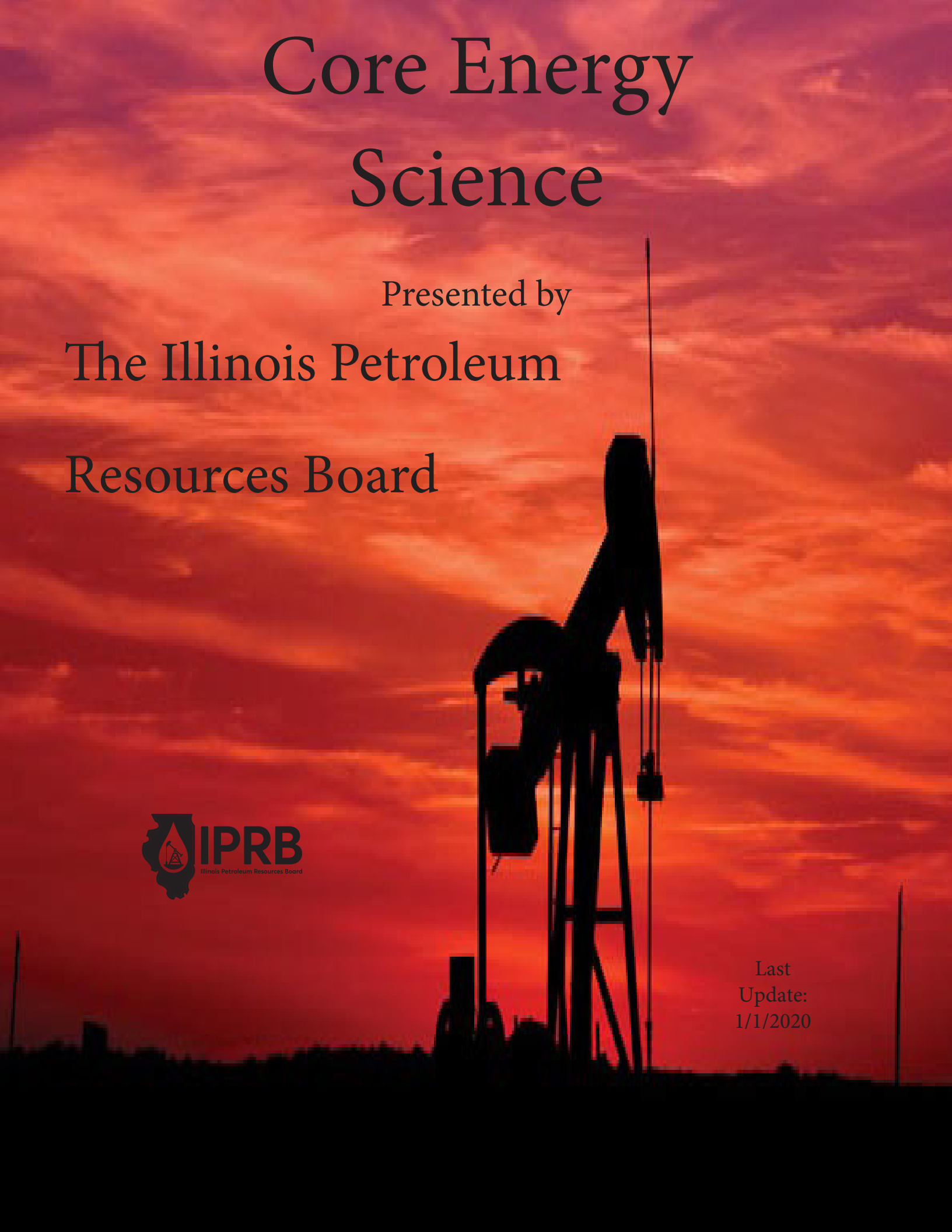
Core Energy Science

Presented by

The Illinois Petroleum Resources Board



IPRB
Illinois Petroleum Resources Board

Last Update: 1/1/2020

The Carbon Connection
Pretest

Name: _____ Class: _____

(Multiple Choice)

1. Gasoline and natural gas are a mixture of:
    a. compounds which contain oxygen and nitrogen
    b. compounds which contain carbon and hydrogen
    c. compounds which contain oxygen and carbon
    d. compounds which contain hydrogen and nitrogen

2. Octane has the molecular formula:
    a. C_8H_8
    b. C_8H_{10}
    c. C_2H_8
    d. C_8H_{18}

3. At room temperature (25° Celsius), the smallest alkanes such as methane, ethane, propane, and butane are:
    a. solids
    b. liquids
    c. gases

4. Structural formulas have advantages over molecular formulas because structural formulas show the:
    a. 2-dimensional arrangement of atoms in the molecule
    b. number of atoms of each element present
    c. percentage composition of the compounds
    d. 3-dimensional geometry of the molecule

5. What is the relationship between the number of carbon atoms and the number of hydrogen atoms in an alkane molecule?
    a. $C_{2n}H_{2n}$
    b. C_nH_{2n+2}
    c. C_nH_n
    d. cannot be predicted

The Carbon Connection

Common Core State Standards

Literacy in Science and Technical Subjects

Key Ideas and Details (Grades 9-10)
1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure (Grades 9-10)
4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

Integration of Knowledge and Ideas (Grades 9-10)
7: Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

8: Assess the extent to which the reasoning and evidence in a text support the author's claims.

Key Ideas and Details (Grades 11-12)
1: Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.

Craft and Structure (Grades 11-12)
4: Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).

5: Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.

Integration of Knowledge and Ideas (Grades 11-12)
7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

8: Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.

9: Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.

Writing Standards Literacy in Science and Technical Subjects

Text Types and Purposes (Grades 9-10)

1: Write arguments focused on discipline-specific content.

a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

d.Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

e. Provide a concluding statement or section that follows from or supports the argument presented.

2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing (Grades 9-10)

4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Research to Build and Present Knowledge (Grades 9-10)

7: Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation

8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

Text Types and Purposes (Grades 11-12)

1: Write arguments focused on discipline-specific content.

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d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

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Research to Build and Present Knowledge (Grades 11-12)

9: Draw evidence from informational texts to support analysis, reflection, and research.

The Carbon Connection

Next Generation Science Standards

Physical Science and Chemistry

Matter and its Interactions

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Illinois State Science Standards; High School & Middle School

STATE GOAL 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

MIDDLE/JUNIOR HIGH SCHOOL
11. A.3c Collect and record data accurately using consistent measuring and recording techniques and media.
11. A.3e Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.
11.A.3f Interpret and represent results of analysis to produce findings.
11.A.3g Report and display the process and results of a scientific investigation.

EARLY HIGH SCHOOL
11.A.4c Collect, organize and analyze data accurately and precisely.
11.A.4d Apply statistical methods to the data to reach and support conclusions.
11.A.4f Using available technology, report, display and defend to an audience conclusions drawn from investigations.

STATE GOAL 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

MIDDLE/JUNIOR HIGH SCHOOL
12.C.3b Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).

EARLY HIGH SCHOOL
12.C.4b Analyze and explain the atomic and nuclear structure of matter.

LATE HIGH SCHOOL
12.C.5b Analyze the properties of materials (e.g., mass, boiling point, melting point, hardness) in relation to their physical and/or chemical structures.

Resources:

Illinois Learning Standards for Science, Illinois State Board of Education, 1997

The Big Lift
Pretest

Name: _____ Class: _____

(Multiple Choice)

1. The study of fluids in motion is called:
   a. hydrophysics
   b. fluid dynamics
   c. viscosity
   d. acceleration

2. Drilling mud is circulated into the well bore as it is being drilled to:
   a. lift rock cuttings from the well bore to the surface
   b. cool the drill bit
   c. reveal oil sand from the reservoir when the final depth of the well is reached
   d. all of the above

3. The fluid that is pumped from the oil formation to the surface is called:
   a. crude oil
   b. sludge
   c. water
   d. shale

4. As the depth of an oil well increases, the oil flow rate at the surface will likely:
   a. increase
   b. decrease
   c. remain unchanged
   d. stop

5. The pressure exerted by a column of fluid is called:
   a. density
   b. weight
   c. hydrostatic head
   d. none of the above

The Big Lift

Common Core State Standards

Reading Standards for Literacy in Science and Technical Subjects

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4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas (Grades 9-10)
7: Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

8: Assess the extent to which the reasoning and evidence in a text support the author's claims.

9: Compare and contrast treatments of the same topic in several primary and secondary sources.

Key Ideas and Details (Grades 11-12)
1: Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.

3: Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.

Craft and Structure (Grades 11-12)
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Writing Standards Literacy in Science and Technical Subjects

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d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

e. Provide a concluding statement or section that follows from or supports the argument presented.

2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

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9: Draw evidence from informational texts to support analysis, reflection, and research.

The Big Lift

Next Generation Science Standards
Environmental Science
Earth and Human Activity

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

The Big Lift
Illinois State Science Standards; High School & Middle School

STATE GOAL 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

MIDDLE/JUNIOR HIGH SCHOOL
11.A.3a Formulate hypotheses that can be tested by collecting data.
11.A.3b Conduct scientific experiments that control all but one variable.
11. A.3c Collect and record data accurately using consistent measuring and recording techniques and media.
11. A.3e Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.
11.A.3f Interpret and represent results of analysis to produce findings.
11.A.3g Report and display the process and results of a scientific investigation.

EARLY HIGH SCHOOL
11.A.4a Formulate hypotheses referencing prior research and knowledge.
11. A.4b Conduct controlled experiments or simulations to test hypotheses.
11.A.4c Collect, organize and analyze data accurately and precisely.
11.A.4d Apply statistical methods to the data to reach and support conclusions.
11.A.4f Using available technology, report, display and defend to an audience conclusions drawn from investigations.

LATE HIGH SCHOOL
11.A.5a Formulate hypotheses referencing prior research and knowledge.
11.A.5c Conduct systematic controlled experiments to test the selected hypotheses.
11.A.5e Report, display and defend the results of investigations to audiences that may include professionals and technical experts.

STATE GOAL 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

MIDDLE/JUNIOR HIGH SCHOOL
12.C.3a Explain interactions of energy with matter including changes of state and conservation of mass and energy.
12.C.3b Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).
12.D.3a Explain and demonstrate how forces affect motion(e.g., action/reaction, equilibrium conditions, free-falling objects).

EARLY HIGH SCHOOL
12.C. 4a Use kinetic theory, wave theory, quantum theory and the laws of thermodynamics to explain energy transformations.
12.D.4a Explain and predict motions in inertial and accelerated frames of reference.

LATE HIGH SCHOOL
12.D.5a Analyze factors that influence the relative motion of an object (e.g., friction, wind shear, cross currents, potential differences).
12.D.5b Analyze the effects of gravitational , electromagnetic and nuclear forces on a physical system.
Resources:
Illinois Learning Standards for Science, Illinois State Board of Education, 1997.

Let It Flow
Pretest

Name:_____ Class: _____

(Multiple Choice)

1. The method used most to transport oil and natural gas is:
   a. railroads
   b. tanker trucks
   c. airplanes
   d. pipelines

2. The flow rate of oil is affected by:
   a. length of the pipe
   b. viscosity of the oil
   c. diameter of the pipe
   d. all of the above

3. What effect does the diameter of a pipe have on the amount of a fluid that can be pumped through that pipe?
   a. As the diameter of a pipe is increased, the flow rate stays the same.
   b. As the diameter of a pipe is increased, the flow rate increases.
   c. As the diameter of a pipe is increased, the flow rate decreases.
   d. As the diameter of a pipe is increased, the flow rate stops.

4. What effect does the length of a pipe have on the flow rate of a fluid through that pipe?
   a. As the length of the pipe is increased, the flow rate increases.
   b. As the length of the pipe is increased, the flow rate decreases.
   c. As the length of the pipe is increased, the flow rate stays the same.
   d. As the length of the pipe is decreased, the flow rate decreases.

5. What factor causes the change in the flow rate as the length of the pipe is increased?
   a. friction between the tube and the fluid
   b. the fluid's density decreases
   c. the fluid's temperature decreases
   d. none of the above

Let It Flow

Common Core State Standards

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Writing Standards Literacy in Science and Technical Subjects

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Let It Flow

Investigating the flow rate of a fluid
Class time needed: 75-100 minutes

Next Generation Science Standards

Physical Science

Matter and its Interactions

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Environmental Science

Earth and Human Activity

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

Purpose/Objective:

- Investigate the relationship between pipe length and flow rate.
- Investigate the relationship between pipe diameter and flow rate.

Let It Flow
Illinois State Science Standards, High School & Middle School
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EARLY HIGH SCHOOL
11.A.4a Formulate hypotheses referencing prior research and knowledge.
11. A.4b Conduct controlled experiments or simulations to test hypotheses.
11.A.4c Collect, organize and analyze data accurately and precisely.
11.A.4d Apply statistical methods to the data to reach and support conclusions.
11.A.4f Using available technology, report, display and defend to an audience conclusions drawn from investigations.

LATE HIGH SCHOOL
11.A.5a Formulate hypotheses referencing prior research and knowledge.
11.A.5b Design procedures to test the selected hypotheses.
11.A. 5c Conduct systematic controlled experiments to test the selected hypotheses.

11.A.5d Apply statistical methods to make predictions and to test the accuracy of results.
11.A.5e Report, display and defend the results of investigations to audiences that may include professionals and technical experts.

STATE GOAL 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

MIDDLE/JUNIOR HIGH SCHOOL
12.C.3a Explain interactions of energy with matter including changes of state and conservation of mass and energy.
12.C.3b Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).
12.D.3a Explain and demonstrate how forces affect motion(e.g., action/reaction, equilibrium conditions, free-falling objects).

EARLY HIGH SCHOOL
12.C. 4A Use kinetic theory, wave theory, quantum theory and the laws of thermodynamics to explain energy transformations.
12.D.4a Explain and predict motions in inertial and accelerated frames of reference.

LATE HIGH SCHOOL
12.D.5a Analyze factors that influence the relative motion of an object (e.g., friction, wind shear, cross currents, potential differences).
12.D.5b Analyze the effects of gravitational, electromagnetic and nuclear forces on a physical system.

Resources:
Illinois Learning Standards for Science, Illinois State Board of Education, 1997.

Introduction:

One might ask, "Why should we want to know about flow rate and of what importance is flow rate to the petroleum industry?"

One reason flow rate is important is that a main objective of the petroleum industry is to move petroleum products from place to place. Crude oil and natural gas are moved from production sites to refineries. Much of this distribution is accomplished by pumping fluid from reservoir rock and then through pipelines to refineries and storage facilities. From the refinery, products such as heating oil and gasoline are distributed to the various consumers around the world.
A complete understanding of what happens to fluids when they are forced through pipelines is of utmost importance to those in the petroleum industry. The efficiency with which we are able to move these vital fluids affects not only the availability of them to the consumer, it also (and possibly more importantly) affects the price. In this activity, you will examine the effect of the length and diameter of vinyl tubing on the flow rate of water.

From Crude to Refined
Pretest

Name:_____Class:_____

(Multiple Choice)

1. Crude oil is:
   a. petroleum in its natural liquid form
   b. a hydrocarbon containing only single covalent bonds
   c. mainly composed of propane and butane which are compressed and liquefied
   d. gasoline

2. Before crude oil can be used commercially it is:
   a. separated
   b. heated
   c. refined
   d. all of the above

3. The principle of fractional distillation depends on:
   a. freezing point
   b. dew point
   c. boiling point
   d. density

4. During distillation, which molecules vaporize first?
   a. molecules with strong forces between the molecules
   b. molecules with the highest boiling points
   c. molecules with the highest freezing points
   d. molecules with the lowest boiling points

5. In the distillation of crude oil, where are the molecules with the higher boiling points located in the fractionating tower?
   a. near the top of the fractionation column
   b. near the bottom of the fractionation column
   c. near the middle of the fractionation column
   d. all of the above

6. What is the relationship between boiling point and the molecular mass of the hydrocarbon?
   a. a hydrocarbon with a large molecular mass has a higher boiling point
   b. a hydrocarbon with a large molecular mass has a lower boiling point
   c. a hydrocarbon with a small molecular mass boils at a higher temperature
   d. the boiling points of the hydrocarbons are not related to the molecular masses

From Crude to Refined

Common Core State Standards

Literacy in Science and Technical Subjects

Key Ideas and Details (Grades 9-10)
1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure (Grades 9-10)
4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas (Grades 9-10)
7: Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.

8: Assess the extent to which the reasoning and evidence in a text support the author's claims.

9: Compare and contrast treatments of the same topic in several primary and secondary sources.

Key Ideas and Details (Grades 11-12)
1: Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.

2: Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.

3: Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.

Craft and Structure (Grades 11-12)
4: Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).

5: Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.

6: Evaluate authors' differing points of view on the same historical event or issue by assessing the authors' claims, reasoning, and evidence.

Integration of Knowledge and Ideas (Grades 11-12)
7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

8: Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.

9: Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.

Writing Standards Literacy in Science and Technical Subjects

Text Types and Purposes (Grades 9-10)
1: Write arguments focused on discipline-specific content.

a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

e. Provide a concluding statement or section that follows from or supports the argument presented.

2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing (Grades 9-10)
4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Research to Build and Present Knowledge (Grades 9-10)
7: Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

9: Draw evidence from informational texts to support analysis, reflection, and research.

Text Types and Purposes (Grades 11-12)
1: Write arguments focused on discipline-specific content.

a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

e. Provide a concluding statement or section that follows from or supports the argument presented.

2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

Production and Distribution of Writing (Grades 11-12)

4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge (Grades 11-12)

7: Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

9: Draw evidence from informational texts to support analysis, reflection, and research.

From Crude to Refined

Next Generation Science Standards

Physical Science and Chemistry

Matter and its Interactions

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Motion and Stability: Forces and Interactions

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

Energy

HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)

From Crude to Refined

From Crude to Refined
Illinois State Science Standards

STATE GOAL 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

MIDDLE/JUNIOR HIGH SCHOOL
11.A.3a Formulate hypotheses that can be tested by collecting data.
11.A.3b Conduct scientific experiments that control all but one variable.
11. A.3c Collect and record data accurately using consistent measuring and recording techniques and media.
11. A.3e Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.
11.A.3f Interpret and represent results of analysis to produce findings.
11.A.3g Report and display the process and results of a scientific investigation.

EARLY HIGH SCHOOL
11.A.4a Formulate hypotheses referencing prior research and knowledge.
11. A.4b Conduct controlled experiments or simulations to test hypotheses.
11.A.4c Collect, organize and analyze data accurately and precisely.
11.A.4d Apply statistical methods to the data to reach and support conclusions.
11.A.4f Using available technology, report, display and defend to an audience conclusions drawn from investigations.

STATE GOAL 12: Understand the fundamental concepts, principles and interconnections of the life, physical and earth/space sciences.

MIDDLE/JUNIOR HIGH SCHOOL
12.C.3a Explain interactions of energy with matter including changes of state and conservation of mass and energy.
12.C.3b Model and describe the chemical and physical characteristics of matter (e.g., atoms, molecules, elements, compounds, mixtures).

EARLY HIGH SCHOOL
12.C. 4A Use kinetic theory, wave theory, quantum theory and the laws of thermodynamics to explain energy transformations.
12.C.4b Analyze and explain the atomic and nuclear structure of matter.

LATE HIGH SCHOOL
12.C.5a Analyze reactions(e.g., nuclear reactions, burning of fuel, decomposition of waste) in natural and man-made energy systems.
12.C.5b Analyze the properties of materials (e.g., mass, boiling point, melting point, hardness) in relation to their physical and/or chemical structures.

Resources:
Illinois Learning Standards for Science, Illinois State Board of Education, 1997.

Bubbling Up Crude

Next Generation Science Standards

Life Science

From Molecules to Organisms: Structure and Processes

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

HS-LS-4 Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Earth and Space Sciences

Earth's Systems

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, an biosphere.

Earth and Human Activity

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

Bubbling Up Crude

Investigating methods of oil recovery

Class-time needed: Two class periods

Purpose/Objectives:

- Introduce students to the methods of oil recovery
- Investigate secondary and tertiary methods of oil recovery
- Explore the process of cellular respiration in the production of carbon dioxide, CO_2.

Background Information:

Crude oil production from reservoirs across the United States can include three distinct phases: primary, secondary, and tertiary (or enhanced) oil recovery. Crude oil, natural gas, and water are under extreme pressure deep underground in geological formations. **Primary recovery** occurs when wells are drilled into a geological formation and the natural pressure of the reservoir drives the fluids into the wellbore. Only about 10% to 20% of a reservoir's crude oil is produced during primary recovery. **Secondary recovery** techniques can extend a reservoir's productive life. One secondary recovery technique involves injecting fluids into the reservoir to increase the pressure and to displace the crude oil towards the wellbore. When the fluid injected into the productive zone of the reservoir is water, the technique is called water flooding. Since water and oil do not mix, water flooding removes only an additional 10% to 20% of the crude oil from the pore spaces of the rock formation. Secondary recovery can also take place with artifical lifting systems, or pumping units, which are used to help pull the oil of the reservoir rock and pump it up the well.

Much of the easy-to-produce oil has already been recovered from reservoirs in the United States. Scientists and engineers continue to research, develop, and test **tertiary, or enhanced oil recovery (EOR)**, techniques to increase oil production. Three major categories of EOR that have been found to be commercially successful are chemical injection, thermal recovery (or steam flooding), and miscible displacement (or gas injection) using carbon dioxide. Carbon dioxide and crude oil are miscible. Carbon dioxide is absorbed by the oil droplets, causing the oil droplets to expand thus reducing the tension that locked them in the pore spaces of the reservoir. Today, most of the carbon dioxide enhanced oil recovery (CO_2 – EOR) operations use carbon dioxide from natural underground domes. Additionally, man-made CO_2 captured from the emissions of power plants and industrial facilities such as fertilizer and steel plants can be used to boost oil production.

In this activity, students will build a model of an oil reservoir and collect some of the oil using the secondary oil recovery process of waterflooding. Next, students will build a carbon dioxide generating facility using biological technology and the tertiary oil recovery process called microbial enhanced oil recovery (MEOR), where the carbon dioxide produced by microorganisms is utilized for the collection of oil that remains in the oil reservoir.

Vocabulary:

Adenosine triphosphate (ATP) – a compound consisting of an adenosine molecule bonded to three phosphate groups, present in all living tissues. Considered by biologists to be the energy currency of life.

Aerobic – organism that requires air or free oxygen (O_2) for life

Anerobic – organism living without air or free oxygen (O_2)

Carbon dioxide – CO_2 - a colorless, odorless, incombustible gas, present in the atmosphere and formed during respiration

Cellular respiration – the process of oxidizing food molecules, like glucose, to carbon dioxide, water, and ATP

Enhanced oil recovery – tertiary oil recovery

Facultative aerobe – organisms that can grow with or without oxygen (O_2) because they can metabolize energy aerobically or anaerobically.

MEOR – microbial enhanced oil recovery; a process of tertiary recovery using microorganisms to extract crude oil from reservoirs

Microorganisms – organisms that can be seen only by using a microscope

Miscible – capable of mixing

Primary recovery – uses natural pressure of the reservoir to push crude oil to the surface

Secondary recovery – injects pressurized gas and water to drive the residual crude oil and gas remaining after the primary oil recovery phase to the surface wells. Artifical lift systems, or pumping units, are also considered a form (or type) of secondary recovery.

Reservoir – a place where fluid collects, especially in rock strata

Tertiary recovery – injects different materials to improve the flow between oil, gas and rock, and to recover crude oil remaining after the primary and secondary recovery

Wellbore – a hole that is drilled to aid in the exploration and recovery of natural resources; the actual hole that forms the well

Yeast – single-celled fungi

Engage

Introduction:

Billions of barrels of oil are trapped in the pore spaces in the oil reservoirs of the United States. Petroleum engineers continue to design methods to recover this trapped oil.

Materials:

- The Phases of Oil Recovery video at https://iprb.org/education/classroom-curriculum/references/ (Provided by the Energy & Environmental Research Center)

Procedure:

1. Introduce the unit by showing the video, The Phases of Oil Recovery video.

2. Discuss the similarities and differences among primary, secondary, and tertiary oil recovery methods.