Rate of Reactions – Fueling a Decision!

Science, Grade 12, Chemistry SCH4U

Overview

In this lesson students think about the issues surrounding the use of alternative fuel sources for vehicles. They consider the issues from the perspective of the consumer and extend their thinking to the societal and environmental implications of alternative fuel sources currently used to power some vehicles.

Students consider the energy available from the combustion of propane and ethanol and the factors involved in selecting an alternative fuel for their cars as informed consumers, who consider issues such as the vehicle's impact on the environment [Environment in STSE] and the personal financial costs [Society in STSE].

Connections to Financial Literacy

Although the use of the internal combustion engine is convenient and affordable, internal combustion engines are raising issues with our environment. Consumers must consider whether costly alternative fuels are worth using. Balancing the consumer's desire for easily available fossil fuels with a deeper understanding of the environmental implications goes beyond the consumer. However, students as consumers need to understand that the 'power of one' can make change happen.

Connections to Curriculum

Connections are made to the scientific investigation skills related to drawing conclusions and communicating ideas in writing. The content focus is on the strand: *Energy Changes and Rates of Reaction*, specifically analysing some conventional and alternative energy technologies.

The curriculum expectations addressed in each lesson are identified within the lesson plan. The curriculum expectations, including examples and other supporting information, can be accessed through a hyperlink within the lesson.

Considerations for Planning

This lesson extends over three periods.

It may be appropriate to introduce the commodities market because oil, refined gasoline, ethanol and propane are all commodities.Their prices fluctuate with supply and demand, similar to shares in a stock market. Students may have a better understanding of comparing fuel prices with a basic understanding of how they are priced, bought and sold. The CME Group, one of the largest commodity groups, provides an education section on their website, **www.cmegroup.com**

Introducing a break-even analysis might be a beneficial exercise for students. "What would the price of oil have to be to make an alternative fuel such as ethanol or propane an economically equal or better alternative?"

A growing complaint about alternative fuels such as ethanol is the amount of energy required to produce it. For example in the production of ethanol, combines are used to harvest corn and additional energy is required to convert the corn to ethanol. It may be beneficial to discuss this as a counterpoint to views on alternative fuel options.

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Fueling a Decision! Lesson

In this lesson students think about the issues surrounding the use of alternative fuel sources for vehicles. They consider the issues from the perspective of the consumer and extend their thinking to the societal and environmental implications of alternative fuel sources currently used to power some vehicles. Students consider the energy available from the combustion of propane and ethanol. They calculate the exothermic value using Hess's law of heat summation to speculate on the best fuel, given the current technology of the combustion engine to power a car.

Students consider the energy available from the combustion of propane and ethanol and the factors involved in selecting an alternative fuel for their cars as informed consumers, who consider issues such as its impact on the environment [Environment in STSE] and the costs on a personal level [Society in STSE].

Connections to Financial Literacy

The cost of keeping our current form of transportation (combustion engine technology), because it is convenient and affordable, is raising issues concerning the environment. Alternative fuels are costly but are they worth it? Understanding needs and wants (availability of fossil fuel) versus environmental implications goes beyond the consumer. However, students need to understand, as consumers, the 'power of one' is how change is made to happen.

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Curriculum Expectations

Click here to access expectations in full, with examples.

A. Scientific Investigation Skills and Career Exploration

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating)

- **A1.10** draw conclusions based on inquiry results and research findings for logic, accuracy, reliability, adequacy and bias
- **A1.11** communicate ideas, plans, procedures, results and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats

D. Energy Changes and Rates of Reaction

D1. analyse technologies and chemical processes that are based on energy changes, and evaluate them in terms of their efficiency and their effects on the environment

- **D1.1** analyse some conventional and alternative energy technologies and evaluate them in terms of their efficiency and impact on the environment. [AI, C]

D2. investigate and analyse energy changes and rates of reaction in physical and chemical processes, and solve related problems

- **D2.1** use appropriate terminology related to energy changes and rate of reaction, including but not limited to: enthalpy, activation energy, endothermic, exothermic, potential energy, and specific heat capacity [C]
- **D2.5** solve problems related to energy changes in a chemical reaction, using Hess's law [AI]

D3. demonstrate an understanding of energy changes and rates of reaction

- **D3.7** explain with reference to a simple chemical reaction (e.g., combustion) how the rate of reaction is determined by the series of elementary steps that make up the overall reaction mechanism

Learning Goals

Students will:

- explain the factors involved in making informed decisions about the use of gasoline or alternative fuels (e.g., ethanol and propane).
- explain one aspect (e.g., transportation costs) of the "cost of living" they will face in the future.

Sample Success Criterion

I can make informed decisions about wise use of fuels after comparing alternative fuels to gasoline.

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Considerations for Planning

Readiness

Students need to know:

- Combustion reactions for hydrocarbons as they apply to the burning of fuels (which impacts on the quantity and cost of fuel)
- The meaning of enthalpy
- How to apply Hess's law in order to solve problems related to energy changes
- How to construct a (fishbone) graphic organizer
- How to research and select facts to use for decision making (judgment)
- How to write an expository report

Terminology

- Consumer awareness
- Enthalpy changes – exothermic and endothermic
- Balanced thermochemical equation
- Hess's law (calculations for heat of reaction)
- Enthalpy of formation

Materials

- Handout: **Consumer Awareness Thinking**
- Handout: **Sample Six-sided Cube Structure Questions**

Further Considerations

This lesson extends over three periods. It starts from knowledge of Hess's law of summation of heat. The *Minds On!* and *Action* part of the lesson may take one period while the consolidation will take place over two periods, during which students produce an opinion piece for assessment of learning, as a culminating performance task.

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Minds On

Whole Class/Individual/Pairs → Problem Solving

Review problem-solving steps used to determine the enthalpy change of reactions.

Individually, students solve the problem: How ethene reacts with water to produce ethanol.

Using Think/Pair/Share, they determine whether the solution is correct.

As a class, determine the enthalpy of the combustion of ethanol, propane and gasoline for comparison, using the appropriate problem-solving steps.

Connections

Action!

Whole Class/Small Groups → Establishing Research Questions

Students observe three images (visual or descriptive) that relate to gasoline or alternative fuels, (e.g., a corn field, a car with visible exhaust coming from the muffler and a bag of cornmeal or bottle of corn syrup.) They brainstorm the connections among all three images in small (table or lab) triad groups.

In a whole class discussion, collect ideas. The discussion leads to the use of ethanol (and propane) as alternative fuels to gasoline.

Students use a K-W-L chart to summarize the class discussion by responding to the question: "Should you, as an informed consumer, use ethanol (or propane) instead of gasoline, as a fuel to power cars?"

Present the concept of being a wise and environmentally informed consumer and guide the discussion, using Consumer Awareness Thinking handout as student complete the K and W columns of their K-W-L charts.

In their small groups, students discuss their responses and then complete their KWL chart, focusing on the "L" column.

In a whole class discussion, create a collective list that they can research in making an informed decision.

In their small groups, students decide on six criteria (using a Six-sided Cubing structure) and write them into questions using the stem: "As a wise and environmentally informed consumer, I need to know…." (See Handout: Sample Six-sided Cube Structure Questions.) They share their responses in a Gallery Walk (using symbols to score) indicating the preferred six questions to research.

Whole Class → Criteria for Evaluating the Final Product

As a class, determine a set of criteria to be used in creating a rubric for assessment *of* learning based on the final product.

Connections

Tip

Include financial considerations in the discussion: e.g., the use of alternative fuels may prove to be more energy efficient but if it costs four times more to run an ethanol car than a gasoline-powered car, this cost difference may be too prohibitive for some people.

Tip

The **Sample Six-sided Cube Structure Questions** (Handout) could provide a choice within the small group to research by giving each student only two questions to research for the group.

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Consolidation

Small Groups → Sharing, Feedback, Refinement

After the research time, group members pool their found facts and make sure that all six questions have an answer. The groups exchange information, analyse the research for completeness, and offer some guiding feedback. Then, the small groups "refine' their research.

Individual → Organizing the Research

Individually, students use their research and construct a fishbone graphic organizer to organize information before writing a report. The *head* is labelled **Consumer**, the *tail* is **Cost** and the *ribs* (6 -8) are divided into **environmental and societal facts**. They submit the organizer for teacher feedback.

Students reflect on feedback and adjust their organizer, as required. Using critical thinking skills, each student makes a judgment and, as an informed consumer answers the topic question: "Should you, as an informed consumer, use ethanol (or propane) instead of gasoline, as a fuel to power cars?"

Students write an opinion piece (a 250-word expository report), using the co-constructed criteria. The writing is done in class and submitted to the teacher.

Connections

Tip

These activities take place on two separate days for 40 minute each day.

A as L Students reflect on the peer feedback given in the research exchange.

A for L Teacher provides feedback on the fishbone organizer.

A of L Teacher assesses the learning based on the final written report, using the co-constructed rubric.

HANDOUT

Consumer Awareness Thinking

Comparison shopping does not always mean paying the lowest price. It means selecting the product that best suits needs, wants, values and attitude. Values are what one believes is important in life and differs from person to person.

Consider these questions:

- To what extent am I willing to pay more for a vehicle that has a reduced impact on the environment?
- How much can I afford to spend on the use of an alternative fuel in my transportation choice?
- Are there incentive programs that will impact my decisions?
- What does the research say about using alternative fuel to make a difference in the environment in the future? What is your opinion?
- What are the environmental pros and cons of using alternative fuels?
- What additional information do I need to know in order to determine whether the environmental benefits of alternative fuels justify the financial costs?

HANDOUT

Sample Six-sided Cube Structure Questions

(for the Teacher)

Sample questions for a wise and environmentally aware consumer to consider

Compared to using gasoline:

- How much will it cost to run a vehicle on an alternative fuel over a year?
- How available is the alternative fuel in this area?
- What needs to be considered in vehicle maintenance when using an alternative fuel?
- How efficient (energy output) is the alternative fuel in a combustion engine?
- How much pollution is produced in a year by the use of an alternative fuel?
- What societal issues are linked to this alternative fuel? (e.g., propane – safety; ethanol – food)

Curriculum Expectations

Financial Literacy in Science

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Fueling a Decision!

Scientific Investigation Skills and Career Exploration

Overall Expectations	Specific Expectations
A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating	**A1. Scientific Investigation Skills** **Analysing and Interpreting [AI]*** **A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge **Communicating [C]*** **A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

Energy Changes and Rates of Reaction

Overall Expectations	Specific Expectations
D1. analyse technologies and chemical processes that are based on energy changes, and evaluate them in terms of their efficiency and their effects on the environment;	**D1. Relating Science to Technology, Society, and the Environment** **D1.1** analyse some conventional and alternative energy technologies (e.g., fossil fuel–burning power plants, hydro-powered generators, solar panels, wind turbines, fuel cells), and evaluate them in terms of their efficiency and impact on the environment [AI, C] **Sample issue:** The cooling of homes and commercial buildings in summer requires more energy than heating in the winter at peak times. Brownouts are more likely in summer than in winter. However, new technologies use deep lake water cooling as an alternative to conventional air conditioning systems in office towers. This significantly reduces energy use and its environmental impact. **Sample questions:** What proportion of Ontario's energy needs is served by solar and wind technologies? What are the pros and cons of expanding the availability of these technologies? What types of chemical reactions occur in different types of fuel cells? What are the advantages and disadvantages, in terms of efficiency and environmental impact, of using corn to produce ethanol fuel?
D2. investigate and analyse energy changes and rates of reaction in physical and chemical processes, and solve related problems;	**D2. Developing Skills of Investigation and Communication** **D2.** use appropriate terminology related to energy changes and rates of reaction, including, but not limited to: enthalpy, activation energy, endothermic, exothermic, potential energy, and specific heat capacity [C] **D2.5** solve problems related to energy changes in a chemical reaction, using Hess's law [AI]
D3. demonstrate an understanding of energy changes and rates of reaction	**D3. Understanding Basic Concepts** **D3.7** explain, with reference to a simple chemical reaction (e.g., combustion), how the rate of a reaction is determined by the series of elementary steps that make up the overall reaction mechanism

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–F to which the particular area(s) relate (see pp. 20–22 for information on scientific investigation skills).