Unit 5 Project

Consumer Chemistry

Student Textbook pages 630–631

There will be a large variety of consumer products from which students can choose for this project. Since students may attempt to purchase the actual item for their project, make sure that they get your approval for their choice before they start to work on the chemical nature of the consumer product and its container or packaging. Alert students to the safe handling of potentially dangerous or hazardous material and its safe disposal.

This project has the Design Criteria, Action Plan, and Evaluation tips fully outlined in the student textbook. Ask students to read through the details and be sure that they understand and follow through. Hint at the suggestion of the environmental health/safety concerns related to the product and/or the packaging in addition to items A to G under Design Criteria.

Do not place any restriction on the format of presentation that students prefer to use, particularly for students that may not have easy access to a computer or a videotape recorder. If you decide on students working in groups of two or three, assign a specific role to each member of a group so that the performance of each student can be assessed.

Assessment and Evaluation

Rubric for Unit 5 Project: Consumer Chemistry is available in the "Assessment and Evaluation" section in the front matter of *Teacher's Resource* CD-ROM.

Unit 5 Review Answers

Student Textbook, pages 632–635

Answers to Knowledge/Understanding Questions

Multiple Choice

1. (d)

2. (c)

3. (b)

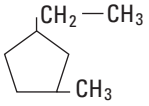
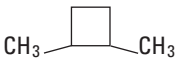
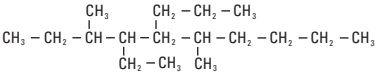
4. (d)

5. (a)

6. (e)

Short Answer

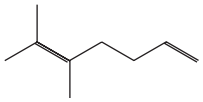
7.

Name	Structural diagram	Molecular formula	Classification
Ethane	CH_3-CH_3	C_2H_8	Alkane
Propyne	$H-C\equiv C-CH_3$	C_3H_4	Alkyne
3-methylhexane	$CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_2-CH_2-CH_3$	C_7H_{16}	Alkane
1-ethyl-3-methyl-cyclopentane		C_8H_{16}	Cyclocalkane
Cis-3-methyl-3-hexene	$CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{\vert}{C}}=\underset{\displaystyle H}{\underset{\vert}{C}}-CH_2-CH_3$	C_7H_{14}	Alkene
3, 4-dimethyl-cyclobutane		C_6H_{12}	Alkane
3, 3, 4-trimethyl hexane	$CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{\vert}{C}}-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_2-CH_3$	C_9H_2	Alkane
1-butyne	$H-C\equiv C-CH_2-CH_3$	C_4H_6 (isomer 1)	Alkyne
Cyclobutane		C_4H_6 (isomer 2)	Cycloalkene
Trans-4-ethyl-6 methyl-3-heptane	$CH_3-CH_2-\underset{\displaystyle H}{\underset{\vert}{C}}=\underset{\displaystyle CH_2-CH_3}{\underset{\vert}{C}}-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_3$	$C_{10}H_{22}$	Alkane
3-ethyl-1-hexyne	$H-C\equiv C-\underset{\displaystyle CH_2-CH_3}{\underset{\vert}{CH}}-CH_2-CH_2-CH_3$	C_7H_{12}	Alkyne
2, 3-dimethylhexane	$CH_3-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_2-CH_2-CH_3$	C_8H_{18}	Alkane
4-ethyl-3, 6-dimethyl-5-propyl-decane		$C_{17}H_{35}$	Alkane

8. (a) There are too many hydrogen atoms around the middle carbon atom.

$CH_3-CH_2-CH_3$

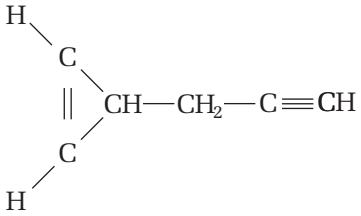
(b) There are five bonds surrounding two carbon atoms due to the triple bond. A carbon atom requires four surrounding bonds to form a stable molecule.



(c) There are too many bonds around the middle carbon atom.

$$CH_3-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-CH_3$$

(d) There are five bonds surrounding a carbon atom due to the triple bond.



9. (a) Including the "2" is unnecessary since the double bond is between the only two carbon atoms.

(b) The longest chain in this molecule contains four carbons. The correct name is 2,2-dimethylbutane.

(c) The numbering should start on the other end of the six-carbon chain. The correct name is 3-ethyl-2,4-dimethyl-2-hexene.

(d) The longest chain in this molecule contains six carbons. The correct name is 4-methyl-2-hexene.

10.

Homologous Series	General formula	Structural diagram	Name	Saturated or unsaturated
Alkane	C_nH_{n+2}	$CH_3 - CH_2 - CH_3$ propane	Propane	Saturated
Alkene	C_nH_{2n}	$CH = CH - CH_2 - CH_3$ butene	Butene	Unsaturated
Alkyne	C_nH_{2n-2}	$H - C \equiv C - CH_2 - CH_3$ butyne	Butyne	Unsaturated
Cycloalkane	C_nH_{2n}	 cyclo hexane	Cyclohexane	Saturated

11. (a) octane > ethanol > methane > hydrogen

(b) $C_8H_{18(l)} + \frac{25}{2}O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(g)}$

$C_2H_5OH_{(l)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$

(c) Benefit: source of energy for heat, transportation, electricity
Risk: global depletion of natural resources (petroleum)

12. The platinum sample will be the first to reach 30°C. Its specific heat capacity is the largest and since all three samples have the same mass and undergo the same temperature change, the specific heat capacity is the variable that will determine the amount of heat energy absorbed. Since platinum has the lowest heat capacity, it will require less energy to raise 1 g of the sample by 1°C.

Answers to Inquiry Questions

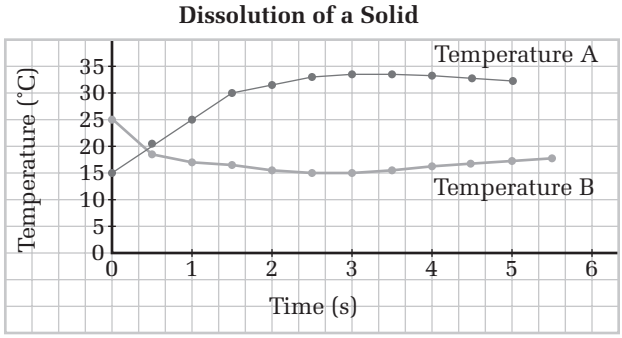
13. It is possible to differentiate between the two compounds by comparing their reactivity with aqueous potassium permanganate, $KMnO_4$. The permanganate ion changes to manganese dioxide, when in contact with unsaturated compounds. The solution changes from purple to brown. When in contact with saturated compounds, the permanganate ion does not react and no colour change is observed.

14. The amount of energy released per gram of kerosene can be determined using a bomb calorimeter. When a known amount of kerosene is ignited in a bomb calorimeter that has been calibrated to a known value. The temperature change associated

with the combustion can be measured using the equation $Q = mc\Delta T$. The heat gained by the calorimeter is equal to the heat lost by the sample. The heat of combustion per gram of kerosene is calculated by diving by the mass of kerosene burned. The use of a kerosene heater in a confined area, where the supply of oxygen is limited, can result in incomplete combustion. Other products besides carbon dioxide and water, namely toxic gases such as carbon monoxide, may be produced during incomplete combustion.

$C_{12}H_{26(l)} + 8O_{2(g)} \rightarrow 10C_{(s)} + CO_{(g)} + CO_{2(g)} + 13H_2O_{(g)}$

15. (a)



(b) Compound A: exothermic (the temperature of the water increases due to the heat released by the compound)
Compound b: exothermic (the temperature of the water decreases due to the heat gained by the compound)

(c) Compound A: $Q = mc\Delta T = 100\text{ g} \times 4.184\text{ J/g°C} \times (31.9\text{°C} - 15\text{°C})$
$= 7070.96\text{ J}$
Heat of solution per gram = 0.707 kJ/g
Compound B: $Q = mc\Delta T = 100\text{ g} \times 4.184\text{ J/g°C} \times (16.4\text{°C} - 25\text{°C})$
$= -3598.24\text{ J}$
Heat of solution per gram = −0.360 kJ/g

(d) Non-linear data indicates that the heat absorbed/released by the solution is not necessarily being transferred to the calorimeter but possibly to the surroundings of the calorimeter (namely the air and the polystyrene)

16. (a) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$
$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$
$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$

(b) Test tube number 3 indicates the most complete combustion because the addition of limewater turned the contents very milky, indicating the presence of a lot of carbon dioxide. The larger the amount of carbon dioxide, the more complete the combustion.

(c) The identity of the gas is propane. The air surrounding us is approximately 20% oxygen. Based on the above balanced equations, the closest ratio of oxygen of fuel is found in that of propane. (1 : 5 or 20%)

(d) $C_3H_{8(g)} + \frac{7}{2}O_{2(g)} \rightarrow C_{(s)} + CO_{(g)} + CO_{2(g)} + 4H_2O_{(g)}$

(e) If methane and propane are burned in areas that do not have adequate ventilation the formation of toxic carbon monoxide can occur. An inadequate supply of oxygen leads to incomplete combustion.

Answers to Communication Questions

17. Typical steps in the production of paint are listed here: (students should use these points in the construction of a concept map)
–extraction of crude oil from the ground

–fractional distillation of the liquid to separate the hydrocarbon fractions (Each of the hydrocarbon components has a different range of boiling points. The liquid is vaporized in a large fractionation tower. As each fraction reaches a level where the temperature is just below its boiling point, it condenses and liquefies. The liquid fractions are removed and separated.
–chemical processing and purification (Reforming uses heat, pressure, and catalysts to convert large hydrocarbons into other compounds)
–further processing and refining
–paint

18. In a saturated hydrocarbon, each carbon atom is bonded to the maximum possible number of atoms. (e.g. Alkanes) Unsaturated hydrocarbons contain carbon atoms that can potentially bond to additional atoms. (e.g. Alkenes, alkynes)

19. Alkanes do not have geometric isomers because single carbon-carbon bonds can freely rotate. Alkenes, on the other hand, are fixed in place about the carbon-carbon double bond. Alkynes do not have geometric isomers because they are linear about the triple bond.

20. Carbon has four bonding electrons, which allow it to form strong covalent bonds with a variety of different elements (primarily H, N, P, and S). Carbon can form single, double, and triple bonds. It can also form long, stable chains. Carbon compounds can have different structural shapes such as chains and rings.

21. The compounds can be classified by making use of the general mathematical patterns underlying the number of carbon and hydrogen atoms in alkanes, alkenes, alkynes and cycloalkanes. Alkanes: C_nH_{n+2}; alkenes: C_nH_{2n}; alkynes: C_nH_{2n-2}; cycloalkanes: C_nH_{2n}.
C_6H_{12} = cycloalkane or alkene
C_4H_6 = alkyne
C_5H_{12} = alkane
C_7H_{14} = cycloalkane or alkene
C_3H_4 = alkyne

22. The reaction of nitrogen gas and hydrogen gas produces ammonia gas and 92.2 kJ of energy. This reaction is exothermic. The energy released in the formation of the bonds in ammonia is greater than the energy required to break the reactant bonds.

23. Calorimetry is the technological process of measuring changes in thermal energy. Two commonly used calorimeters are bomb calorimeters and polystyrene calorimeters. In a polystyrene calorimeter, the temperature of a known amount of water placed inside is measured before and after the reaction takes place. These calorimeters are used to measure heat transferred in system kept at constant pressure. Bomb calorimeters are used to measure heat transferred during reactions at constant volume. Reactants are placed inside the "bomb" and ignited. The temperature of a known amount of water surrounding the bomb is measured before and after the reaction.

24. To obtain accurate measurements, the heat capacity of the calorimeter must be known because the calorimeter itself can also absorb or release small quantities of energy. The heat capacity of the calorimeter takes into account the heat that all parts of the calorimeter, such as the water, thermometer, stirrer, and container, can lose or gain.

25. Two exothermic processes include the combustion of propane and dissolution of ammonium nitrate in water.
Two endothermic processes include the evaporation of isopropanol and the formation of acetylene from its elements.

26. (a) Specific heat capacity : J/g · °C

Heat capacity : J/°C

(b) Specific heat capacity: $Q = mc\Delta T$

Heat capacity : $Q = C\Delta T$

Answers to Making Connections Questions

27. heptane < 2-methylhexane < 2,2,4-trimethylpentane.
Heptane does not have any branching and therefore has the lowest octane rating. 2,2,4-trimethylpentane has the highest octane rating because it has the highest degree of branching. With one branch, 2-methylhexane has an octane rating between the other two.

28. (a) serving of cereal = 126 Cal
Converting to kilojoules yields 126 Cal × 4.184 kJ/Cal = 527.2 kJ
Amount expended per minute of walking = 20 kJ
Amount of time you could walk with 527.2 kJ = 27.2 kJ ÷ 20 kJ/min
= 26.4 min

(b) 26.4 min = 0.44 hours
Distance of walk = 6.0 km/h × 0.44 h = 2.6 km

29. (a) Energy produced = 0.702 kg × (–41.3 kJ/g) = –29.0 kJ
29.0 kJ of energy is produced in the combustion of 0.702 kg of octane

(b) Mass of hydrogen needed to produce 29.0 kJ of energy = 29.0 kJ ÷ 141.5 kJ/g
= 0.2 g
Mol of hydrogen required = 0.2 g ÷ 1.008 g/mol = 0.2 mol
Volume at STP of hydrogen = 0.2 mol × 22.4L/mol = 4.6 L

(c) Hydrogen gas is normally stored in large steel tanks. In passenger vehicles, hydrogen is obtained through the electrolysis of water and is stored in fuel cells. One possible danger of storing hydrogen is its explosive nature.
http://www.electrolysisofwater.bigstep.com/

30. Students can use the following web sites to research an answer to this problem.
http://www.energy.ca.gov/education/index.html
http://calvin.biotech.wisc.edu/jeffries/
http://www.solarenergy.net/
http://www.eren.doe.gov/wind/
http://www.nei.org/
http://www.brucepower.com/media/candu.htm