4.1 Chemistry past and future

Lesson outcomes

At the end of this activity students will be able to:

- discuss how future applications of chemistry might affect our lives
- recognise that the values and needs of contemporary society can influence the focus of scientific research.

Equipment list

Each GROUP will require:

- *Science by Doing Student Digital.*

Things to consider and hints for success:

This should be a stimulating discussion/research lesson. After the opening brainstorm, students can explore the development and future applications of paint in the digital links. This works well in groups, with students combining information and then discussing the historical chronology and future applications of paint (see ***Notebook*** Q1).

Students could choose between ***Notebook*** Q2 and 3, depending on their interest, and report back to the class.

Lesson plan

Step 1: Brainstorm using the stimulus material in the *Science by Doing Student Guide*. Students consider why we innovate and make new things, and the role of science in innovation.

Step 2: Students work in groups to explore digital resources on the history and possible future of paint (see **Things to consider and hints for success**).

Step 3: Student groups investigate material science or pharmaceuticals and share their information with the class.

Step 4: Finish with a discussion about the future roles of chemistry and biochemistry and possible career opportunities.

Follow up:

Materials for the future are covered in more detail in **Activity 4.2** and **Part 5**.

4.2 Super carbon

Lesson outcomes

At the end of this activity students will be able to:

- use models to investigate the structure of organic compounds
- recall the names and structure of simple hydrocarbons
- investigate the structure, properties and uses of allotropes of carbon.

What ideas might your students already have?

Students should have some understanding of the bonding of carbon.

Key vocabulary:

Allotrope, organic, hydrocarbon, alkane, alkene, alkyne, allotrope, diamond, graphite, buckyball (fullerene), nanotube, graphene, carbyne.

Equipment list

Each STUDENT will require:

- modelling hydrocarbons worksheet.

Each GROUP will require:

- molecular model kit (organic)
- *Science by Doing Student Digital.*

Things to consider and hints for success:

It is important to use molecular models throughout this lesson so students visualise structural patterns.

Allotropes: The digital activities can be a group research project. If each group is allocated a different allotrope. The lesson can conclude with a short presentation on each allotrope.

Links

- **Graphene and the carbon revolution** (7’12”): a good summary of the allotropes, from diamond and graphite, to fullerenes and nanotubes.
- **Allotropes of carbon** (1’51”): describes the structure, properties and uses of diamond, graphite and Buckminster fullerenes.
- **Allotropes of carbon** (7’11”): Royal Institute of Chemistry lecture with Professor Sir Harry Kroto, Nobel Prize winner for the discovery of fullerenes. The structure of carbon allotropes is discussed together with a demonstration that they all have the same chemical properties.
- **Buckyballs (C60) – Periodic table of videos** (9’): video of the discovery, structure and properties of buckyballs.
- **Bucky balls - cosmic soccer balls:** (2’40”): video of how buckyballs, the largest molecules in space, were detected, their structure and properties.
- **What is a nanotube?** (2’18”) Their definition and structure.

- **Nova: carbon nanotubes** (5'42"): their structure and how they are made. Their strength is discussed in relation to uses in racquets and bumper bars. They can be pulled into fibres stronger than steel.
- **Where are carbon nanotubes used?** Explains their uses as a light, strong, electrically conductive material.
- **Spinning carbon nanotubes** (5'): CSIRO video of how nanotubes can be used as a yarn for textiles and the possibilities for specialised clothing, muscle replacement (electrically operated due to conductivity) and robotics.
- **What is graphene?** (6') Video of the structure and properties of graphene and its potential uses, e.g. in robotics.
- **How to make graphene? Veritasium** (3'40"): how to make graphene from a pencil 'lead', its strength and electrical conductivity.
- **Graphene - the strongest material in the world** (1'04"): describes its single hexagonal layer of carbon, its great strength and potential uses.
- **Scientists master super-fast graphene microchips** (1'45"): Graphene can be used to make microchips 50 times faster than those used today.
- **What is graphene?** (2'): animation of the properties of graphene.
- **Carbyne** (1'23"): the new hardest material, its structure and uses.

Lesson plan

Step 1: Using the stimulus material in the *Science by Doing Student Guide*, discuss 'What is organic?' and revise bonding in carbon in relation to the periodic table, with the help of molecular models.

Step 2: Review naming of hydrocarbons, using models to allow students to explore and complete guide activities.

Step 3: Students form groups to complete **Activity Sheet 4.2 Modelling Hydrocarbons**.

Review at intervals to ensure all students are progressing.

Step 4: Students use the interactive to explore the allotropes of carbon and, with the **Find out more** resources, answer the ***Notebook*** questions.

Step 5: Conclude with group presentations on each allotrope (Q6) and a discussion of their properties and potential as materials of the future.

Follow up:

The links in this section may also be useful in **Activity 5.5**.

4.3 Carbon is everywhere

Lesson outcomes

At the end of this activity students will be able to:

- recognise the presence of organic substances in many household chemicals
- safely conduct an investigation to obtain reliable first-hand and second-hand data.

What ideas might your students already have?

Students should have an idea of how to recognise an organic compound by its name from **Activities 4.1** and **4.2**.

Equipment list

Teacher demonstration - extracting limonene from orange peel

- Quickfit distillation apparatus
- boiling chips
- mortar and pestle
- Bunsen burner
- tripod, clamps and boss heads
- retort stands
- orange peel (1 segment without pith) or mandarin peel (½ mandarin without pith)
- small beaker to collect distillate.

Each GROUP will require:

- samples of organic compounds e.g. detergent, vaseline, dencorub, napthalene (moth balls), aspirin, antifreeze, food flavouring, sugar, gelatin, methylated spirits, turpentine, kerosene, nail polish remover, saccharin (or other sweetener) etc.
- test tubes with stoppers
- test-tube rack
- spatula
- data tables or access to the internet to find formulae.

Things to consider and hints for success:

Teacher demonstration - extracting limonene from orange peel. This demonstration may take about half an hour. Have the class observe and help set up the equipment, then continue their practical work, observing at intervals. Reform the class to observe the final product.

Care is needed to set up and clamp the equipment to prevent breakages and while using the Bunsen flame to steadily maintain boiling.

Procedure:

1. Bruise the peel using a mortar and pestle.
2. Transfer to the distillation flask, using water to rinse the mortar (about 20 mL so the flask is about half full.

3. Add a few boiling chips.
4. Connect up the distillation flask to the tap (water in at lower end) and gently boil to collect the distillate in a beaker as it drips from the condenser.

Further information about the distillation and limonene can be found at:

http://www.reading.ac.uk/web/FILES/chemistry/Limonene.pdf

Class experiment - what organic compounds do we use?

Use a wide variety of organic compounds (see equipment list) but ensure that any containing dangerous chemicals remain unopened, with students reading the label to find ingredients.

An easy website to find formulae is:

http://chemistry.about.com/od/organiccompounds/a/a-organic-compounds.htm

Lesson plan

Step 1: Brainstorm household substances that contain organic compounds, discussing how names can indicate if a compound is organic.

Step 2: Teacher demonstration of the extraction of the alkene, limonene (see **Things to consider and hints for success**).

Step 3: Students complete the experiment 'What organic compounds do we use?' in groups, tabulating results (see **Things to consider and hints for success**). Discuss any patterns noticed.

Suggested questions:

- Can you see any similarities in the names of the chemicals? Do these substance have anything in common?
- How can you decide whether a substance is soluble in water?
- Are most of the organic substances soluble in water?

.

4.4 Making the car go

Lesson outcomes

At the end of this activity students will be able to:

- outline the processes involved in the formation of crude oil and its processing to produce useful chemicals
- investigate technologies to conserve fossil fuels and reduce carbon pollution in transport
- evaluate material from secondary sources as part of the research process.

Key vocabulary:

Fractional distillation, fuel cell, ethanol, diesel.

Equipment list

Each STUDENT will require:

- *Science by Doing Student Digital.*

Things to consider and hints for success:

This lesson can readily be expanded into two lessons depending on the depth of study.

Fractional distillation of petroleum

The video at: http://ffden-2.phys.uaf.edu/212_spring2011.web.dir/kristine_odom/temp/10956/ftddrops/Downstream.html can be used in conjunction with discussions about fractional distillation (Step 2) or students can explore the links in **Find out more 1**.

On-line links

- **What is combustion?** (3'25"): explains complete and incomplete combustion as exothermic reactions with equations. Discusses environmental effects.

Find out more: Obtaining and refining crude oil.

- **Separating crude oil into different fuels** (2'30"): Explains the principles of fractional distillation in an oil refinery.
- **Slow formation of oil and natural gas deposits** (2') animation explaining the formation of an oil deposit.
- **Petrol refining** (5'): video of how fractionating column works and catalytic cracking to obtain more of small chain hydrocarbons, particularly those used in petrol.

Lesson plan

Step 1: Use the stimulus material and questions in the *Science by Doing Student Guide* to discuss the origin of fossil fuels and crude oil.

Step 2: Use the guide to introduce fractional distillation. This can be expanded by use of the digital interactive (see **Things to consider and hints for success)**.

Step 3: Students review combustion using the ***Notebook*** video, before attempting Q1.

Step 4: Introduce the possibility of future alternative, environmentally friendly fuels by looking at the information on ethanol on page 55 of the *Science by Doing Student Guide*. The digital interactive can then be used to explore the possibilities.

4.5 Combustion of organic compounds

Lesson outcomes

At the end of this activity students will be able to:

- safely carry out first-hand activities to investigate combustion of fuels
- analyse data from first-hand investigations to develop evidence-based conclusions.

What ideas might your students already have?

Students should recall combustion and its products as a reaction type from **Activity 1.6**.

Equipment list

Each GROUP will require:

- spirit burners containing ethanol and kerosene
- 2 large test tubes
- 100 mL measuring cylinder
- matches
- thermometer
- test-tube rack
- wooden test-tube holder.

Things to consider and hints for success:

Class experiment – investigating combustion

For this experiment to be meaningful, as many factors as possible must be controlled, e.g. size of burner, length of wick, no draughts, starting temperature and amount of water. Introduce the activity with a discussion about what factors need to be controlled and how students will do this.

Teacher content information:

In similar amounts of oxygen, ethanol will burn more cleanly than kerosene because it does not require as much oxygen per molecule.

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

$C_{12}H_{26(l)} + 9.5O_{2(g)} \rightarrow 12CO_{2(g)} + 13H_2O_{(l)}$

Incomplete combustion will produce varying amounts of carbon ($C_{(s)}$) and carbon monoxide ($CO_{(g)}$) depending on the amount of oxygen available.

Lesson plan

Step 1: Review complete and incomplete combustion with the class, using the stimulus material in the *Science by Doing Student Guide*.

Step 2: Students complete the combustion experiment in groups of two or three and complete discussion questions.

Step 3: Conclude with a discussion of the significance of the results obtained in relation to fuel efficiency and pollution.

Suggested questions:

- How will you make your experiment a fair test?
- Was the experiment a valid comparison of the combustion of kerosene and ethanol?
- How would you improve the experiment?