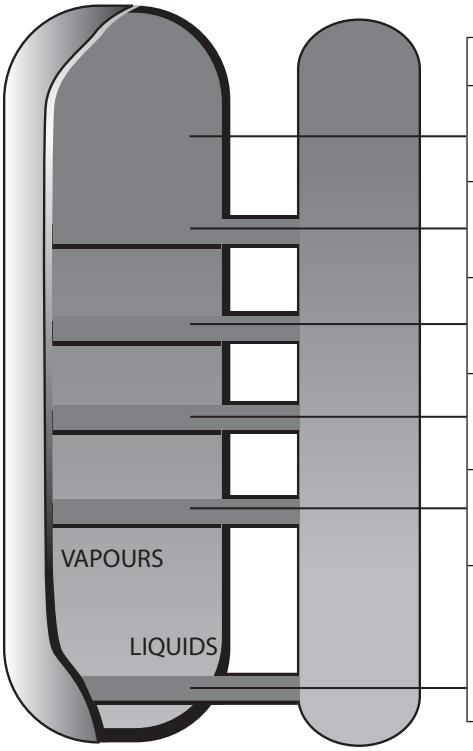
Pre-Lab Questions:
**Use the* Petroleum *poster to answer the questions below. Focus on the section titled Refining Process.*

1. What is crude oil? **Crude oil is the complex mixture of hydrocarbons.**

2. What are some products that the petroleum industry manufactures from crude oil?
waxes, industrial fuel oil, plastics, diesel, kerosene, automotive gasoline, etc.

3. What is the name of the piece of equipment used in the oil and gas industry to separate the hydrocarbon components of crude oil? **fractional distillation tower**

4. The list below shows common crude oil fractions that result from fractional distillation. Place the hydrocarbons in order in the distillation tower and match them to their boiling points.



FRACTIONATING TOWER

Hydrocarbon	Boiling Point
gas	<40°C
naptha & gasoline	200-250°C
kerosene	250-300°C
gas oil & diesel	300-370°C
lubricating oil	300-370°C
residuals & asphalt	>375°C

6. Refinery gases have the (highest/**lowest)** boiling points. An example is **raw gasoline** and is removed from the distillation tower. These gases undergo **chemical purifying treatment** to create these two products: **aviation gasoline** and **automotive gasoline** .

7. Refinery sludges have the (**highest**/lowest) boiling points. They are typically referred to as the **heavy bottoms** . These fractions are refined to create products such as **asphalt** .

Fractional Distillation Activity: Answer Key

Observation Table:

	Fraction 1	Fraction 2	Fraction 3
Odour	**strong**	**moderate**	**weak**
Flammability	**ignites easily**	**ignites with difficulty**	**does not ignite**
Solubility	**low**	**medium**	**high**

Analysis:

1. What property of the liquids allowed you to separate the fractions? **boiling point**

2. Which component of crude oil separated in the fractional distillation tower are represented by your fractions? **light, medium & heavy distillates**

3. Given that your initial mixture was a combination of 50% alcohol and 50% water, what fraction did each test tube contain?
   i. Test tube 1 **alcohol**
   ii. Test tube 2 **alcohol + water**
   iii. Test tube 3 **water**
   iv. On a separate piece of graph paper, graph the changes in temperature over time. Explain any rapid rises in temperature and/or periods where temperatures remained constant.
   Graph should show steady rise until around 82°C when most of alcohol has evaporated, a rise again until water begins to boil and then a leveling off at the boiling point of water (100°C).

4. What are some methods that could be used to further refine and separate the contents of test tube 2?
   distill again (once or twice more), chemical treatments

Oil Spill on a Plate

Time: 45 minutes

Curriculum Connections

Science 14 – Investigating Matter and Energy in the Environment

Science 24 – Unit A: Applications of Matter and Chemical Change

Biology 20 – Energy and Matter Exchange in the Biosphere

Objectives

Students will develop and carry out a recovery plan for a mock oil spill. Students will appreciate the complexities of environmental remediation.

Rationale

This problem-solving lab allows students to experience a visual and hands-on representation of the challenges faced by those involved at the forefront of an oil spill. This lab can be adapted to fit a wide variety of curricular outcomes for high school students.

Background Information

Oil spills refer to the unintentional release of petroleum products into the environment. Oil spills range in size and can occur both on land and in water. They have varying environmental effects depending on the type and amount of petroleum released. Spills can be cleaned up using techniques such as absorbent booms, bioremediation (use of biological agents to remove oil), dredging or skimming. Depending on the nature of the spill it can take weeks, months or even years to clean up.

Materials

Petroleum posters

Pie plates (1 per group)

Water

Blue food colouring

Canola oil

Cocoa powder

Popsicle sticks

Fresh Parsley

Twigs

Bird feathers (available at craft/pet stores)

Small rocks

Detergents (hand soap, laundry detergent)

A variety of absorbent materials (shredded wheat, cotton balls, paper towel, sponges)

Corks

Toothpicks

Digital camera (optional)

Activity

Anticipatory Set (10 minutes)

1. Distribute or post a copy of the *Petroleum* poster. Discuss the ways that petroleum is transported (pipelines, trains, trucks, boats) and explain that there is risk involved in the transport of these potentially harmful substances. Spills are one of the risks we take in meeting the demand for the petroleum-based products we use everyday.
2. Discuss real life examples of oil spills. You may want to bring in old newspaper clippings, Internet articles, etc.
3. Have students examine the poster front. Brainstorm possible clean-up methods and the factors one must consider when choosing a clean-up approach specific to an area.

   Ask students if an oil spill would be treated the same way regardless of where it took place on the poster landscape? How would they differ? Cite examples from the different regions on the poster front.

Oil Spill on a Plate

Main Activity (35 minutes)

Pre-lab set up (can be done prior to class):

1. Create "crude oil" by mixing canola oil and cocoa powder in 2:1 ratio. You will need approximately 15 mL of crude oil per group.
2. Fill pie plates 2/3 full with water and add 2-3 drops of food colouring.
3. Place 1 or 2 bird feathers in the pie plate to simulate wildlife, some twigs in the oil to simulate logs, rocks to show shorelines or islands and parsley around the edges to represent vegetation.

Lab:

1. Show the class the variety of detergents and absorbent materials available.
2. Very slowly, from about 1 cm above the water, pour 15 mL crude oil into each pie plate.
3. Give the groups 5 minutes to plan their cleanup strategy. Time is often a limiting factor in environmental emergencies.
4. Have each group hand in a rough action plan at the end of the planning time. Their action plan must contain a sketch or digital picture of their spill.
5. Groups then have 10 minutes to implement their action plan.
6. When time is up, groups must sketch or photograph the results of their clean up.
7. Have the groups evaluate their action plan. Some questions to consider:
   - Was the spill actually cleaned up or just contained?
   - Were the wildlife and vegetation saved?
   - Would the clean-up materials pose additional risks to the clean-up personnel, nearby wildlife, or vegetation?
   - How expensive would a wide scale clean up be?
   - Is it realistic?
8. Have groups share their results with the class. Conduct a culminating discussion on the most successful strategies and how these are related to the current techniques used in oil spill clean up.

Extension

Students complete individual or group research projects on actual spills that have occurred in the past (Exxon Valdez, Lake Wabamun, etc.).

Topic suggestions include:

- What actions were taken on these spills?
- Were these actions successful? Why?
- Environmental implications?
- Associated costs?
- Impacts on industry and nearby communities?
- Was new technology developed because of this oil spill?

Reference

Environment Canada. "An Environmentally Friendly Oil Spill Experiment" *Oil, Water and Chocolate Mousse*. 1994. Accessed August 1, 2007. www.ec.gc.ca/ee-ue/default.asp?lang=en&n=6AEDF280

Rolling Through Reactions

Time: 30 minutes

Curriculum Connections

Science 20 – Unit A: Chemical Changes

Science 24 – Unit A: Applications of Matter and Chemical Change

Chemistry 20 – Unit D: Quantitative Relationships in Chemical Changes

Chemistry 30 – Unit C: Chemical Changes of Organic Compounds

Prior Knowledge

Students should have prior exposure to naming and drawing alkanes and knowledge of the following alkane reactions – cracking, reforming, combustion, and substitution. The ability to balance chemical reactions is also required.

Objectives

This activity reviews the hydrocarbon reactions of cracking, reforming, combustion and substitution and shows how they can be used in the refining process to create a wide variety of petroleum products. Each group is assigned an alkane, after naming and drawing their compound they must work together to complete a series of alkane reactions.

Rationale

This activity shows the wide variety of hydrocarbons that can be produced using chemical reactions. It is also useful for reinforcing IUPAC naming and drawing of the alkane family of organic compounds and basic hydrocarbon reactions (cracking, reforming, combustion, substitution). This activity can also be modified to address the more complex compounds such as alkenes, alkynes, and associated reactions.

Background Information

Hydrocarbon reactions are a crucial step in the refining process. If it were not for these reactions and associated technologies we would need to extract significantly more petroleum from the ground to accommodate the consumer demand.

Materials

Rolling Through Reactions student worksheet (see following pages or resource CD)

Rolling Through Reactions review sheet (see following pages or resource CD)

Dice (one per group)

Petroleum posters

Activity

1. Display or hand out copies of the *Petroleum* poster. Focus on the refining process area located inside, top centre, under the poster heading. Use the visuals on the poster to explain the refining process.

   Once extracted, crude oil, a mixture of thousands of hydrocarbons, is transported to a refinery. The first stop in the refining process is the fractional distillation tower where crude oil is separated by heat to create crude oil fractions such as naphtha, ethylene, and diesel oil (see *Fractional Distillation Activity*, pg 8). Instead of extracting more crude oil from the ground, chemical reactions are used to transform one product into another. The reactions that will be studied in this activity are important, as they are examples of the many ways that petroleum is refined to create a wide variety of products.
2. Using the *Rolling Through Reactions* review sheet to assist you or as a student handout, describe each of the hydrocarbon reactions.
3. Divide students into groups of 2 or 3.
4. Assign each group an alkane hydrocarbon that has 7 or more carbon atoms. (heptane, octane, nonane, decane, undecane [11 carbons], dodecane [12 carbons]).
5. Students proceed through the worksheet, filling in the reactants and products for a series of reactions that refine their assigned alkane. Students roll dice to represent the number of carbon atoms in the hydrocarbon required to complete the reactions. (e.g. if the students roll a 6 then the alkane has 6 carbons = hexane)
6. Repeat using a different starting alkane.

Extension

Try this activity with alkenes, alkynes and other organic compounds and their reactions.

Rolling Through Reactions: Review Sheet

Cracking
By-products of the fractional distillation process have many long chain alkane residues that have limited commercial value. Converting these alkanes into shorter chain alkanes or alkenes creates a valuable commercial product. This conversion is possible through a process called cracking. Cracking can be done using high temperatures or a catalyst such as aluminum oxide. Cracking is the most important process for the commercial production of gasoline.

Cracking = Breaking down large hydrocarbons into smaller ones
i.e. $C_{20}H_{16} + H_2 \rightarrow C_8H_{18} + C_{12}H_{26}$

Reforming
Used to create larger hydrocarbon molecules from smaller ones, reforming is the rearrangement of the molecular structure of a hydrocarbon to alter its properties. Reforming is usually used on low-quality gasoline stocks to improve their combustion characteristics.

Reforming = Creating large hydrocarbons from smaller ones
i.e. $C_7H_{16} + C_7H_{16} \rightarrow C_{14}H_{30} + H_2$

Combustion
Combustion is a rapid chemical reaction between substances that produces carbon dioxide, water, and energy in the form of heat and/or light.

Combustion = Using oxygen to release the energy stored in hydrocarbons
i.e. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ + energy

Substitution
A substitution reaction is a general type of organic reaction where a hydrocarbon containing one functional group or substituent in the reactant molecule is replaced by another. Substitutions usually involve oxygen, nitrogen or halogens, such as chlorine.

Substitution = A reaction that alkanes undergo in the presence of halogens
i.e. $C_3H_8 + Cl_2 \rightarrow$ 1-choloropropane + HCl

Rolling Through Reactions: Worksheet

Name _____ Class _____

1. Identify the hydrocarbon that was assigned by your teacher.
   a) Name: _____ b) Chemical formula: _____
   c) Structural formula:

Refine the hydrocarbon using the following reactions. Role the dice to represent the hydrocarbon that will allow you to complete the questions below. For example, if you roll a 6 the hydrocarbon represented will contain 6 carbons = hexane.

2. Your compound undergoes a cracking reaction with the alkane represented by the dice (roll 1).

   _____ → _____ + _____
   your compound — hydrocarbon roll # 1 — product 1

3. Demonstrate a reforming reaction between product 1 and the alkane represented by the dice (roll 2).

   _____ + _____ → _____
   product 1 — hydrocarbon roll # 2 — product 2

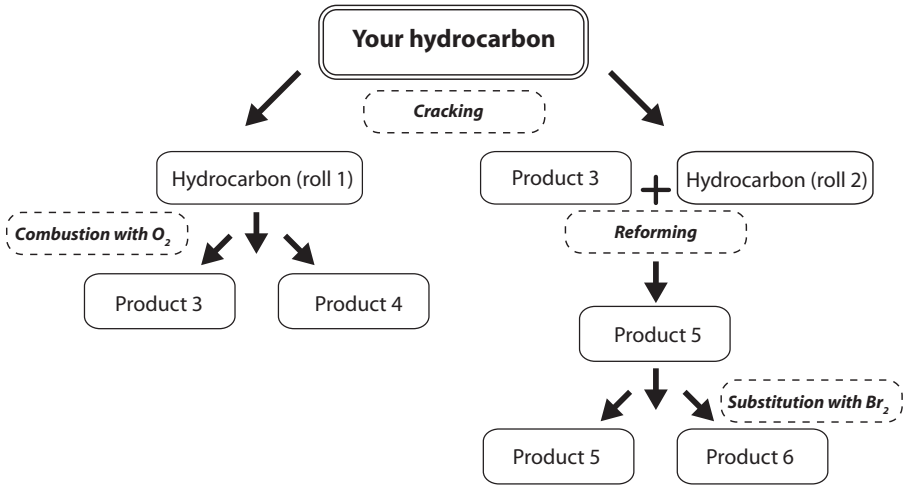
4. Demonstrate a combustion reaction using the hydrocarbon from roll 1. (Don't forget to balance.)

   _____ + O_2 → _____ + _____
   hydrocarbon roll #1 — product 3 — product 4

5. Demonstrate a substitution reaction between product 2 and Br_2

   _____ + Br_2 → _____ + _____
   product 2 — product 5 — product 6

Congratulations, you have refined your hydrocarbon! You completed all four hydrocarbon reactions and made six different products.



Petroleum-Related Websites

Petroleum Information/Facts

Government of Alberta
www.energy.alberta.ca
The *Our Business* tab contains definitions and statistics related to energy in Alberta. Topics include natural gas, oil, oil sands, petrochemicals, land access and aboriginal relations.

www.albertacanada.com/about-alberta/oil-and-gas-technology-and-services.html
Contains information on crude oil and oil sands.

Canadian Association of Petroleum Producers
www.capp.ca
A detailed look at the petroleum industry in Alberta. The website contains facts and issues facing the industry as well as current news and publications.

The Pembina Institute
www.pembina.org
Contains a comprehensive overview of the energy sector from an environmental perspective. Information regarding both renewable and non-renewable energy sources.

Canadian Society for Unconventional Gas
www.csug.ca
Site contains frequently asked questions, "Did-You-Know?" section, as well as information regarding industry challenges and regulations.

Interactive Websites for Students

www.edukits.ca/petroleum
An educational tool for learning more about Alberta's petroleum heritage. It features teaching units, stories, historical photographs and audio.

See the resource CD for additional websites.

Glossary

Alkane – any of the series of saturated hydrocarbons including methane, ethane, propane, and higher members. Alkanes have the general formula: C_nH_{2n+2}.

Alkene – any of the series of unsaturated hydrocarbons containing a double bond, including ethylene and propylene. Alkenes have the general formula: C_nH_{2n}.

Alkyne – any of the series of unsaturated hydrocarbons containing a triple bond, including acetylene. Alkynes have the general formula: C_nH_{2n-2}.

Biodegradable – substances capable of being decomposed.

Bioremediation – micro-organisms or other forms of life that consume and break down environmental pollutants used to clean up a polluted site

Bitumen – a thick, sticky form of crude oil. At room temperature, bitumen is like cold molasses. It must be heated or diluted before it will flow into a well or through a pipeline. It is sometimes called extra-heavy oil.

Cracking – refining process involving the break down of larger, heavier, and more complex hydrocarbon molecules into simpler lighter molecules through the use of heat, pressure, and sometimes a catalyst.

Carbon dioxide – a non-toxic gas produced from decaying materials, respiration of plant and animal life, and combustion (burning) of organic matter, including fossil fuels.

Combustion reaction – a rapid chemical reaction with oxygen that produces carbon dioxide, water and energy in the form of heat and/or light.

Conventional oil / gas – oil and gas that can be produced by traditional recovery techniques normally employed by the oil and gas industry since the 19th century, like drilling wells and pumping, if necessary.

Crude oil – a naturally-occurring mixture of hydrocarbons trapped in underground

Emissions – substances discharged into the air from factories, chimneys and car exhausts.

Energy – the power necessary for things to function. Energy can be as simple as food nourishment needed by humans, or supplied through non-renewable (fossil fuels) or renewable sources (e.g. wind turbines).

Fuels – any substances that provide energy to make things work.

Fossil fuels – fuels such as crude oil or natural gas formed from plant and animal remains. The remains were buried in the Earth's crust, hardened and compressed (squeezed) over millions of years. They gradually changed to oil and gas.

Fractional distillation – the initial step in refining where crude oil is separated into fractions based on their boiling points.

Hydrocarbon – a large class of liquid, solid or gaseous organic compounds, containing only carbon and hydrogen, that are the basis of almost all petroleum products.

Hydro-electric power – the generation of electric power from moving water, such as rushing water at dams and waterfalls.

In-situ recovery – the various methods used to recover deeply buried bitumen, including steam injection.

Natural gas – a naturally-occurring mixture of hydrocarbons found in sedimentary rock in the Earth's crust. It is considered a cleaner burning fuel.

Nitrogen oxides – gases formed mainly from nitrogen in the atmosphere when fuels are burned at a high temperature.

Oil – a complex mixture of chemicals containing carbon, hydrogen and oxygen. Oil can be made into different fuels.

Oil sands – naturally-occurring mixtures of bitumen, water, sand and clay that are found in various parts of the world. In Canada, oil sands are found mainly in three areas of Alberta.

Glossary

Petroleum – a naturally-occurring mixture of hydrocarbons in the gaseous, liquid or solid state.

Refinery – a large plant that takes raw material such as crude oil, and transforms (changes) it into gasoline and hundreds of other products.

Reforming reaction – a chemical reaction that involves rearranging the molecular structure of a hydrocarbon to alter its properties. Typically used to create larger hydrocarbons from smaller ones. Used on low quality gasoline stocks to improve their combustion characteristics.

Remediation (environmental) – the process of stopping or reversing environmental damage.

Unconventional gas – natural gas that requires specialized technology to remove it from the ground. Unconventional sources are typically classified as shale gas, coalbed methane or tight sands gas.

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