It's Organic, How Can That Be a Problem?

Developed by
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For the
My Environment, My Health, My Choices project

University of Rochester
Rochester, NY

Abstract:

Organic solvents encountered in many common activities can pose a risk to our health. This can occur at home, work, during recreational activities, or at school. Understanding organic chemistry and molecular polarity can help understand this risk. In this activity students relate the events in a real-world scenario to the chemistry and risks of solvents. This directed case study also includes a hands-on molecular modeling activity. Students will research the answers to questions in all parts of the activity and learn about various aspects of toxicology. The culminating activity involves short student group presentations about plans to remediate the site of a gasoline spill.

Table of Contents

Teachers, we would appreciate your feedback. Please complete our brief, online Environmental Health Science Activity Evaluation Survey after you implement these lessons in your classroom.
The survey is available online at: www.surveymonkey.com/s.asp?u=502132677711

Student Pre/Post Test

Name _____ Class _____

1. Which statement correctly describes the solvent in a solution?

    1. A solvent is dissolved when a solution forms.
    2. A solvent does the dissolving when a solution forms.
    3. In solutions, a solvent reacts with water to form a solution.
    4. In solutions, a solvent reacts with the solution to release water.

2. Which formula is the molecular formula of ethanol?

    1. C_2H_6OH
    2. H_3CH_2COH
    3. C_2H_6O
    4. H_2OHCH_3

3. Which hydrocarbon compound is commonly found in gasoline?

    1. ammonia
    2. benzene
    3. naphthalene
    4. water

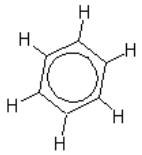
4. Given a drawing of a molecule of diethyl ether:

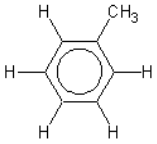
    

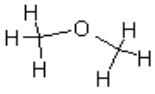
    Considering the bonds within the molecule *and* molecular polarity, a molecule of diethyl ether has

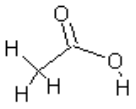
    1. covalent bonds and is slightly polar
    2. ionic bonds and is very polar
    3. covalent bonds and is nonpolar
    4. ionic bonds and is slightly nonpolar

5. Which structural formula represents toluene?

1. 

3. 

2. 

4. 

6. The acronym, TLV stands for the term

    1. total lead vapor
    2. time limit velocity
    3. toxic level variance
    4. threshold limit value

7. Solvents having nonpolar molecules have the highest solubility in

    1. acetone
    2. benzene
    3. ethanol
    4. water

8. Based on molecular polarity, which compound has the highest vapor pressure?

    1. acetic acid
    2. acetone
    3. ethanol
    4. water

9. Which two routes of exposure for toxic solvents in the workplace are most common?

    1. ingestion and injection
    2. inhalation and ingestion
    3. injection and skin absorption
    4. skin absorption and inhalation

10. A sample of groundwater is tested and found to contain acetone at a concentration of 149 μg/L (149 μg per 1000 g of water). What is this concentration of acetone in parts per million?

    1. 0.149
    2. 1.49×10^{-3}
    3. 1490
    4. 1.49×10^{8}

Pre/Post-Test Teacher's Answer Key

Correct alternative in bold

1. Which statement correctly describes the solvent in a solution?

    1. A solvent is dissolved when a solution forms.
    2. **A solvent does the dissolving when a solution forms.**
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    3. **C_2H_6O**
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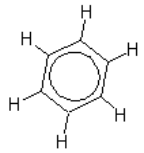
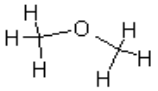
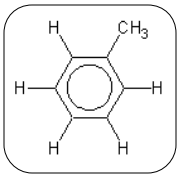
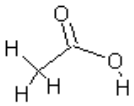
1. 

2. 

3. 

4. 

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    4. water

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Learning Context

This activity can be used with students at an honors level through lower-ability level students. The activity will take approximately four 45-minute class periods. The activity is a directed case study intended for use with high school chemistry classes. This case study will generate the most student-centered learning if the students work in cooperative groups with four students in each group. As the teacher for this activity, be diligent in monitoring group work. Use non-threatening questioning techniques to guide students to achieve a rich understanding of the content as well as helping them develop important skills. For more information about conducting lessons using cooperative learning strategies go to: www.co-operation.org

Before starting the activity with your students, administer the pre-test. Score the pre-test using the answer key provided. The pre-tests must be saved to be sent in after completing the activity and post-test.

Be sure that each group member produces their own copy of the work in the case study. Check that the groups work on one question at a time, as a group.

Student Outcomes for the Activity:

- Relate dissolving to molecular polarity and intermolecular forces
- Distinguish among various organic solvents in terms of molecular structure
- Compare solvents based on their uses
- Compare the toxicity of various organic solvents
- Develop a possible solvent spill site decontamination plan

Student Prerequisites:

Students should have some experience with covalent and ionic bonding, basics of organic chemistry (carbon chains/rings and some functional groups), a sense of geometric shapes/symmetry, and the dissolving process including "like dissolves like".

This activity will require 4 class periods including time for group presentations for the summative assessment; the New Castle site decontamination plan.

Materials Needed:

1. Printed resources from Internet sites about solvent use and risk, solvent leak/spill decontamination and/or
2. A list of the Internet sites about these topics for students and access to computers and the Internet
3. Molecular modeling kits to create models of organic compounds (1 kit for each pair of students) Inexpensive modeling kits work well for this as it's better to have one kit per two students.
4. A collection of MSDS or access to an Internet MSDS site
5. NYSED Physical Setting/Chemistry Reference Tables
6. Other chemistry reference books; e.g., CRC Handbook

Procedure

Part 1:

1. Students should read the newspaper article in Model 1. Next have the students work in their group on the Key Questions for Model 1.
2. Provide print and/or Internet resources for solvents used in automotive service (including gasoline and other fuels, solvents in maintenance, and solvents in automotive painting), determining blood-alcohol levels, and defining threshold limit value (TLV).
3. As student groups work, question them about their progress and discuss their responses to the Key Questions.
4. For the questions in Part 1, provide a collection of MSDS and/or access to Internet MSDS sites.
5. Assist them with the structural formulas they draw using their textbook or other resources.
6. Discuss and assist them in developing explanations to the questions posed in the Exercises.

Answers to Part 1 questions:

1. Define the term, solvent.

A solvent is typically a liquid that will dissolve other substances by attracting the particles of the substance and/or allowing intermolecular space for the substance particles

2. Ethanol is a solvent found in most gasoline. Use a resource to find four other solvents used in automotive products and/or services. Make a list of the names and the molecular formulas of these five organic solvents. Have your instructor check your list.

A list of possible solvents including ethanol:

Ethanol, CH_3CH_2OH
Acetic acid, CH_3COOH
Benzene, C_6H_6
Methyl tertiary butyl ether, $CH_3OCH(CH_3)_3$
Diethyl ether, $CH_3CH_2OCH_2CH_3$ (and other ethers)
Octane (and its isomers), C_8H_{18}
Acetone, CH_3COCH_3 (and other ketones)
Toluene, $C_6H_5CH_3$
Xylenes, $C_6H_4(CH_3)_2$
Methylene chloride, $CHCl_3$
Hexane, C_6H_{14}
2-propanol, $CH_3CHOHCH_3$

3. What is the human blood-alcohol level for an individual to be considered impaired?

In the U.S. the BAC to be legally impaired is 0.08% (80. mg/dL).

4. Define: Threshold Limit Value

TLV is the maximum allowable concentration for human exposure in the workplace.

5. Use material data safety sheets (MSDS) to determine the TLV (threshold limit value) for ethanol and other the four solvents in your response to Key Question 2. Record the solvents and TLVs.

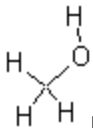
Answers will vary. The solvent TLVs should include proper units.

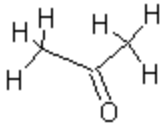
6. Convert the U.S. legal blood alcohol level to parts per million. Compare this value to the TLV for ethanol.

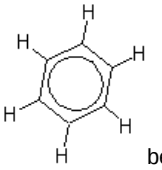
The BAC of 0.08% is equal to 800 ppm. This less than the TLV for ethanol.

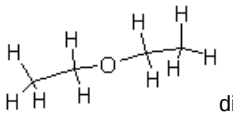
7. Draw the structural formulas for each of the solvents listed in your table. Have your instructor check your structural formulas.

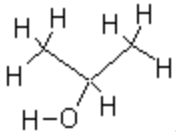
Answers will vary. Examples of some structural formulas: (note students will probably have drawn in all C and H atoms)

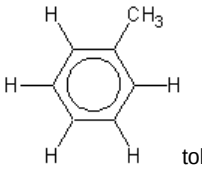

methanol

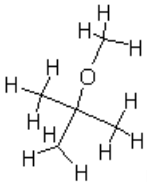

acetone

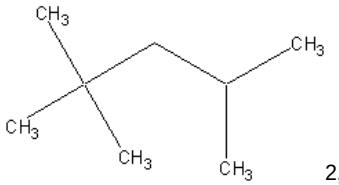

benzene

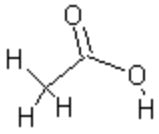

diethyl ether


2-propanol


toluene


methyl t-butyl ether


2,2,4-trimethyl pentane (octane isomer)


acetic acid

8. Compare the chemical information about the compounds available from the molecular formulas of the solvents to the chemical information available from the structural formulas of the solvents.

While structural formulas show which atoms are connected by bonds, molecular formulas only show the elements present and the ratio of element's atoms in the compound.

9. What factors determine the molecular polarity of solvent molecules?

…the bond polarity and the molecular geometry

<u>Part 2</u>: Constructing Molecular Models

1. Help the student pairs construct the first 1 or 2 models. Check that the models are correct. Check their geometric description of the molecular models and assist them with the descriptions as needed.

2. Along with checking the models and descriptions, discuss the molecular polarity of the molecules based on bond polarity and molecular geometry. Check their list of solvents that are soluble in water and their explanation for the solubility using molecular solubility.

3. The vapor pressures of benzene, hexane, ethanol, acetone, acetic acid, and water should be easily found using the Reference Tables for Physical Setting Chemistry (from NYSED) and other chemistry reference books (e.g., CRC). The vapor pressure of a solvent can be a factor in the risk since those with high vapor pressures are a risk both as liquids and in the gaseous phase.

Answers to Part 2 Questions:

Answers to Key Questions

1. Write a description of the molecular geometry of each solvent molecule.
   Answers will vary; look for geometric terms; linear, bent, tetrahedral, zigzag chain…

2. Based on the atoms in the molecule and the molecular geometry, determine the relative polarity of the solvents. List the solvent names in rank order from the solvent with the least polar molecules to the solvent with the most polar molecules.

   Least Polar _____ Most Polar

   Answers will vary; hydrocarbons – less polar, alcohols – more polar

3. Which solvents in your list are soluble in water? Explain why these solvents are soluble in water in terms of molecular polarity.
   Answers will vary; alcohols, aldehydes, ethers, organic acids, etc.} The solvents soluble in water are more polar than others usually due to a functional group containing –OH, or =O.

Answers to Exercises:

1. Define: vapor pressure and describe how vapor pressure relates to molecular polarity.
   Vapor pressure is the pressure at the surface of a liquid caused by the molecules escaping the liquid as a gas. When a liquid's molecules are more polar there is typically a lower vapor pressure.

2. Compare the vapor pressures of water, benzene, hexane, ethanol, acetone, and acetic acid (at 25^{o}C). Vapor pressure values can be found in a reference document available from your instructor or in other reference books.
   Vapor pressures at 25^{o}C: water = 3 kPa, benzene = 12 kPa, hexane = 20 kPa, ethanol = 8 kPa, acetone = 31 kPa, acetic acid = 2 kPa

3. Explain how the vapor pressure of a solvent can be a factor in toxic exposure.
   Solvents having a high vapor pressure pose a greater risk for inhalation exposure. Solvents having a low vapor pressure don't dissipate by evaporation as quickly and there could be a greater risk from skin contact.

Answer to Problems:

1. Why can exposure to a polar solvent be more of a health risk than exposure to a nonpolar solvent?
   A polar solvent is more likely to be taken up by body fluids, tissues, and cell since water is the basis for the functioning units of living things.

2. Why can exposure to a nonpolar solvent be more of a health risk than exposure to a polar solvent?
   A nonpolar solvent can pose more of a risk because any accumulation due to exposure is more difficult for the body to excrete or decompose.

3. Research solvent exposure and predict the cause of Mr. Castle's stumbling that resulted in his fall. Cite evidence from a reliable source to support your prediction.
   Students should find the article, "Solvent exposure and the risk of slips, trips, and falls among painters." Students should get enough from the article to conclude that solvent exposure from painting automobiles and/or gasoline caused Mr. Castle to fall.

Part 3:

Students should read the second newspaper article ("New Castle Site Soil Test Finds Gasoline") to find out more about the environmental health science issue in Lakeville. They should then answer the questions.

Answers to Part 3 Questions:

1. Students may need some help making the connection between gasoline leaked into soil and the fact that gasoline is **less dense than water**, so **it should migrate toward the surface** if the soil is moist or there is a period of rain.

2. The two most harmful routes of exposure to gasoline are **inhalation and absorption through the skin**.

3. The risk from gasoline in groundwater is from **drinking the water**.

4. If the contamination is not from a gasoline leak, it may be from **leaks or spills of the solvents used in the painting in the collision shop or from mechanical service** on vehicles. The solvents from these activities will be somewhat different than from gasoline but have similar toxicities.

5. The list of harmful effects from solvent exposure including affected organs/tissues will require significant research by the groups. They will need Internet access and/or print resources. Meet with groups to review their list against their resources. Answers will vary.

6. The definition of LD_{50} is **the dose of the toxin that is lethal for 50% of a population. Often the value is accompanied by the species used in the test; often rats.**

7. The risk to children from just about any toxin is **due to their lower body weight. A dose that may not affect an adult may cause significant damage to a child.**

8. Carcinogenic solvents are those that can cause cancer if the individual is exposed to enough of the solvent (acute exposure) or the exposure occurs over a long period of time (chronic exposure). The list of carcinogenic solvents will vary. One example is **benzene.**

9. Other scenarios for toxic solvent exposure could be **a leak at an industrial site, a spill in the chemistry storeroom or technology classroom at school, a train derailment, a flood that breaks open storage tanks...**

Part 4:

1. Students use the Internet and/or print media to find four examples of processes used to decontaminate sites where a solvent leak or spill has occurred. They list the sites and describe the decontamination process.

2. Students then propose a course of action to decontaminate the New Castle Collision and Service site. They prepare a presentation of their decontamination plan to the class. They use a rubric to guide their work.

For Part 4 the students will have to do some difficult research. They may need to contact an environmental remediation company; by phone, or email. Check the phone book for such companies in your area.

The student groups may need materials and help for their decontamination plan presentations. Provide materials such as poster paper and markers, paper for signs, etc. A presentation rubric is provided. Give a copy of the rubric to student groups. Have each group post their poster sheet on the wall or board in front of the room. The group should use their poster during their presentation. Score each group during their presentation including any anecdotal comments to give them feedback.

Evaluation suggestion:

Another good teaching technique when having students work in groups is to ask for an evaluation from each group member that includes warm and cool comments about how the group functioned and a self-evaluation of how the student rates their own work in the group.

After completing the activity with your students, administer the post-test. This is the same set of questions as the pre-test.

Resources:

The following list includes several resources available on the Internet. There is a brief description of each resource and the URL for the site.

1. **Common Pollutant Eyed in Cancer Study**: by JOHN HEILPRIN (Associated Press Writer) Associated Press July 27, 2006 1:27 PM EDT This article describes exposures and risk of cancer from TCE (trichloroethylene). The article also describes sites that have been contaminated by TCE.
   http://www.intelihealth.com/IH/ihtIH/WSI/333/7228/480596.html

2. **Frequently asked questions on solvents**: This article is from OSHA Europe and gives information about the general risks of solvents, including a good example comparing ethanol and methanol.
   http://europe.osha.eu.int/good_practice/risks/dangerous_substances/faq4.stm

3. Huge cleanup ahead for Kodak: An article about the large (1900 acres) and long-time pollution at the Kodak manufacturing complex in Rochester and Greece, NY. Plans for remediation of the pollution and changes to the manufacturing complex are outlined in the article.
   http://www.democratandchronicle.com/apps/pbcs.dll/article?AID=/20040822/BUSINESS/408220301

4. **Solvent exposure and the risk of slips, trips, and falls among painters: This article from the George Washington University Medical Center is about physical symptoms of solvent exposure.**
   http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=1928112&dopt=Abstract

5. **Methylene Chloride and OSHA**: This site provides information on a common solvent, methylene chloride including properties and exposure symptoms. There are also exposure limits and safety requirements.
   http://www.ecu.edu/oehs/LabSafety/MethyleneChloride.html

6. **Properties of Common Organic Solvents**: This is a table of various properties of organic solvents including boiling point, density, solubility in water, flash point, and more.
   http://www.speckanalytical.co.uk/products/Tips/bps.html

7. **Properties and Toxicities of Organic Solvents**: The values in this table, except for relative polarities, have been extracted from MSDS compilations. Table 1 is arranged alphabetically and table 2 is arranged according to increasing polarity.
   http://virtual.yosemite.cc.ca.us/smurov/orgsoltab.htm

8. **Risk Assessment: Transport, Storage and Use of Solvents and Other Flammable Liquids:** This site describes risks, handling, storage, and disposal of solvents.
   http://www.chm.bris.ac.uk/safety/solvent.htm

9. **Pregnant women exposed to organic solvents on the job are 13 times more likely to deliver a baby with major birth defects**: This site has information on the risks of exposure to solvents by expectant mothers and others. It describes risks and safety measures to avoid exposure.
   http://www.gciu.org/safety/solvent.shtml

10. **Solvents**: This is a document on basic risks and safety regarding solvents. It includes good detail of exposure effects in the body. There is a lot of information about benzene exposure.
    http://www-ilo-mirror.cornell.edu/public/english/protection/safework/cis/products/safetytm/solvents.htm

11. **Spill Response and Remediation**: This article is from the NYS DEC and describes, in general terms, the spills and response in NYS related to everything from petroleum products to cooking grease.
    http://www.dec.state.ny.us/website/der/spills/#problem

12. **Pipeline spill nets Tidewater $240,000 fine**: This is an article about a gasoline spill in the Spokane, WA area. It describes the extent of the spill and the response plan.
    http://www.ecy.wa.gov/news/2000news/2000-209.html

13. **Subsurface spills of gasoline and other petroleum products**: This article is from the USGS and has good information about leaks and spills of gasoline. There is a lot of information about MTBE, a solvent used in gasoline.
    http://pubs.usgs.gov/fs/FS-019-98/

14. **In-Situ DUOX™ Chemical Oxidation Technology**: An EPA report about a study performed to investigate the feasibility of applying the DUOX™ chemical oxidation technology to chlorinated solvent contaminated media at the Roosevelt Mills site in Vernon, Connecticut.
    http://www.epa.gov/nrmrl/pubs/540r05008/540r05008.pdf#search=%22In-Situ%20DUOX%E2%84%A2%20Chemical%20Oxidation%20Technology%22

15. **Organic solvent exposure, genes, and risk of neuropsychological impairment**: This is a report of a study on cognitive and neurological impairments found in some workers exposed to organic solvents.
    http://qjmed.oxfordjournals.org/cgi/content/full/95/6/379

16. **Restoration Following a Gasoline Spill**: This is an article about a gasoline spill in Montreal and the remediation that followed.
    http://www.sanexen.com/pdf/english/Restoration_following_a_gasoline_spill.pdf

17. **MtBE Contamination in Lake Tawakoni from Gasoline Pipeline Rupture**: This is the executive summary of a very large gasoline spill in Texas in 2000. It focuses on the MTBE contamination from the spill.
http://www.sra.dst.tx.us/srwmp/special_reports/lake_tawakoni_gasoline_spill/MtBEReportExecutiveSummary.pdf#search=%22Sabine%20River%20Authority%20of%20Texas%20Summary%20Report%22

18. **In Situ Remediation Technology Status Report: Cosolvents**: This document describes the development and application of in situ solvent enhancement as a technology to remove contaminants from soils and ground water at waste disposal and spill sites. The activities described include research, demonstrations, and field applications of the technology.
http://www.epa.gov/tio/download/remed/cosolv.pdf#search=%22%22In%20Situ%20Remediation%20Technology%20Status%20Report%22%22

19. **Safe Home Program – Fact Sheet #7**: The purpose of this fact sheet is to help identify and properly use and dispose of petroleum liquids in the home. It contains practical information and a chart of use, storage, and disposal.
http://mainegov-images.informe.org/dep/blwq/docgw/shp7.pdf#search=%22%22The%20purpose%20of%20this%20fact%20sheet%20is%20to%20help%20you%20identify%20and%20properly%20use%20and%20dispose%22%22

20. **They All Like It Hot: Faster Cleanup of Contaminated Soil and Groundwater**: This is a link to an issue of Science and Technology Review. This method for treating underground contaminants with heat is much faster and more effective than traditional treatment methods.
http://www.llnl.gov/str/pdfs/05_98.pdf#search=%22%22Faster%20Cleanup%20of%20Contaminated%22%22

New York State Learning Standards - Physical Setting: Chemistry

Standard 1: Key Idea 1:
The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

S1.1 Elaborate on basic scientific and personal explanations of natural phenomena, and develop extended visual models and mathematical formulations to represent thinking.
- use theories and/or models to represent and explain observations
- use theories and/or principles to make predictions about natural phenomena
- develop models to explain observations

S1.2 Hone ideas through reasoning, library research, and discussion with others, including experts.
- locate data from published sources to support/defend/explain patterns observed in natural phenomena

STANDARD 2: Key Idea 1:
Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.
Examples include:
- use the Internet as a source to retrieve information for classroom use, e.g., Periodic Table, acid rain

Standard 4: Major Understandings

3.1ff Organic compounds contain carbon atoms, which bond to one another in chains, rings, and networks to form a variety of structures. Organic compounds can be named using the IUPAC system.

3.1gg Hydrocarbons are compounds that contain only carbon and hydrogen. Saturated hydrocarbons contain only single carbon-carbon bonds. Unsaturated hydrocarbons contain at least one multiple carbon-carbon bond.

3.1hh Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are categories of organic compounds that differ in their structures. Functional groups impart distinctive physical and chemical properties to organic compounds.

5.2n Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.

3.1nn Differences in properties such as density, particle size, molecular polarity, boiling and freezing points, and solubility permit physical separation of the components of the mixture.

3.1oo A solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent.

3.1pp The concentration of a solution may be expressed in molarity (M), percent by volume, percent by mass, or parts per million (ppm).

It's Organic; How Can That Be a Problem?

Part 1:

Organic solvents encountered in many common activities can pose a risk to our health. This can occur at home, at work, during recreational activities, or even at school. Understanding organic chemistry and molecular polarity can help us to avoid this risk. In this activity your group will relate the events in a real-world scenario to the chemistry and risks of solvents. Your work starts with reading a newspaper article from the Lakeville Chronicle:

Local Businessman Rushed to Hospital

WORKPLACE FALL CAUSES MINOR INJURIES

BY ELAINE COOK
Lakeville Chronicle Staff Reporter

Yesterday Jack Castle, owner and operator of New Castle Collision and Service in Lakeville was rushed to Westside Hospital with multiple injuries that resulted from a fall. The fall occurred while he was working with contractors on the expansion of the service center at his popular automotive facility. Mr. Castle was diagnosed to have a mild concussion and minor abrasions from the fall. Passer-bys, Joan Restin and her daughter, Britney said they saw Mr. Castle walking erratically, then stumble and fall as he returned to the construction site from his collision shop. Ms. Restin is quoted as saying, "He looked as though he'd had way too much to drink." Blood tests at Westside determined that Mr. Castle had elevated levels of several organic solvents but the tests did not find blood alcohol. Mr. Castle's doctors are working to find the cause of the solvent exposure. The three contract workers from the construction site were also tested for solvents. All three were found to have concentrations of various octane isomers, benzene, and MTBE (methyl tertiary butyl ether) above the threshold limit values. These solvents are typically found in gasoline. Daylight Environmental Services of Pottstown has been hired to test the soil at the New Castle construction site.

Questions

1. Define the term, solvent.

2. Ethanol is a solvent found in most gasoline. Use a resource to find four other solvents used in automotive products and/or services. Make a list of the names and the molecular formulas of these five organic solvents. Have your instructor check your list.

3. At first, it was thought that Jack Castle was drunk. What is the human blood-alcohol level for an individual to be considered legally impaired or "under the influence"?

4. Define: Threshold Limit Value

5. Use material data safety sheets (MSDS) to determine the TLV (threshold limit value) for ethanol and the four other solvents in your response to Key Question 2. Record the solvents and TLVs.

6. Convert the U.S. legal blood alcohol level to parts per million. Compare this value to the TLV for ethanol. Which unit is best to express this value? Explain.

7. Draw the structural formulas for each of the solvents listed in your table. Have your instructor check your 5 structural formulas.

8. Compare the chemical information about the compounds available from the molecular formulas of the solvents to the chemical information available from the structural formulas of the solvents.

9. What factors determine the molecular polarity of solvent molecules?

Part 2: Solvent Molecule Models

Why?

A solvent's ability to dissolve a given solute is dependent in large part on the molecular polarity of the solvent molecules. Building and analyzing molecular models will help you better understand solvents.

Success criteria

- Relate molecular bonding and shape to molecular polarity and intermolecular forces
- Distinguish among various organic solvents in terms of molecular structure

Prerequisites

Bonding concepts, basic knowledge of organic chemical structures, experience with molecular models

Resources

Chemistry textbook, Reference Tables for Physical Setting Chemistry (from NYSED), other chemistry reference tables and books (e.g., CRC Handbook of Chemistry and Physics), molecular modeling kits

Concepts

Organic solvent molecules: molecular structure and polarity, dissolving, toxic exposure and effects

Molecule Models

1. Obtain two organic molecular model kits for your group.

2. Working in pairs, construct a model of one molecule of each solvent listed in the table you made for question 2 in Part 1. The other pair of students in your group should model the same solvent as you and your partner.

3. For each model, compare your model to the model made by the other pair of students in your group.

4. Have your instructor check each solvent molecule model your group constructed. Answer Key Question 1 for each model.

Key Questions

1. Write a description of the molecular geometry of each solvent molecule. Once you have completed the description of the model, build the next solvent molecular model.

Answer questions 2 and 3 only when your group has completed all the models of the solvents in your list.

2. Based on the atoms in the molecule and the molecular geometry, determine the relative polarity of the solvents. List the solvent names in rank order from the solvent with the least polar molecules to the solvent with the most polar molecules.

Least Polar _____ Most Polar

---

3. Which solvents in your list are soluble in water? Explain why these solvents are soluble in water in terms of molecular polarity.

Exercises

1. Solvents often easily evaporate due to a high vapor pressure.
   Define: vapor pressure and describe how vapor pressure relates to molecular polarity.

2. Compare the vapor pressures of water, benzene, hexane, ethanol, acetone, and acetic acid (at 25^{o}C). Vapor pressure values can be found in a reference document available from your instructor or in other reference books.

3. Research routes of toxic exposure and explain how the vapor pressure of a solvent can be a factor in exposure to toxic substances.

Problems

1. In what ways can exposure to a polar solvent be more of a health risk than exposure to a nonpolar solvent?

2. In what ways can exposure to a nonpolar solvent be more of a health risk than exposure to a polar solvent?

3. Research solvent exposure and predict the cause of Mr. Castle's stumbling that resulted in his fall. Cite evidence from a reliable source to support your prediction.

Part 3:

Read this second newspaper article to find out more about the environmental health science issue in Lakeville.

New Castle Site Soil Test Finds Gasoline

STORAGE TANK LEAK SUPECTED

BY ELAINE BURNS
Lakeville Chronicle Staff Reporter

The results of the soil testing by Daylight Environmental Services showed moderate levels of solvents in the soil. A leak from the gasoline storage tanks at New Castle Collision and Service is suspected. Further tests will be conducted to determine the extent of the soil contamination. A compound will be added to the gasoline storage tanks that will show if there is a leak or if the contamination is a result of another source. Gasoline storage tank leaks are an all too common source of solvent exposure. Exposure to solvents from gasoline in soil is especially harmful to children. Parents are cautioned to keep their children away from the New Castle site.

Questions

1. Gasoline leaking into the soil will be closer to the surface after a period of heavy rain. Explain this statement citing information from a resource on gasoline spills and leaks?

2. Determine the two most harmful routes of human exposure to the solvents in gasoline.

3. What is the route of exposure to solvents in gasoline that has leaked into groundwater?

4. If the solvent contamination at New Castle Collision and Service is not only from gasoline, what might be another source of the solvent contamination? Explain.

5. Start a three-column table of the solvents listed in Key Question 2 of Part 1. In the first column record the solvent name, in the second column list the toxic effects of each solvent. Include the affected organs and/or tissues in the body.

6. Define: LD_{50}

7. Label the third column of your table; LD_{50}. In this column of your table, record the LD_{50} for each solvent.

8. Which solvent in your table is most lethal?

9. Explain why the exposure to gasoline is a greater risk for children than adults.

10. Indicate any solvents that are considered to be carcinogenic.

11. Describe one other example of a toxic solvent exposure scenario that is different than what happened to Mr. Castle and the construction workers in Lakeville.

Part 4: Group Presentation

1. Preparation

Using an Internet search and/or print media, find four examples of processes used to decontaminate sites where a solvent leak or spill has occurred. List the sites and describe the decontamination process.

2. Presentation

Propose a course of action to decontaminate the New Castle Collision and Service site. Include the qualifications of the company to be hired for the job, the method the company should use, and indicate the highest acceptable concentrations that should be found in soil and groundwater after the decontamination. Prepare a presentation of your decontamination plan to the class. Use the rubric provided by your instructor to guide you as you work.

Name _____ Date _____

It's Organic; How Can That Be a Problem?

New Castle Site Decontamination Presentation Rubric

For this presentation, you were asked to develop a plan to decontaminate the New Castle site, using the concepts developed in this activity. As you prepare your presentation, use the four criteria listed below as guidelines. Your performance will be evaluated according to these standards. Your instructor may also ask you to evaluate the presentation of other students in your class.

Guidelines	Instructor's Comments	Score
Concerns and opinions addressed Benefits, drawbacks, problems, common misconceptions and incorrect ideas with solvent spill decontamination are addressed in an objective, unbiased manner.		/(20)
Quality of information The scientific content included in the presentation is informative and correct and addresses the types of solvents, the consequences of solvent exposure, and removal of the solvents using specific scientific terminology.		/(30)
Proof of evidence All claims made in presentation are supported by multiple credible sources. Claims are reasonably and logically made from information obtained from multiple credible sources		/(30)
Presentation The article is well-organized, visually appealing, and confidently presented.		/(20)
Total (100 points possible)		