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SCHOOLGEN ACTIVITIES

CARBON EMISSIONS

Teacher-led Activity

In this activity, the students will calculate the molecular mass of a range of carbon-based fuels and write balanced equations that represent common reactions for combustion of carbon-based fuels. They will calculate the amount of carbon dioxide released when known amounts of carbon-based fuels are burnt. The students will also articulate their views on the value of knowing how to calculate the carbon dioxide emissions from combustion of carbon-based fuels.

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CARBON EMISSIONS

1. INTENDED LEARNING OUTCOMES

The students will be able to:

- Calculate the molecular mass of a range of carbon-based fuels
- Write balanced equations that represent common reactions for combustion of carbon-based fuels
- Calculate the amount of carbon dioxide released when known amounts of carbon-based fuels are burnt
- Articulate their views on the value of knowing how to calculate the carbon dioxide emissions from combustion of carbon-based fuels.

2. WHAT YOU NEED

- Samples of charcoal, petrol, diesel, methanol (a little over 10 ml of each liquid)
- A balance, accurate to 0.01 g
- 5 ml pipette and pipette pump
- Molymod® or similar atomic models (one set per group of 4 students each set needs 8 carbon, 18 hydrogen, 3 oxygen atoms)
- Enough copies of the worksheets **Composition of Carbon-based Fuels** and **Carbon Emissions** for students to work in pairs (these worksheets are at the end of this activity)
- Website access or copies of relevant material downloaded from the internet.

3. FOCUS

- What are carbon emissions?
- Why are many scientists concerned about carbon emission levels?
- How do carbon emissions differ between different fuels?
- Does adding methanol to petrol reduce emissions?
- How are carbon emissions estimated for vehicles?
- Can we estimate carbon emissions from electricity generation?

4. MANAGING THE ACTIVITY

Part A: Density of Various Carbon-based Fuels

(i) Arrange the samples of carbon and carbon compounds and ask the students what they have in common.

(ii) Have the students assist in arranging the samples into two groups – elements and mixtures/compounds. Establish what the major components are of each fuel and molecular formulae of these compounds and write this on the board.

(iii) Calculate the density of each liquid fuel (gL^{-1}). This could be a demonstration using student support, or the students could do the task independently and compare results.

- (a) Place an empty 50 ml beaker on the balance and record its mass (or use the tare function).
- (b) Using the pipette and pump, measure 5 ml of one liquid fuel into the beaker and reweigh.
- (c) Repeat for each liquid fuel.

(iv) Calculate the density of each fuel and write the fuel densities on the board. *density = mass(g)÷volume(L)*

Part B: Demonstration of the Combustion of Liquid Fuels

(i) Demonstrate the combustion of liquid fuels using the following method. (This is a demonstration only – see **7. SAFETY GUIDE** below.)

(a) Use the pipette pump to pipette 5 ml of petrol into a crucible, place it securely on a tripod and ignite the fuel. Cool the crucible and repeat the exercise using methanol and again with diesel.

(b) For each fuel establish if there is any residue after the fuel has been burnt. Also establish which fuels burn cleanly (little soot released).

(ii) Discuss with the students what products could result from each reaction and how this involves applying the "principle of conservation of matter".

Part C: Molecule Modelling

(i) Divide the class into bench groups depending on modelling equipment availability.

(ii) Ask each group to use the atomic models provided to construct models of carbon (element), an octane molecule C_8H_{18}, and then a methanol molecule CH_3OH. Check the student's model before they move onto the next model.

(iii) Ask each group to demonstrate, using the models, what the products of complete combustion of methanol are and then write a balanced equation for this reaction.

Part D: Calculating Carbon Emissions from Combustion of Carbon-based Fuels

Divide the class into pairs to collaborate on completing the task on the work sheets **Composition of Carbon-based Fuels** and **Carbon Emissions**.

5. REFLECTION

Lead a discussion around the following questions:

- What is the relevance of knowing CO_2 emissions to environmental problems?
- Which fuel seems to produce the lowest carbon footprint per kg?
- Which fuel seems to produce the lowest carbon footprint per L?
- Which fuel seems to produce the lowest carbon footprint per km?
- Which value would be the most useful to a driver?
- How does knowledge of chemical principles contribute to monitoring of CO_2 emissions?
- How can we (individually) reduce our carbon emissions?

6. EXTENSION

Lead a discussion around the following questions and activity:

- What are the fuels used in thermal electricity generation in New Zealand?
- Use http://www.geocities.com/daveclarkecb/GhouseImpact.html to find out the CO_2 emissions for producing 1 kWh of electricity using each of the common New Zealand fuels
- What is meant by carbon sequestering? How is it relevant to electricity generation in New Zealand?
- What is the relevance of chemistry to future planning in the energy industry?

If an internet connection is not available, gather the information in advance and present it to the class.

7. SAFETY GUIDE

- For the teacher demonstration of combustion use only small quantities of liquid fuels (max 5 ml of flammable liquids)
- Keep liquid fuels away from other flammable materials.

8. RESOURCES

Websites

- http://www.geocities.com/daveclarkecb/GhouseImpact.html
- http://www.fuelsaver.govt.nz/

Work Sheet 1: Composition of carbon-based fuels

Use the background information to answer the questions at the end of this worksheet.

Background Information

Definitions

Petrol is largely a mixture of hydrocarbons with between 5 and 12 carbon atoms per molecule. This can be approximated to octane C_8H_{18}.

Diesel is also mainly a mixture of hydrocarbons. These are between 10 and 15 carbon atoms per molecule, but it also contains aromatic hydrocarbons such as naphthalenes and alkyl-benzenes. Its empirical formula can be approximated to $C_{12}H_{13}$.

Note: there are many other compounds added in very small quantities to both petrol and diesel but these will be omitted to allow easier calculations.

Products of complete combustion (excess oxygen available) of hydrocarbons are carbon dioxide and water.

Relative atomic masses ($g.mol^{-1}$)

Carbon	12.01
Hydrogen	1.008
Oxygen	16.00

Questions: Combustion of fuels

1. Calculate the relative molecular mass of each fuel (petrol, diesel, methanol) using the data.
2. Write balanced equations for the complete combustion of one molecule of each fuel
3. Calculate the mass of carbon dioxide. produced by burning one mole of each fuel.

How to calculate molecular masses (suggested method)

1. Write correct formulae for the compound*.	for example, propane C_3H_8
2. Substitute the relative atomic mass for each elemental symbol and convert to an algebraic equation.	(12.01x3)+(1.008x8)
3. Calculate the expression	44.09 g.mol^{-1}

How to calculate mass of reaction product (suggested method)

1. Write correct formulae for each reactant (for example, hydrocarbon* and oxygen) and product (for example, carbon dioxide and water).	for example, propane + oxygen → carbon dioxide + water $C_3H_8 + O_2 \rightarrow CO_2 + H1O$
2. Apply the principle of conservation of matter to balance the number of atoms of each element between the reactants and products; write coefficients. Begin with one molecule of the fuel.	$C_3H_8 + nO_2 \rightarrow 3CO_2 + 4H1O$ (because there are 3 C and 8 H atoms) $C_3H_8 + 7O_2 \rightarrow 3CO_2 + 4H1O$ (because 14 O atoms are needed)
3. Use relative molecular masses and equation coefficients to calculate total mass of one mole of fuel and of the carbon dioxide produced from that fuel.	$C_3H_8 + 7O_2 \rightarrow 3CO_2 + 4H1O$ 44.09 g (C_3H_8) → 3 x 44.01g = 132.03g (CO_2)

* For petrol and diesel use the approximations above.

Work Sheet 2: Carbon Emissions

Use the background information to answer the questions at the end of this worksheet.

Background Information

To compare fuels we need to calculate the CO_2 emissions per equivalent quantities of fuel burnt, equal masses (1kg). For vehicle CO_2 emissions it is common to convert to $g.L^{-1}$ or $g.km^{-1}$

1. Use ratio and proportion to calculate the mass of CO_2 produced from 1kg of each fuel.
2. Use the density data you determined at the start of the lesson to find the mass of 1L of each fuel in kilograms.
3. Calculate CO_2 emissions in $g.L^{-1}$ of each fuel.

Questions: Finding the official fuel consumption of your favourite car

1. Use http://www.fuelsaver.govt.nz/ for most makes and models.
2. From this data and the CO_2 emissions in $g.L^{-1}$ of each fuel that you have just estimated calculate the theoretical CO_2 emission of your car in $g.km^{-1}$.
3. Find out how much CO_2 you would produce on a trip of 10 km?