

(c) (i) one (ii) three (iii) three

(d) (i) There is no functional group for which we need to indicate a location.

(ii) The carbon chain should be numbered in the opposite direction to give the lowest number: 2-hexene.

(iii) There can be no triple bond formed by a single carbon atom.

(e) A wooden stick is used to form the first bond in a multiple bond; the second or third bonds are formed by a spring, which more readily comes undone.

(f)

Isomer: 1-hexene

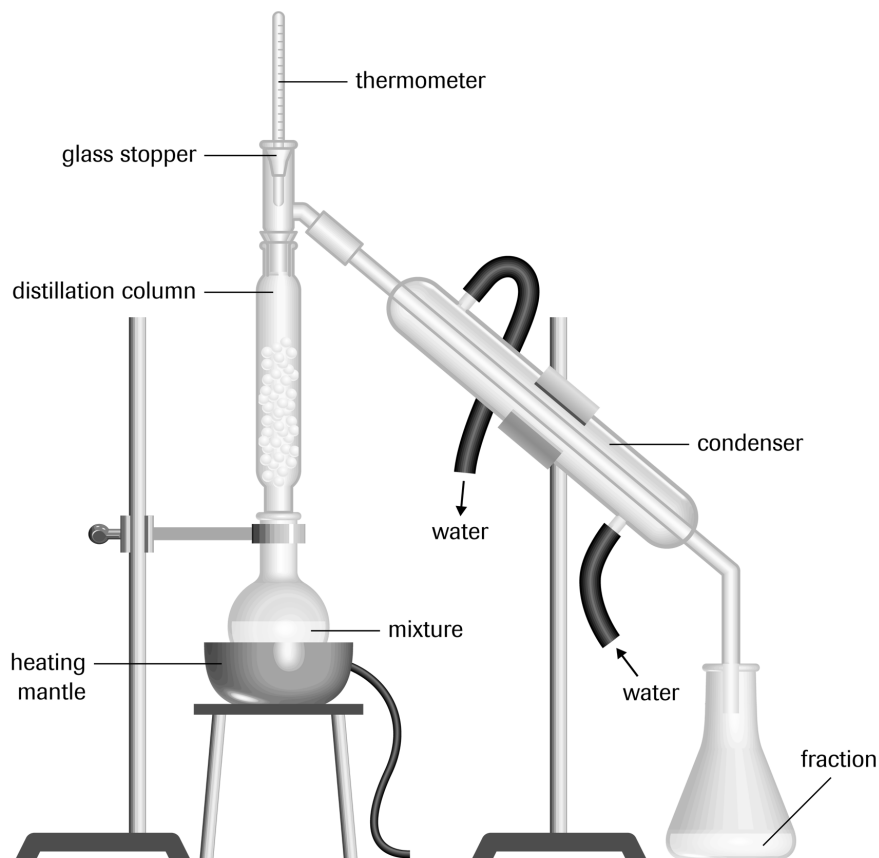
NEL

condense. As the gases ascend higher, the smaller molecules also condense. As each fraction condenses, the liquid formed is collected on trays.

3. This fraction boils at 10°C ; that is, it is a liquid below 10°C because it has not yet boiled, and is a gas above 10°C because it has already boiled. Therefore, it is a gas at 20°C .
4. Cracking is the process used to convert large straight-chain hydrocarbons into smaller branched-chain hydrocarbons, usually by heating with a catalyst. This process is important because one of the most valuable and profitable petroleum products is high-octane gasoline, which contains highly branched alkanes.
5. The approximate boiling point of propane is under 30°C , while waxes boil at over 450°C . The difference is due to intermolecular forces. As the length of the hydrocarbon molecules increases, the strength of the van der Waals forces between molecules increases as well, so more heat is required to pull the molecules apart. Therefore, higher temperatures are required to pull the molecules far enough apart to change the substance to a gas.
6. Student answer will vary.
 - (a) propane in a gas barbecue; butane in a lighter
 - (b) kerosene in a camping stove or lamp; lubricating oil for a bicycle chain
 - (c) wax in candles; asphalt on roads

Applying Inquiry Skills

7.



The mixture can be separated by distillation, using the apparatus shown. The distillation column allows the evaporated gases to rise; the thermometer reads the temperature of the gases; the condenser, cooled by cold water, condenses the evaporated gases. The mixture is placed in the round-bottom flask and heated gently. The hydrocarbon with the lower boiling point will evaporate first, condense, and be collected. The temperature of the column will then rise until the boiling point of the other hydrocarbon is reached. At that point, the hydrocarbon with the higher boiling point will evaporate and be collected.

Making Connections

8. Canada exports approximately 60% of its crude oil—mainly heavy crude oil from western Canada to the United States. Canada also imports light crude oil from the United States by pipeline, or from abroad by tankers. Canada's northern territories—Yukon, Northwest Territories, and Nunavut—have large resources of crude oil. Exploration for crude oil also began in Atlantic Canada about 50 years ago, in Nova Scotia, Newfoundland, New Brunswick, and Prince Edward Island. Alberta remains the focus of the petroleum industry in Canada, producing 70% of the country's crude oil. Crude oil is fractionated, and the collected components are used for fuel such as gasoline, jet fuel, kerosene, diesel oil, and for other purposes, such as lubricating oils, waxes, and asphalt.
9. Motor oils may contain viscosity improvers, anti-wear additives, anti-oxidants, anti-foam agents, and detergents to maintain engine cleanliness. 5W30 and 10W30 are the most commonly used motor oils. They are thin enough for cranking at low temperatures, and thick enough to lubricate satisfactorily at high temperatures. In warmer seasons, use more viscous motor oils (higher numbers). In colder seasons, use less viscous motor oils (lower numbers). The following motor oils are recommended for the lowest expected temperatures listed:

Lowest expected temperature	Type of motor oil	Brand	Cost
0°C	5W20, 5W30, 10W30, 10W40, 20W50		Under \$4/L
-18°C	5W20, 5W30, 10W30, 10W40		Under \$4/L
Below -18°C	5W20, 5W30		Under \$4/L

10. In Canada, fossil fuels provide over 85% of our total energy use. These fuels, which include coal, crude oil, and natural gas, are formed over millions of years from long-dead plant and animal material. That is why they are called fossil fuels. There is a concern about their use because they are non-renewable: when we have exhausted the existing supply, there will be no more fossil fuels available. Another concern about the use of fossil fuels is that, when burned, these hydrocarbons produce carbon dioxide—a product that may be partly responsible for global warming.
11. Student answers will vary. Possible answers include: home heating (service technician, furnace maintenance, air conditioning installation); furniture stripping and refinishing (repairs and restoration); hobby shops—plastic model cars and airplanes (salesperson); painting service (home painting and renovations); hot tubs and spas (service technician and installer); insulation contractors (installers and maintenance technicians); lamination products and services (service personnel); lawn maintenance (fertilizer application); automotive industry (oil changes and lubrication services); packaging services (materials supplier); plastic patio furniture supplier (retail staff); driveway sealing (asphalt sealing); photo finishing (film developing); pipe fabricating (factory staff); plastics (moulders); plumbing contractors (installers); recording services (sound and video technicians); refrigerators and freezers (technicians)

3.4 INVESTIGATION: SEPARATING A MIXTURE BY DISTILLATION

(Pages 197–198)

Prediction

- (a) Substances with the lowest boiling point will be recovered first. Components will be recovered in the following order (from first to last): hexane, 2-methyl-2-propanol, and paraffin wax. The reasons for this order are that propanol contains an -OH group, which causes hydrogen bonding between molecules. Hydrogen bonds are stronger intermolecular forces than the van der Waals forces that exist between hexane molecules. Paraffin wax consists of much longer molecules than either hexane or propanol, and thus has stronger van der Waals forces than the other two hydrocarbons.