### Test 5 Tests to dissolve polymers

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| What are polymers?  Polymers are long chain-like molecules.  "Poly" means "many" and "mer" means "parts." So "polymer" means "many parts."  The parts are usually the same small molecule that repeats to form a large chain-like molecule.  Polymers are also referred to as plastics because they are easily molded. But polymers are not just man made. Many polymers occur in nature. Natural fibres such as cotton and wool are polymers as is wood. | polymers  We usually think of polymers as plastics. <http://www.chemistryland.com/CHM107/index.html> |

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| In this test we try to dissolve two polymer materials:  a Styrofoam cup, made of polystyrene  (a man made polymer)  and  a packing material made from starch  (a naturally occurring polymer). | sc  Polystyrene cup | cpp  Starch packing material |

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| Polymers are made by chaining one or two smaller molecules one after another, creating a linked chain.  Polymer molecules are very large, and can contain hundreds of atoms.  A section of the polystyrene molecule and the starch molecule is shown below. | |
| ps-2  A section of the polystyrene molecule.  section of the amylose molecule  A section of the starch molecule. |  |
| benzene  There is a carbon atom at each corner, but they are not shown to make it easier to view each molecule. |
|  |

Source: <http://chem.chem.rochester.edu/~chem421/intro1.htm> <http://winnieboo.blogspot.com/2008/09/52-concepts.html>

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| **Q 9.** | (a) Look at the structure of the polystyrene molecule below and explain why it is **not** polar.  ps-2  …………………………………………………………………………  ……………………………………………………………………………………………………………………………………………………  (b) Identify which chemical bonds in the starch molecule are polar.  section of the amylose molecule |

### Tests to dissolve each polymer in water

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| Two large beakers are placed side by side.  Water is poured into the each beaker until they are about half full.  A Styrofoam cup is placed into one beaker. Packing material made of starch is placed in the other beaker. | |
| styro_water  The polystyrene cup in water remains unchanged. | starch_water2  The starch packing material in water breaks down. |

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| **Q 10.** | Based on the structure of each molecule, explain the differences in solubility in water.  …………………………………………………………………………  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

**Tests to dissolve each polymer in acetone**

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| Two more large beakers are placed side by side.  Acetone is poured into both beakers until they are about half full.  A Styrofoam cup is placed into one beaker. Packing material made of starch is placed in the other beaker. | | |
|  | The polystyrene cup in acetone breaks down. | starch_aceto1  The starch packing material in acetone remains unchanged. |

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| **Q 11.** | We saw in Test 3 that acetone dissolves in both water and carbon tetrachloride, showing that it has some polar properties and some non-polar properties.  Based on ‘like dissolves like’ we would expect acetone to dissolve both polar and non-polar materials. However, in this test acetone only dissolved the non-polar polymer.  Suggest a reason why acetone could not dissolve the polar starch polymer.  …………………………………………………………………………  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

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| **SEND Your answers to discussion questions 1 to 8 on pages 15 – 19.**  **CORE-PLUS students also complete questions 9 to 11 on pages 20 – 22.** |

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| **LESSON 4** | Covalent network lattices |

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|  | **Go to Chapter 6 in your textbook.** |
| Read pp 129 – 132 on covalent lattices.  Do **Revision questions 28**, **29** and **31** on page 132. Correct your answers from the back of the textbook. |

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|  | **On the net** |
| To see 3D covalent network lattice structures online  <http://www.dynamicscience.com.au/tester/solutions/chemistry/bonding/bonding10a.htm> |

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| **SEND Skills question 5 on page 24**  *CORE-PLUS students also do Q11 on p.26* |

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| **LESSON 5** | A review of chemical bonding |



**The chemical bonding we have covered includes metallic, ionic and covalent compounds. In this lesson we review these bonding models.**

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| **DVD** | **Watch a video about intermolecular forces**  *(forces between molecules)* |
| Watch the video titled *‘Covalent molecules’* onyour Chemistry DVD. |

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|  | **Go to Chapter 6 in your textbook.** |
| * Read pages 133 to 135, including **sample problem 6.8**.   Do **Revision questions 34** and **35**. Correct your answers from the back of your textbook.   * Read **sample problem 6.9** on page 137 of your textbook.   Do **Revision questions 36, 38** and **42**. Correct your answers from the back of your textbook. |

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|  | **On the net** **Test yourself. *Take a test on the net.*** |
| To test yourself on **ionic and covalent compounds**, do the quiz (test) *classifying compounds* at the site below. Go to  <http://antoine.frostburg.edu/chem/senese/101/compounds/compound-classify-quiz.shtml>  To test yourself on **interpreting chemical formulas**, do the quiz (test) *interpreting formulas* at the site below. Go to  <http://antoine.frostburg.edu/chem/senese/101/compounds/interpret-formulas-quiz.shtml> |

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| **SEND Skills questions 6, 7 and 8 on pages 24 – 25** |

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| **SEND Skills Questions** |
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|  | **1.** | Use the table of electronegativities on the page 3 to help you fill in the table below. |

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| **Atoms bonded** | **Difference in electronegativity** | **Type of bond (non-polar covalent, polar covalent, or ionic)** |
| F ⎯ Cl |  |  |
| H ⎯ F |  |  |
| N ⎯ N |  |  |
| S ⎯ F |  |  |
| P ⎯ H |  |  |

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|  | **2.** | (a) | Show the bond dipoles in the molecules below. | | | |
|  |  | (b) | Predict whether the molecules are polar and explain why. | | | |
|  |  |  | (i) | CHF3 | (ii) | CF4 |
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| **3.** | (a) | Sketch the shape of ammonia, NH3 and carbon dioxide, CO2, showing the bonding and non-bonding electron pairs. |
|  | (b) | At room temperature, both ammonia and carbon dioxide are gases. They are also both small molecules about the same size. However, when the temperature is lowered, ammonia forms a liquid (condenses) at a much warmer temperature more than carbon dioxide.  Consider the differences in forces between molecules of ammonia compared with carbon dioxide. Explain why these differences cause ammonia to condense before carbon dioxide does. |

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| **4.** | CH3OH and HCl both dissolve in water, but the dissolved HCl conducts electricity, while the dissolved CH3OH doesn’t. Explain why. |

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|  | **5.** | Briefly explain why graphite can conduct electricity, but diamond cannot. |

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|  | **6.** | The electron configurations of four elements are: | | | | |
|  |  | 2, 8, 1 | | 2, 7 | 2, 8, 6 | 2, 8 |
|  |  | (a) | Identify the elements | | | |
|  |  | (b) | Which pairs of elements are likely to form an ionic bond? Show the formulas of the ionic compounds. | | | |
|  |  | (c) | Which pairs of elements are likely to form a covalent bond? Show the formulas of the covalent compounds. | | | |
|  |  | (d) | Which element will be unreactive? Why? | | | |

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|  | **7.** | Work out the formula of the compounds listed below.  Use the flowchart on page 136 of your textbook to help you identify the type of bonding in each compound above (ionic, metallic, covalent molecule, covalent lattice). | | |
|  |  | **The compound** | **Its chemical formula** | **Its chemical bonding** |
|  |  | Magnesium chloride |  |  |
|  |  | Sulfur dioxide |  |  |
|  |  | Hydrogen peroxide |  |  |
|  |  | Silicon dioxide |  |  |
|  |  | Gold |  |  |

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|  | **8.** | | | The table below shows the properties of four unknown substances. | | | |
|  | |  | | | Electrical conductivity | | | |
| Substance | | | Melting point | | in solid form | in liquid form | when dissolved in water | |
| A **B**  **C**  **D** | | | 18200C  8000C  280C  −100C | | High  None  None  None | High  High  None  None | Won’t dissolve  Dissolves  Dissolves  Won’t dissolve | |

Use the information in the table to help you complete the following sentences:

Substance \_\_\_ could have ionic bonding because\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Substance \_\_\_ could have non-polar covalent bonding because\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Substance \_\_\_ could have polar covalent bonding because\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Substance \_\_\_ could have metallic bonding because\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **SEND** |  | Extratheory questions for CORE-PLUS students |

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|  | **9.** | The diagram below shows the molecular structure of water and hydrogen fluoride. | |
|  |  | In each molecule the –H bond is polar, and the molecules are a similar size, but they have markedly different boiling points.  The polarity of the –H bond and the boiling points are shown below. |  |

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| Polarity of –H bond  (Differences in electronegativity) | O—H  3.5 − 2.1 = 1.4 | F—H  4.0 − 2.1 = 1.9 |
| Boiling points | 100 °C | 20 °C |

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|  |  | The molecule with the strongest dipole does **not** have the highest boiling point.  Explain why this is the case, in terms of the number of Hydrogen atoms available for the lone pairs in each molecule. |

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|  | **10.** | The table shows the boiling points of group 17 hydrides, and the polarity of the –H bond. |

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|  | **group 17 hydrides** | | | |
| Molecular formula | HF | HCl | HBr | HI |
| Polarity of —H bond  (Difference in electronegativity) | F—H  4.0 − 2.1 = 1.9 | Cl—H  3.0 − 2.1 = 0.9 | Br—H  2.8 − 2.1 = 0.7 | I—H  2.5 − 2.1 = 0.4 |
| Boiling point | 20 °C | −85 °C | −67 °C | −35 °C |

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|  | (a) | Rank the molecules in order of decreasing dipole-dipole strength. |
|  | (b) | Based on dipole strength only, what order of boiling point would you expect the molecules to follow? |
|  | (c) | Explain why the boiling points do not correspond to the dipole strength of the molecules. |

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|  | **11.** | The elements carbon and silicon are both group (IV) elements. They both form a dioxide (CO2 and SiO2). However CO2 is a gas at room temperature, while SiO2 is an abrasive solid (sand). Explain the different forms in terms of the different structures of each compound. |

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| **SEND Modelling hydrocarbons**  ***…modelling propane*** |

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| **Propane** is an alkane with 3 carbon atoms. Its semi-structural formula is CH3CH2CH3. | | |
| * Draw the structural formula of propane (to show which atoms are bonded to which). * **View propane in Rasmol**. Open the Rasmol folder on the chemistry CD. Open Rasmol, then open the propane molecule. * Identify the geometry around each carbon atom * Draw a 3D sketch of the molecule. |  | The structural formula, geometry and the 3D sketch go in **Worksheet 1** on page 22. |
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| **Trigonal planar geometry** |

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| **In Week 6 we saw an example of trigonal planar geometry.**  **The atoms lie in a flat plane at the points of a triangle.**  **Other organic compounds also have a trigonal planar arrangement around the carbon atoms. Ethene is another example.** | The carbonate ion is **trigonal planar**.  The atoms around carbon form the shape of a flat triangle. |

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|  | **Ethene** is an alk**ene** with 2 carbon atoms and a double bond CH2==CH2 | | |
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|  | A flat diagram of ethene.  Each C atom has 4 covalent bonds.  Each H atom has 1 covalent bond. |  | Ethene shown as a ball and stick figure.  **C**  **C**  **H**  **H**  **H**  **H** |
|  |  |  |  |
| Notice that Rasmol does not show double bonds.  That’s why we need to draw a sketch and check that each C atom has 4 bonds and each H atom has only one bond.  By checking the carbon bonds we can see where the double bonds occur. | ethene sticks  ethene flat  Ethene in stick form gives a better idea of its geometry.  Viewed in Rasmol, ethene is a flat molecule. |  | The geometry around each carbon atom is trigonal planar.  The triangles overlap. |

**A 3D sketch of the molecule**

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| A 3D sketch of ethene | When an atom is joined with a plain line, , the bond is **flat** on the page.  **H**  All of the bonds are shown as plain straight lines, showing that the molecule is flat. |

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| **SEND Modelling hydrocarbons**  ***…modelling propene and benzene*** |

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| **Propene** is an alkene with 3 carbon atoms.  It’s semi-structural formula is CH2CHCH3.  **Cyclohexene** is a ***cyclic*** alkene (a ring formation) with 6 carbon atoms. It’s semi-structural formula is shown in the diagram. | | | **CH**  **CH2**  **CH2**  **HC**  **H2C**  **H2C**  Cyclohexene |
| * Draw the structural formula of propene (to show which atoms are bonded to which). * **View propene in Rasmol**. Open the Rasmol folder on the chemistry CD. Open Rasmol, then open the propene molecule. * Identify the geometry around each carbon atom. * Draw a 3D sketch of propene. * Close the propene molecule and open **cyclohexene in Rasmol.** Identify the geometry around each carbon atom and draw a 3D sketch of the cyclohexene molecule. |  | The structural formula, geometry and the 3D sketches go in **Worksheet 1** on page 22. | |
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| **Linear geometry** |

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|  | **Ethyne** is an alk**yne** with 2 carbon atoms and a triple bond CH≡≡CH |

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|  | A flat diagram of ethyne.  Each C atom has 4 covalent bonds.  Each H atom has 1 covalent bond. |  | Ethyne shown as a ball and stick figure.  **C**  **H**  **C**  **H**  The geometry around the carbon atoms is linear. |
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|  |  |  |  |
| A 3D sketch of ethyne  The molecule is flat, so all bonds are shown as straight lines. |
|  |



**Notice that Rasmol does not show triple bonds.**

**That’s why we need to draw a sketch and check that each Carbon atom has four bonds and each Hydrogen atom has only one bond.**

**By checking the carbon bonds we can see where the triple bonds occur.**

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| **SEND Modelling hydrocarbons**  ***…modelling propyne*** |

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| **Propyne** is an alkyne with 3 carbon atoms. It’s semi-structural formula is CHCCH3. | | |
| * Draw the structural formula of propyne (to show which atoms are bonded to which). * **View propyne in Rasmol**. Open the Rasmol folder on the chemistry CD. Open Rasmol, then open the propene molecule. * Identify the geometry around each carbon atom. * Draw a 3D sketch of each molecule. |  | The structural formula, geometry and the 3D sketch go in **Worksheet 1** on page 22. |
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| **Organic compounds with functional groups** |



**Many organic molecules usually contain a combination of geometries in their structure, as we see in the example below.**

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| Diethyl ether, (or just ‘ether’), was once used as a general anaesthetic.  Its semi-structural formula is  CH3CH2—O—CH2CH3  Its functional group is the ether group —O— | The structural formula of diethyl ether |

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|  | Check that: | Each C atom has 4 covalent bonds.  Each H atom has 1 covalent bond.  O has 2 covalent bonds |

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|  | Viewed in Rasmol we can see the geometries around each C atom. | | |
|  | **C**  **C**  **C**  **C**  **O**  Diethyl ether as a ball and stick figure. |  | diethyl ether sticks  Diethyl ether as a stick figure gives a better idea of the geometries around each C atom. |

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| There are two different geometries in this molecule.  Bent geometry around Oxygen.  This part of the molecule is flat.  The geometry around each Carbon is tetrahedral.  The geometry around Oxygen is bent.  Tetrahedral geometry around each Carbon atom. |

**A 3D sketch of the molecule**

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| A 3D sketch of diethyl ether | The plain straight lines show the –C–O–C–section of the molecule is flat.  The dotted and wedge lines show the –H bonds occupy 3D space around the C atoms.  Remember:  When an atom is joined with a plain line, , the bond is **flat** on the page.  **H**  When an atom is joined with a dotted line, , the bond is directed **away from you** the page.  **H**  When an atom is joined with a wedge line, **,** the bond is directed **towards you** out of the page.  **H**  4  3  2  1  **CH3**  **CH3**  **CH2**  **CH**  **CH2**  **CH2**  **H3C**  **CH3**  **CH3**  **CH2**  **CH**  **CH2** |
|  |

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| **SEND Modelling organic compounds**  ***… ethanol, ethanamine and ethanoic acid*** |

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| The organic compounds **ethanol**, **ethanamine** and **ethanoic acid** are all derived from ethane, CH3CH3 | | | |
| Their semi-structural formulae are | **ethanol** (ethyl alcohol) CH3CH2OH  **ethanamine** (ethyl amine) CH3CH2NH2  **ethanoic acid** (acetic acid) CH3COOH | | |
| * Draw the structural formula of each molecule (to show which atoms are bonded to which). * Identify the functional group and name it. * **View ethanol in Rasmol**. Open the Rasmol folder on the chemistry CD. Open Rasmol, then open the **ethanol** molecule. * Identify the geometries present in ethanol. * Draw a 3D sketch of each molecule. * Close ethanol and **open ethyl amine in Rasmol.** Identify the geometry around each carbon atom and draw a 3D sketch of the ethyl amine molecule. * Close ethyl amine and **open ethanoic acid in Rasmol.** Identify the geometry around each carbon atom and draw a 3D sketch of the ethanoic acid molecule. | |  | The structural formula, geometry and the 3D sketch go in **Worksheet 2** on page 23. |
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| **SEND** |  | **Modelling methyl ethanoate** |

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| **Methyl ethanoate**, |  | is an **ester**. | | |
| * Draw the structural formula of methyl ethanoate (to show which atoms are bonded to which). * Identify the functional group and name it. * **View methyl ethanoate in Rasmol**. Open Rasmol on the chemistry CD, then open the **methyl ethanoate** molecule. * Identify the geometries present. * Draw a 3D sketch of the molecule. | | |  | The structural formula, geometry and the 3D sketch go in **Worksheet 2** on page 23. |
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**SEND Worksheet 1 : Modelling hydrocarbons**



**Use Rasmol to view each molecule in the table below.**

**Fill in this worksheet as you investigate the 3D structure of each molecule.**

**See pages 15 –19 for details.**

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| --- | --- | --- | --- |
| **Molecule** | **Structural formula** | **Identify geometry around each C atom** | **Draw a 3D sketch** |
| **Propane CH3CH2CH3** |  |  |  |
| **Propene CH2CHCH3** |  |  |  |
| **Cyclohexene (CH2)4(CH)2** |  |  |  |
| **Propyne CHCCH3** |  |  |  |

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| **SEND**  **Worksheet 2: Modelling organic compounds** | **Use Rasmol to view each molecule in the table below.**  **Fill in this worksheet as you investigate the 3D structure of each molecule.**  **See pages 19 – 21 for details.** |

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| --- | --- | --- | --- | --- |
| **Molecule** | **Structural formula** | **Identify functional group and name it** | **Show geometries present in each molecule** | **Draw a 3D sketch** |
| **Ethanol CH3CH2OH** |  |  |  |  |
| **Ethyl amine CH3CH2NH2** |  |  |  |  |
| **Ethanoic acid CH3COOH** |  |  |  |  |
| ***For CORE-PLUS students only***  **Methyl ethanoate**  **CH3OCOCH3** |  |  |  |  |

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|  | **SEND Practical exercise 1:**  **The properties of candle wax (a hydrocarbon)** |
| **This experiment can be done at home.**  Sources: <http://images.sub-studio.com/images/2006/0922candle2.jpg> |

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| **Aim** | * To predict some of the properties of candle wax and test them. | |
| **Background**  Untitled-13 | Candle wax is a made of a group of hydrocarbon molecules called **paraffin** molecules.  The simplest paraffin molecule is methane, CH4, a gas at room temperature. Heavier members of the series, such as that of octane C8H18, appear as liquids at room temperature.  The solid forms of paraffin, called *paraffin wax*, are from the heaviest molecules from C20H42 to C40H82. This includes candle wax. | |
| **Materials** | \* A candle  \* Two glasses  \* A saucer  \* A heat source, oven mitt or tea-towel | |
| **Your predictions** | Candle wax is a covalently bonded molecule, and it is a waxy solid at room temperature. | |
| (a) | Do you think candle wax will dissolve in water? Explain why.  …………………………………………………………………………………………………………………………………………………… |
|  | (b) | Do you think candle wax will need a lot of heat to be applied before it melts? Explain why.  …………………………………………………………………………………………………………………………………………………… |
|  | (c) | Do you think candle wax will conduct electricity in its molten state? Explain why.  …………………………………………………………………………………………………………………………………………………… |
| **Test your predictions** | Place a few flakes of candle wax in a glass of warm water. Stir to dissolve. Record your results.  Place a teaspoon of candle wax flakes in a dry glass and cover with a saucer. ***Gently* heat** the glass and saucer. You may need to stand the glass in a double boiler saucepan. | |

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| **Observations** | | Describe the changes that occur as the candle wax heats. When the changes have finished, lift the saucer (you may need to use an oven mitt or tea towel). Look at the bottom of the saucer and describe what you see.  ……………………………………………………………………………………………………………………………………………………………… | | |
| **Questions** | 1. | Were your predictions about the properties of candle wax correct? Explain.  ……………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 2. | A main component of candle wax has the formula C25H52. From the chemical formula, what type of hydrocarbon is candle wax?  ……………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 3. | Propane C3H8 is a gas at room temperature, while candle wax, C25H52, is a solid at room temperature.  (a) What forces exist between molecules in propane and in candle wax?  ………………………………………………………………………………………………………………………………………………………………………………………………………  (b) Explain why propane is a gas at room temperature but candle wax is a solid.  ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

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| **SEND Skills Questions** |
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|  | **1.** | (a) | Show the structural formulae of hexane and chlorine gas. | | | | |
|  |  | (b) | Hexane and chlorine will react. Write a structural equation for the substitution reaction between hexane and chlorine gas. | | | | |
|  | **2.** | Complete and balance the following chemical equations. | | | | | |
|  |  | (a) | C8H18 (g) + O2(g) | | | | |
|  |  | (b) | C2H6 (g) + O2(g) | | | | |
|  | **3.** | (a) | Draw the structural formulae of propene. | | | | |
|  |  | (b) | Write a structural equation for the addition reaction between propene and fluorine gas. | | | | |
|  | **4.** | Why is the compound C6H10 not an alkane? Draw its structural formula and identify whether it is an alkane, an alkene or an alkyne. | | | | | |
|  | **5.** | The chemical formula for butene is C4H8.  When a hydrocarbon burns in a limited supply of oxygen, it produces carbon **monoxide**, CO, and water.  Write a balanced equation for the combustion of butene in a limited oxygen supply. | | | | | |
|  | **6.** | For the two compounds shown below: | | | | | |
|  |  | (a) | Draw the structural formula of each compound. Identify the double bond in Compound 2. | | | | |
|  |  | (b) | Show the steps required to correctly name each compound. | | | | |
|  |  | (c) | Only one of these compounds reacts with hydrogen bromide. Identify which one and explain why it will react. | | | | |
|  |  |  | Semi-structural formulae | | | |
|  |  |  | Compound 1 | **H3C**  **CH**  **CH3**  **CH**  **CH3**  **CH3** | **H3C**  **CH**  **CH3**  **CH**  **CH2** | Compound 2 |

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|  | **7.** | Name the following organic compounds. | | | |
|  |  | (a) | **C**  **C**  **C**  **OH**  **H**  **H**  **H**  **H**  **OH**  **C**  **H**  **H**  **H**  **H** | (b) | **C**  **C**  **C**  **H**  **H**  **H**  **H**  **H**  **O**  **OH** |

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|  |  | (c) | **C**  **C**  **C**  **H**  **H**  **H**  **H**  **H**  **H**  **H**  **NH2** | (d) | **C**  **C**  **C**  **Br**  **H**  **H**  **H**  **H**  **Cl**  **C**  **H**  **H**  **H**  **H** |

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|  | **8.** | Show the structural formulae of the following compounds. | | | |
|  |  | (a) | 1–bromo 2–fluoro ethane | (b) | 2, 2–dichloro propane |
|  |  | (c) | 2–butanamine | (d) | Butanoic acid |

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| **SEND** |  | ExtraTheory questions for CORE-PLUS students |
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|  | **9.** | (a) | What is the chemical formula for propyne? |
|  |  | (b) | Write a balanced equation for the combustion of propyne in a **limited** oxygen supply. |

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|  | **10.** | For the compound **CH3CH2C(CH3)CH2** | |
|  |  | (a) | Sketch the structural formula of the compound. |
|  |  | (b) | Identify the position of the double bond and the substituent group. |
|  |  | (c) | Name the compound. |

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|  | **11.** | Sometimes it is possible to select more than one longest chain in a hydrocarbon.  The compound **(CH3)2CHCH2CH(C2H5)C(CH3)3** has two possible longest chains. | |
|  |  | (a) | Sketch the structural formula of this compound and identify the two possible longest chains. |
|  |  | (b) | If we have two possible longest chains, we choose the chain having the largest number of substituents (groups).  Apply this rule to select the correct structural formula and name the compound. |

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|  | **12.** | For the compound **CH3COOCH2CH2CH3** | |
|  |  | (a) | Identify the functional group and name it. |
|  |  | (b) | Name the compound. |

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|  | **13.** | (a) | Show the structural formulae of propanol and methanoic acid. |
|  |  | (b) | Show the reaction that produces an ester from the reaction of propanol and methanoic acid.  Name the ester formed in each reaction. |

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| **Investigate the properties of a thermosetting polymer** |

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|  | **SEND Practical exercise 1:**  **Polymers made from milk** |
| **This experiment can be done at home.** Source: [*http://www.chemsoc.org/networks/learnnet/Word\_files/Kev71-80.doc*](http://www.chemsoc.org/networks/learnnet/Word_files/Kev71-80.doc) |

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| **Introduction** | A thermoplastic polymer and a type of glue can be made from the protein in milk called casein.  In this experiment, both types of polymers are prepared from milk.  The casein is separated from milk by processes called coagulation and precipitation. |
|  | Fig p |
| **You will need** | * 125 mL of skimmed milk (fat-free) * 25 mL of ethanoic acid (or vinegar) * Water * Approximately 20 grams sodium hydrogen carbonate (or half a teaspoon of bicarb soda) * a 250 mLbeaker (or saucepan) * stirring rod or spoon * filter funnel and filter paper, or a piece of muslin and a rubber band * 250 mL conical flask or a bowl * paper towels. * a jelly mould or cookie cutter (optional). |
| **Safety** | Wear eye protection. |

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| **Method** | 1. | Place 125 cm3 of skimmed milk (fat-free) into a 250 cm3 beaker (or saucepan). Add approximately 25 cm3 of ethanoic acid (or vinegar).  Heat gently with constant stirring until small lumps begin to form. **Do not boil.**  Remove from the heat and continue to stir until no more lumps form. |
|  | 2. | Allow the curds to settle. Decant (strain off) some of the liquid (the whey). Filter off the remainder using the filter funnel (or muslin) resting on the 250 cm3 conical flask (or bowl)  Gently remove excess liquid from the curds using a paper towel until you have recovered all of the solid, rubbery casein polymer.  Separate into solid into two halves. |
|  | 3. | The first half: Press the casein polymer into a jelly mould, or shape with a cookie cutter, or shape it by hand.  Leave it in a warm place to sit and cure. It will harden as it cures. |
|  | 4. | For the second half of the casein polymer, prepare a sample of glue as follows:  Return the casein polymer to the empty beaker (or saucepan).  Add 15 mL of water to the solid and stir.  Add most of the sodium hydrogen carbonate (bicarb soda) to neutralise any remaining acid. Watch for bubbles of gas to appear then add a little more sodium hydrogen carbonate (bicarb soda) until no more bubbles appear. The substance in the beaker is glue. Record its appearance in your observations. |
| **Discussion** | * Find a way to test your glue. Describe the tests you perform and your observations. * Return to the cured casein polymer, after it has hardened Record its appearance in your observations. | |
| **Observations** | The casein polymer glue:  The cured casein polymer: | |

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| **Questions** | 1. | How does the cured casein polymer differ from the glue polymer?  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 2. | What properties of the polymers you have made classify them as thermoplastic, not thermosetting?  ……………………………………………………………………………………………………………………………………………………  …………………………………………………………………………………………………………………………………………………… |
|  | 3. | Why is skimmed milk used instead of full-fat milk?  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 4. | What is the purpose of the ethanoic acid (vinegar) in this experiment?  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 5. | Why is sodium hydrogen carbonate added?  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

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| **Chemical bonding and intermolecular forces of polymers** |



**The bonding in polymer molecules is covalent bonding. There are also intermolecular forces of attraction that influence the properties of a polymer.**



**Thermoplastic polymers are flexible and can be reshaped through heating. Weak forces of attraction between the molecules explains this property.**

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| **In thermoplastic polymers** | **Strong covalent bonds** within **each molecule**  **Weak dispersion forces** between **the molecules** |

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|  | The weak dispersion forces between the molecules mean that the molecules are not held in place and they can slip past each other. This is why a thermoplastic polymer can bend and flex.  When the polymer is heated it gains kinetic energy. The energy causes the molecules to move past each other and we see the polymer starting to soften before melting. The molecules themselves are still intact because the covalent bonds within the molecule are very strong. |

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| Tangled polymer molecules. | | |  | Polymer molecules separate with heating. |
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| Apply heat |  |  | Heat energy is used to separate tangled chains before they can slip past each other. The polymer softens before it melts. Melting means the chain molecules can slide past each other. Each molecule remains intact. | |



**Thermosetting polymers are not flexible and cannot be reshaped by heating. Covalent bonding between the molecules explains this property.**

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| **In thermosetting polymers** | **Strong covalent bonds** within **each molecule**  **Strong covalent bonds, called** cross-links**, exist** between **the molecules** |
| The polymer chains are joined by covalent bonds in a process called **cross-linking**. Cross-linking can happen by heating the polymer molecules or by reacting them with another compound that joins the chains together. |
| The cross-linking between the chains holds them in place. This explains why thermosetting polymers are rigid materials. The more cross-links between the chains, the more rigid the material.  If you heat a piece of laminex you’ll see it char and leave a black residue of carbon. Thermosetting polymers don’t melt. They **decompose**.  Decomposing is a chemical reaction, and new compounds are formed. This is why charring is different to melting. Melting is just a change of state; no new compound is formed when a compound melts. |

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| **SEND Skills questions 1 and 2 on page 14**  *CORE-PLUS students also do Q9 on page 15* |
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|  | **SEND Practical exercise 2:**  **Investigate the tangling of thermoplastic polymer chains** |
| **This experiment can be done at home.** |

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| **Aim** | To test the theory that tangling of thermoplastic polymers depends on their length. | |
| **You will need** | From a reel of cotton, cut twenty 10 cm lengths and twenty 40 cm lengths. | |
| **Method** | 1. Place the 10 cm lengths in one glass and the 40 cm lengths in another glass. Add enough water to cover. Place a hand over the top and shake each glass vigorously for 1 to 2 minutes 2. Pour off the water and gently squeeze the water out of each bundle. Pick up one bundle and try to tear it in two by hand. Do the same with the other bundle. Record your observations. 3. Now try to separate the threads into two bundles. Record your observations. | |
| **Questions** | 1. | Which bundle was more tangled, the long lengths or short lengths?  ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | 2. | What effect would tangling have on forces existing between polymer molecules?  ……………………………………………………………………………………………………………………………………………………  …………………………………………………………………………………………………………………………………………………… |
|  | 3. | What you might expect of the strength, rigidity and melting points of long chain polymers compared with short chain polymers? Give reasons.  ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

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| **LESSON 2** | Manufacturing polymers |

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| **DVD** | **Watch a video about polymers** |
| Watch the video titled *‘Polymer Chemistry’* on your Chemistry DVD. |

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|  | The process of manufacturing a polymer is called **polymerisation**.  We look at two ways of manufacturing polymers:   * **Addition polymerisation**: identical small molecules react to bond covalently in long chains. There are no by-products. * **Condensation polymerisation**: two different compounds react to bond covalently in long chains. There is a by-product of the reaction |

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| **Addition polymerisation** |

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| **C**  **C**  **H**  **H**  **H**  **H**  An ethene molecule | Ethene molecules can react to produce polyethene. The double bond of ethene is broken and the molecules are covalently bonded into a long chain | | |
| **C**  **C**  **H**  **H**  **H**  **H**  **+**  **C**  **C**  **H**  **H**  **H**  **H**  **C**  **C**  **H**  **H**  **H**  **H**  **+**  **+**  **↓**  **+** | | |
|  |
|  | **H**  **C**  **C**  **H**  **H**  **H**  **C**  **C**  **H**  **H**  **H**  **H**  **H**  **C**  **C**  **H**  **H**  **H**  **H** | Although it’s difficult to show in a diagram the electron pairs are still arranged in a tetrahedron around each carbon atom |

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| At lower temperature and pressure, **high-density** polyethene is produced. It has little or no branching so that the chains can pack closely together. | At higher temperature and pressure **low density** polyethene is produced. It has branched chains that cannot pack very closely together. |

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| **Cross-linked rubber… a tale of discovery** |

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|  | Rubber is a natural polymer consisting of long tangled molecules.  Rubber was extracted as a milky liquid (latex) from certain trees and was used to make elastic, bouncing balls in South and Central American civilisations.  European explorers used latex to waterproof their clothes, but weather affected its properties. It melted in the sun, and became brittle during the cold.  An American inventor, Charles Goodyear, experimented with rubber for 10 years, until he discovered a mixture of rubber and sulphur that had reacted on a hot stove.  To his surprise this compound did not melt or become brittle as rubber did. With further experimentation he discovered the right amounts of rubber and sulphur to use and the best conditions for heating to produce the best product.  He applied for a patent, and called the process vulcanisation after Vulcan the Roman god of war.  However, he had to defend his patent against people who tried to use his discovery, and he incurred debts from which he never recovered.  He was quoted as saying  “Life should not be estimated exclusively by the standard of dollars and cents. I am not disposed to complain that I have planted and others have gathered the fruits. A man has cause for regret only when he sows and no one reaps”. |

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|  | **Go to Chapter 9 in your textbook** |
| Read the section on *Addition polymerisation* on pages 199 to 201 of your textbook, and the section on *Commonly used polymers* (ethene and rubber) on pages 202 to 206. |

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| ***Quick Check***  **Exercise 1** |  | **Addition polymers and cross-linking** |
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|  | 1. | Do the following **multiple choice questions** on **page 213** of your textbook.  **Questions 5, 6, 7 and 8**  Correct your answers from the back of your textbook. |
|  | 2. | Do the following **review questions** on **page 214** of your textbook.  **Questions 3, 4, 5, 6 and 7**  Correct your answers from the back of your textbook. |

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| **SEND Skills questions 3 to 6 on page 14**  *CORE-PLUS students also do Q10 on page 15* |
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| **LESSON 2** | Condensation polymerisation |



**Many thermosetting polymers are made by reacting different monomers together.**

**One example is the production of nylon.**

**Two different monomers react to produce nylon. The process used is called condensation polymerisation.**

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| **DVD** | **Watch a movie about the invention of nylon** |
| Watch the movie [***Invention of Nylon***](Interactives/Nylon/nylon_invention.html) on the Chemistry CD in Further Resources.  The movie explains the history behind the invention of nylon. |

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| The reaction that produces nylon |

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|  | The two monomers used to produce nylon are shown below. |

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| **The monomers that react to produce nylon** | |
| *1,6-diamino hexane.*  *Functional group –NH2* | *Adipic acid; a carboxylic acid*  *Functional group –COOH* |
| **(CH2)6**  **N**  **H**  **H**  **N**  **H**  **H** | **(CH2)4**  **C**  **O**  **OH**  **C**  **O**  **OH** |

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| The condensation reaction produces nylon and water |
| **(CH2)4**  **C**  **O**  **OH**  **C**  **O**  **(CH2)6**  **N**  **H**  **H**  **N**  **H**  **↓**  **(CH2)4**  **C**  **O**  **OH**  **C**  **O**  **(CH2)6**  **N**  **H**  **H**  **N**  **H**  **+**  **H2O**  **OH**  **H** |

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|  | **On the net** |
| The site below shows a demonstration of what you would see in an experiment to produce nylon fibre.  Go to  <https://www.chem.wisc.edu/deptfiles/genchem/demonstrations/Gen_Chem_Pages/22organicpage/organicmain.htm> then click on *Nylon 6 - 10* |

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|  | **Go to Chapter 9 in your textbook** |
| Read the section on *Condensation polymerisation* on pages 206 to 208 of your textbook. |

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| **SEND Skills questions 7 and 8 on pages 14 – 15**  *CORE-PLUS students also do Q11 on page 15* |
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| **LESSON 3** | Recycling and reusing plastics |

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|  | There are two problems with our increasing use of plastics (more than more million tonnes per year in Australia). Firstly, most plastics are made form oil, a non-renewable resource which will become scarce in the future. Secondly, what do we do with plastic objects when we are finished with them? At present most are dumped or burned, but there are many different ways of reusing them. For example, you can use old ice-cream containers to store things in. |
|  | **There are three different ways of recycling plastics:** |
| **1.** | Thermoplastics can be melted and remoulded. However because there are so many different types of plastic, they must first be washed and sorted, otherwise the recycled plastics will not have the properties you want. This costs money and the recycled plastic maybe more expensive than new plastic. However a number of manufacturing plants in Australia now use recycled plastic. For example milk bottles are recycled to make products such as garbage bins and detergent bottles and plastic banknotes are recycled to make compost bins. |
| **2.** | Mixed plastic waste can be crushed and moulded into a range of products such as plant pots and park benches. It can also be mixed with wood to make a composite material. For these uses the lower quality product is not a problem. |
| **3.** | Because plastics burn, they can be used as fuel. However, this has proven to be difficult because of the toxic gases produced and the sticky nature of many plastics as they burn. However, technologists have found a way of converting waste plastics into oil. In this system (see diagram below) some of the gases formed as the plastic decomposes are condensed to give valuable oil products. The rest of the gases are used to heat the plastic waste. Such a system can handle 8000 tonnes of plastic waste in a year. It is an expensive process but a useful way saving out our non-renewable oil reserves. |
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| **SEND Recycling plastics: Summary table** |
| **Complete the missing sections in the table below.** |

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| **Recycling plastics** | | |
| **Recycling method**  **↓** | **Advantages of this recycling method** | **Disadvantages of this recycling method** |
| Melting and remoulding. |  |  |
|  |  | Lower quality product. |
|  | The system can handle 8000 tonnes of plastic waste in a year. Valuable oil products are produced and the uncondensed gases heat the plastic wastes. |  |

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| **SEND Skills Questions** |
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|  | **1.** | Would a thermoplastic or a thermosetting polymer be the most suitable for the following purposes? Give reasons for your choice. | |
|  |  | (a) | plastic mixing bowls |
|  |  | (b) | electrical cable |
|  |  | (c) | the knob of a saucepan lid |
|  |  | (d) | shoe heels |
|  |  | (e) | the handle on a frypan |
|  | **2.** | Elastic bands, golf balls and saucepan handles are made from polymers with some cross-linking. Which of these materials has the greatest degree of cross-linking? Why? | |
|  | **3.** | Explain the difference between **isotactic** and **atactic** polymers. | |
|  | **4.** | (a) | Cross-linking can increase the strength of a polymer. How does cross-linking differ from dispersion forces? |
|  |  | (b) | Explain how the amount of cross-linking can affect the elasticity of a polymer. Use rubber as an example. |
|  |  | (c) | What structural feature does a monomer need to have for cross-linking to be possible? |

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|  | **5.** | The styrene monomer can react to produce the polymer polystyrene. Polystyrene is used to make yoghurt containers, fridge doors and crispers, radio cabinets, shoe heels.  Draw a section of the polystyrene polymer.  stands for C6H5 | **C**  **C**  **H**  **H**  **H**  Styrene |

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|  | **6.** | PVA glue contains the polymer polyvinyl acetate. A section of the polymer is shown below. | |
|  |  | **C**  **C**  **H**  **OCOCH3**  **H**  **H**  **C**  **C**  **H**  **OCOCH3**  **H**  **H**  **C**  **C**  **H**  **OCOCH3**  **H**  **H**  **C**  **C**  **H**  **OCOCH3**  **H**  **H** | |
|  |  | (a) | Give the structural formula of its monomer. |
|  |  | (b) | Name the monomer. |

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|  | **7.** | Nylon can be produced in different ways. The example on page **9** is 6:6 nylon, meaning that there are 6 carbon atoms in each monomer.  Another form of nylon is 6:10 nylon. | |
|  |  | (a) | How many carbon atoms would be in each monomer to make 6:10 nylon? |
|  |  | (b) | Draw the structures of each monomer. |
|  | **8.** | What is the difference between cross-linking and hydrogen bonding? Give an example. | |

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| **SEND** |  | Extratheory questions for CORE-PLUS students |

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|  | **9.** | Water is a covalent molecule that melts at 00C, while a plastic ice-cream container melts over a temperature range, softening at first, and gradually becoming more liquid. Explain the different behaviour of each compound in terms of their molecular structures, and the forces between the molecules. |

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|  | **10.** | Polyethene can be manufactured as high density or low density. Which type would be more rigid and resist softening? Explain in terms of the forces of attraction that exist between the molecule chains. |

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|  | **11.** | The monomers below can undergo a condensation reaction. | |
|  |  | **(CH2)2**  **C**  **O**  **Cl**  **H**  **N**  **H**  **CH2**  **C**  **O**  **Cl**  **H**  **N**  **H** | |
|  |  | (a) | Draw a section of the polymer chain. |
|  |  | (b) | Why must each of the monomers in this case have two functional groups? |
|  |  | (c) | After the polymer is formed, hydrogen bonding can occur between the polymer chains.  Show where the polar sections of the polymer are and where the hydrogen bonding would take place. |
|  |  | (d) | What effect would hydrogen bonding have on the properties of a polymer? |

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|  |  | Checklist |
|  | ***This week you should have sent the work shown below to your teacher.***  Tick the items you have sent and keep this as your record. |
|  |  | * Skills Questions 1 to 8 on page 14. * CORE-PLUS students also do Questions 9 to 11 on page 15. * Practical Exercise 1: Polymers made from milk (page 3). * Practical Exercise 2: The tangling of polymer chains (page 8). * The summary table on recycling plastics (page 13). |

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| **SEND Graded Task 2: Organic Chemistry** |

**Graded Task Investigate the properties of polymers and organic compounds.**

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| This Graded Task contains three activities: | |
| **Experiment 1**  *Pages 3 – 6* | Slime away; the properties of a hydrogen bonded polymer. |
| **Models of molecules**  *Page 7* | Use Rasmol to model isomers of butane. |
| **Summary**  *Pages 8 – 10* | Complete two summary diagrams:  A Venn Diagram summary of key terms in organic chemistry.  A flow chart summary of chemical bonding. |

All students do these three tasks.

CORE-PLUS students include these tasks as well.

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|  | CORE-PLUS students add the following activities to this assessment task. |
| **Experiment 2**  *Pages 11 – 17* | Part A: Solubility tests of organic compounds.  Part B: Combustion tests of organic compounds.  Part C: Addition reaction of an organic compound. |
| **Models of molecules**  *Page 18* | Use Rasmol to name unknown compounds from their molecular structure. |

**Experiment 1 Slime away**

*This experiment will need to be done in a laboratory*

**Aim** To explore the change in physical properties of a polymer as a result of hydrogen bonding.

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| **Introduction**  →  **C**  **C**  **H**  **OH**  **H**  **H**  **C**  **C**  **H**  **H**  **C**  **C**  **H**  **H**  **H**  **H**  **OH**  **OH**  **C**  **C**  **H**  **H**  **OH**  **H**  Vinyl alcohol | Slime is made form a linear polymer hydroxyethene, commonly called vinyl alcohol.  *Polyvinyl alcohol* |
| *The borate ion*  **B−**  **OH**  **OH**  **HO**  **HO** | An addition polymerisation can produce polyvinyl alcohol. In this experiment polyvinyl alcohol mixes with borax.  The borate ion has the structure shown on the left.  The polar –OH group on the polymer and the –OH group on polyvinyl alcohol form hydrogen bonds. The result is a gel-like slime where the hydrogen bonds can break and reform easily. |

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| **Materials needed** | * Styrofoam cup * paddle pop stick * 50 mL of 6% solution of polyvinyl alcohol * 10 mL of 4% solution of borax * green food dye * 1 zip lock bag |

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| **Safety procedures and precautions** |
| * Wear safety glasses and lab coats at all times, and gloves as required. * Wash your hands thoroughly with soap and water before and after handling chemicals. * Both the borax and the PVA can irritate skin. Wear gloves. Wash hands after handling the ‘slime’ produced in this experiment. Do not touch your mouth, eyes or skin during and after handing the ‘slime’. |

**Safety form**

|  |
| --- |
| Please indicate that you have understood the information on safety rules in the procedure in this experiment  Name (Print):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  I understand the safety information of this prac (signature) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

|  |  |  |  |
| --- | --- | --- | --- |
| **Method**  slime  <http://play.powerhousemuseum.com/makedo/slime.php> | 1. 50 ml of the 4% poly vinyl alcohol, (PVA), is added to a Styrofoam cup. 2. Food colouring can be added to the PVA in the cup to make different colours. Simple food colouring is recommended. This colouring should be added before the borax solution has been added, or it can be added directly to the borax solution. 3. Add 10 ml of the 4% borax to each cup. Begin stirring the mixture immediately with the paddle pop stick. Within a couple of minutes the slime will be formed.   Record your observations as you stir the mixture. | | |
|  | | Observations:  ……………………………………………………………. |
|  | | *The slime is non-toxic and is safe to handle, so you can put it in a Zip-lock bag (or latex glove) and seal it to take home.*  ***Do not*** *touch your mouth, eyes or skin after handling the slime until you have* ***washed your hands*** *with soap and water.*  *Keep it in a plastic bag until it is discarded.*  ***Do not*** *put it down the sink because it can clog drains.* |

|  |  |
| --- | --- |
| **Tests and observations** | 1. Perform the following tests on the slime and record your observations of each test. Wear gloves as you handle the slime. |
|  | * Take some slime in your hand and stretch itslowly.   ……………………………………………………… |
|  | * Repeat the stretching exercise only this time stretch it rapidly.   ……………………………………………………… |
|  | * Roll some slime into a ball. Throw the ball onto a hard surface.   ……………………………………………………… |
|  | * Place the ball of slime onto a surface. Press down on it slowly.   ……………………………………………………… |
|  | * Repeat the pressing test only this time press down rapidly.   ……………………………………………………… |
|  | * Place a small amount of the slime on a paper towel and set it off to the side to dry until tomorrow. Repeat the stretching tests.   ……………………………………………………… |

|  |  |  |
| --- | --- | --- |
| **Discussion questions** | **Properties of the slime**  Slime is an example of a non-Newtonian fluid; under some conditions it behaves as a fluid, under other conditions it behaves like a solid. | |
|  | 1. Based on your tests | |
|  | 1. under what conditions does slime behave as a fluid?   …………………………………………………………………………………………………………………………   1. under what conditions does slime behave as a solid?   ………………………………………………………………………………………………………………………… | |
|  | 1. After testing the slime left out overnight how does amount of the water affect the elasticity of the slime?   …………………………………………………………………………………………………………………………………… | |
| **quicksand**  http://www.e-trip.com/fernando/fernando1.htm | 1. Quicksand is another example of a non-Newtonian solid with individual grains of sand suspended in water. It behaves in much the same way as the slime you made in this experiment.   If you started to sink in quicksand, why should you **not** move quickly to drag yourself out? Use your test observations to support your answer.  ……………………………………………………………………………………………………………………………………………………………………………………………………… | |
|  | **Structure of the slime** | |
|  | The slime is the result of hydrogen bonding between polar sections of the PVA polymer and the borate ion. | |
|  | 1. Find and circle the repeating unit in the PVA polymer molecule below. Draw a section of the vinyl alcohol monomer. | |
| **C**  **H**  **OH**  **H**  **H**  **C**  **H**  **H**  **C**  **OH**  **H**  **C**  **H**  **H**  **C**  **OH**  **H**  **C**  **H**  **H**  **C**  **OH**  **H**  **C**  **H**  **H**  **C**  **OH**  **H**  **C**  **H**  **H**  **C**  **OH**  **H**  **C**  **H**  **H** | |  |
| Polyvinyl alcohol (PVA) polymer | | Vinyl alcohol monomer |

|  |  |
| --- | --- |
|  | 1. Draw a diagram showing the polar sections of the PVA molecule and the borate ion. |
| **Discussion continued** | 1. What type of bond formed between PVA and the borate ion?   Show where this bond occurs on your diagram above.  Why is this “bond” not a chemical bond?  …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………   1. How can the elasticity of the slime be explained by its structure and bonding?   …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………   1. Would adding more borax solution affect the elasticity of the slime? Discuss why or why not?   ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

|  |  |
| --- | --- |
|  | **On the net** |
| The site below shows a demonstration of what you would see in an experiment to produce this sort of hydrogen-bonded effect used as slime. Go to  <http://www.dynamicscience.com.au/tester/solutions/chemistry/slimesynthesis.htm> |

**Models of molecules Isomers of butane**

*You will need access to Rasmol on the Chemistry CD to complete this activity.*

**Aim** To use a computer application (Rasmol) to analyse and name isomers of hydrocarbons.

**Procedure**

* 1. Open the [**Rasmol Week 12**](Interactives/Rasmol%20Week%2012) folder on your chemistry CD (in Further Resources). Double click the **reswin** icon to start the program.
  2. Open **butane** and **isobutane**. Set the display to ball & stick.
  3. View each molecule and draw a 3D sketch of each in the boxes below.

Use the sketching conventions shown in Week 11.

* 1. What is the geometry around each carbon atom?
  2. State the correct name of each molecule.

|  |  |  |
| --- | --- | --- |
| Structural formula of Butane  IUPAC name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Empirical formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  | Structural formula of Isobutane  IUPAC name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Empirical formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Some organic compounds have the same molecular formula but different structural formulae. See page 176 in your textbook for further information.

What do these two structures have in common and what do have different? What is this called?

………………………………………………………………………………………………………………………………………………………………………………………………………

**Summary diagrams**

**1. Key terms in organic chemistry.**

Summarise your findings of the three experiments by placing the following terms in the correct sections in the **Venn diagram on the next page.**

**Key terms from this week’s experiments**

|  |  |
| --- | --- |
| * Saturated hydrocarbon | * Unsaturated hydrocarbons |
| * Non-polar molecules | * Undergo addition reactions |
| * General formula Cn H2n | * Organic compounds |
| * Dissolve in non polar solvent | * Contain at least one double bond |
| * Undergo combustion | * Undergo substitution reactions |
| * General formula Cn H 2n+2 | * From long chains called polymers |
| * Contain only carbon- carbon single bonds | * Held together by dispersion forces. |

**1. Summary of key terms in organic chemistry**

Place the terms on the previous page in the correct sections on the Venn diagram below.

**Applies to alkanes only**

**Applies to alkenes only**

**Applies to alkanes *and* alkenes**

**2. Summary of chemical bonding**

Throughout this unit we have studied the chemical bonding in different materials.

Summarise your understanding of chemical bonding by filling in the missing parts of the following diagram.

Elements

Can be classified as

Metals

Non-metals

Its chemical bonding is

Its structure is

Its structure is

Intermolecular forces include

Its chemical bonding is

Its chemical bonding is

An example

An example

An example

Its structures are

|  |  |
| --- | --- |
|  | **The following experiments and activities are for**  **CORE-PLUS students** |

**Experiment 2 Solubility and combustion of carbon compounds**

**Addition reactions of carbon compounds**

*This experiment will need to be done in a laboratory*

**Introduction**

Hydrocarbons are the simplest organic compounds in that they contain only carbon and hydrogen. Water is usually always used as a solvent for most experiments in chemistry.  However, water, which is a polar molecule, and many organic compounds, which are often not polar, are not miscible. Organic compounds which are soluble in water usually also contain polar bonds due to the presence of oxygen, such as the alcohols and acids. Do you expect hydrocarbons, which contain only hydrogen and carbon to be polar?

**Safety note:**

**This experiment needs to be done as a teacher demonstration. It should be carried out in a fume cupboard.**

One of the most important uses of organic compounds, especially hydrocarbons, is combustion. This is the basis of the internal combustion engines and other heat generating sources such as using methane as the fuel for a gas furnace or water heater and propane for your home barbecue. In fact, the only reaction most alkanes undergo is combustion, combining with molecular oxygen to produce carbon dioxide and water. If the combustion is incomplete, carbon or carbon monoxide and water form.

**You will need:**

Dropper bottles containing different organic compounds for example,

* + - * heptane
      * heptene
      * cyclohexane
      * cyclohexene
      * ethanol
      * ethanoic acid

Test tubes

Two cork stoppers

100ml plastic squeeze bottle

Bunsen burner

Tongs

Tapers

Safety glasses

0.02 M (mol per L) potassium permanganate solution, KMnO4.

|  |
| --- |
| **Safety procedures** |
| * Wear safety glasses and lab coats at all times. * Wash your hands thoroughly with soap and water before and after handling chemicals. * A fume cupboard must be used for these experiments. * The vapours of the organics used are toxic, so ensure that direct inhalation is avoided. * Dispose of waste properly- do not pour organic compounds down the sink. Place all organic waste in a waste bottle in the fume cupboard. |

|  |  |
| --- | --- |
| **Materials hazards in experiment 2** | |
| **Material used** | **Hazard and control** |
| **Heptane** | Highly flammable. Keep away from naked flame. Wear suitable clothing and eye protection. Use fume cupboard. |
| **1- heptene** | Highly flammable. Keep away from naked flame. Wear suitable clothing and eye protection. Use fume cupboard. |
| **Cyclohexane** | Highly flammable. Keep away from naked flame  Harmful, vapours may cause dizziness. Wear suitable clothing and use eye protection. Use fume cupboard. |
| **Cyclohexene** | Highly flammable. Keep away from naked flame.  Harmful. Wear suitable clothing and use eye protection. Use fume cupboard. |
| **Ethanol** | Highly flammable. Keep away from naked flame.  Irritating to the eyes. Wear suitable clothing and eye protection. |
| **Ethanoic acid** | Highly flammable and caustic. Keep away from naked flame. Wear suitable clothing and eye protection. Use fume cupboard. |

**It is important that you follow the safety guidelines. Complete the safety form below, to let us know that you have read and understood them.**

**Safety form**

|  |
| --- |
| Please indicate that you have understood the information on safety rules in the procedure in this experiment  Name (Print):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  I understand the safety information of this prac (signature) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Procedure**

**PART A: Test of solubility in water**

**Carry out the following tests in a fume cupboard.**

**Safety note:**

**This experiment needs to be done as a teacher demonstration. It should be carried out in a fume cupboard.**

1. Place five drops of heptane, with ten drops of water in a test tube. Shake the mixture and record your observations about the solubility of heptane in water. Shake the test-tube occasionally and observe several times before you make a decision about the solubility of the substance.
2. Repeat step 1 for the other substances in the table. Record your observations in the **observation table on page 15**.

**Discussion of the solubility tests**

1. Explain your observations about the solubility of organic compounds in water in terms of the polarity of the molecules.

………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

1. Draw a diagram to show why some organic compounds dissolve in water and others don’t.

|  |  |
| --- | --- |
|  | **EXPERIMENT 2 continued** |

**PART B: Combustion of hydrocarbons**

**Carry out the following tests in a fume cupboard.**

* 1. Place about 2 drops (*no more*) of heptane in an evaporating dish. Start the chemical burning by carefully bringing a lighted match, or burning splint, next to the liquid surface.

**Safety note:**

**This experiment needs to be done as a teacher demonstration. It should be carried out in a fume cupboard.**

* 1. Repeat this process with an equally small volume of cyclohexane. Record your observations in the **observation table on page 15**.
  2. Methane, CH4, is the major component of the gas we use domestically. The gas flame we see is combustion of methane. Observe differences in the gas flame when the amount of air is controlled. Observe the Bunsen flame with the air hole closed. Then open the air hole of the Bunsen burner. Observe the change in flame colour.

**Discussion of the combustion tests**

* + 1. Describe the difference in the flame when an alkane and a cycloalkanes combusts.

Alkane flame …………………………………………………….

Cycloalkane flame ………………………………………………

* + 1. Explain why methane is a gas at room temperature while the other hydrocarbons tested are liquid.
    2. Write balanced chemical equations for the combustion of natural gas(CH4):
  1. When the air hole of the Bunsen burner is open (unlimited oxygen).
  2. When the air hole is closed (limited oxygen).

**Experiment 2 Observation table.**

**Record your observations of the solubility tests and combustion tests in Experiment 2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organic compound** | **Molecular structure** | **Solubility in water** | **Combustion test:**  **flame observations** |
| **Heptane C7H16** | **CH3−CH2−CH2−CH2−CH2−CH2−CH3** | **⬜ Soluble ⬜ Insoluble** |  |
| **1- heptene C7H16** | **CH2**= **CH2−CH2−CH2−CH2−CH2−CH3** | **⬜ Soluble ⬜ Insoluble** |  |
| **Cyclohexane** | **CH2**  **CH2**  **CH2**  **H2C**  **H2C**  **H2C** | **⬜ Soluble ⬜ Insoluble** |  |
| **Cyclohexene** | **CH**  **CH2**  **CH2**  **HC**  **H2C**  **H2C** | **⬜ Soluble ⬜ Insoluble** |  |
| **Ethanol** | **CH3−CH2−OH** | **⬜ Soluble ⬜ Insoluble** |  |
| **Ethanoic acid** | **CH3−COOH** | **⬜ Soluble ⬜ Insoluble** |  |
| **Methane (air hole open)** | **CH4** |  |  |
| **Methane (air hole closed)** | **CH4** |  |  |

|  |  |
| --- | --- |
|  | **EXPERIMENT 2 continued** |

**PART C: Addition reactions that break double bonds in organic compounds**

*This experiment will need to be done in a laboratory*

**Aim:** To investigate the relative reactivity of the alkenes

**Introduction**

Alkenes are hydrocarbon compounds that have a carbon-carbon double bond. The double bond is the site where reactions occur. In these experiments, you will investigate the difference in the reactivity of an alkenes (double bond) compared with an alkanes (single bonds).

**You will need:**

Dropper bottles containing cyclohexane, cyclohexene and 0.02mol per litre (mol L-1) potassium permanganate solution (KMnO4), two test tubes with a cork stopper.

**Procedure**

**Carry out the following tests in a fume cupboard.**

**Safety note:**

**This experiment needs to be done as a teacher demonstration. It should be carried out in a fume cupboard.**

* + 1. Place 10 drops of cyclohexene in one test tube and 10 drops of cyclohexane in another test tube.
    2. Add 2 ml of potassium permanganate solution to each tube. Cork the tube and shake. Observe any colour changes.
    3. Record your result in the observation table below.

**Observation Table**

|  |  |  |
| --- | --- | --- |
| **Organic compound** | | **Observation** |
| **Cyclohexane** | **CH2**  **CH2**  **CH2**  **H2C**  **H2C**  **H2C** |  |
| **Cyclohexene** | **CH**  **CH2**  **CH2**  **HC**  **H2C**  **H2C** |  |

**Discussion**

1. Saturated hydrocarbons contain only single C–C bonds. Unsaturated hydrocarbons contain at least one double C==C or triple C≡≡C bond. Tick the correct choice below.

Cyclohexane ⬜ Saturated ⬜ Unsaturated

Cyclohexene ⬜ Saturated ⬜ Unsaturated

1. Which hydrocarbon reacts with the potassium permanganate solution?

………………………………………………………………………

1. What does the disappearance of the purple colour suggest?

………………………………………………………………………………………………………………………………………………

1. Which part of the hydrocarbon molecule was responsible for decolourised the potassium permanganate solution?

………………………………………………………………………

1. Unsaturated hydrocarbons react readily with bromine gas and the colour of bromine disappears as the bromine reacts with the double bond. The example below shows the reaction of propene with bromine.

**C**

**C**

**H**

**H**

**OH**

**H**

Vinyl alcohol

H2C==CH—CH3  + Br2

→

*Colourless gas*

*Brown gas*

H2C—CH—CH3

Br

Br

*Colourless gas*

Predict the reaction between vinyl alcohol and Bromine gas.

Write a balanced equation of the reaction.

We learned about different types of reactions of alkenes. See page 179 in your textbook to refresh your memory.

1. What type of reaction is this?

……………………………………………………………………..

|  |  |
| --- | --- |
|  | **Models of molecules: Identify unknown molecules** |

*You will need access to*[***Rasmol Week 12***](file:///J:\ch011\Interactives\Rasmol%20Week%2012\Molecules%201,%202%20and%203) *on the Chemistry CD to complete this activity.*

**Aim** To use a computer application (RasMol) to identify and name organic compounds.

**Procedure**

* 1. Open the Rasmol folder on your chemistry CD and double click the **reswin** icon to start the program.

Examples showing how to use RasMol were given in Week 10.

* 1. Go to the **File** menu, choose **Open** then select **molecule** **1**. Set the display to ball & stick.
  2. View the molecule to work out its structural formula and correct name. Identify any double bonds. Complete the table below.
  3. Repeat steps 1, 2 and 3 for **molecules** **2** and **3**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Compound | Formula | Structural formula | IUPAC Name | Saturated or unsaturated |
| **Molecule 1** |  |  |  |  |
| **Molecule 2** |  |  |  |  |
| **Molecule 3** |  |  |  |  |

|  |  |  |
| --- | --- | --- |
|  |  | Checklist |
|  | ***This week you should have sent the work shown below to your teacher.***  Tick the items you have sent and keep this as your record. |
|  |  | * Observations and discussion of Experiment 1 on pages 3 – 6. * ‘Modelling Isomers of butane’ on page 7. * The completed summary diagrams on pages 9 – 10 * CORE-PLUS students also send observations and discussion from Experiment 2, (on pages 13 – 17) and ‘Identifying unknown molecules’ (on page 18). |

|  |  |
| --- | --- |
|  | **SEND Practical exercise 1:**  **Investigate the surface tension of water.** |
| *This experiment can be done at home.* |

|  |  |
| --- | --- |
| **Aim** | To investigate the effect of a surfactant on surface tension. |
| **Materials** | A 5-cent coin, an eye-dropper, some water, some dishwashing detergent. |
| **Method** | 1. Estimate how many drops of water you could get onto a 5-cent coin without water spilling over the edge.   From a very small height, place water onto the coin, drop by drop, slowly and carefully.  Record the number of drops that stay on the coin before spilling over the edge.  Estimated number of drops …… Actual number of drops…… |
|  | 1. Repeat the test using water with a few drops of dishwashing liquid mixed through the water. Record the number of drops that now stay on the coin.   Estimated number of drops …… Actual number of drops…… |
| **Discussion** | How close was your estimate to the actual number of drops in each case? Explain your observations in terms of surface tension.  …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………. |

|  |  |
| --- | --- |
|  | **SEND Practical exercise 2:**  **Investigate the strength of surface tension** |
| **This experiment can be done at home.** |

|  |  |
| --- | --- |
| **Aim** | To observe the strength of surface tension of water and the effect of a surfactant on surface tension. |
| **Materials** | Two glasses of water  A plastic spoon or fork  A few drops of dishwashing detergent.  A paperclip or straight pin  A few 5-cent coins |
| **Method** | 1. Place a paper clip or straight pin onto a plastic spoon or fork. Carefully slide the paperclip into a glass of water. Then slowly remove the spoon so that the pin or paperclip floats. |

|  |  |
| --- | --- |
| Untitled-1 | 1. Add a couple drops of dishwashing detergent to the water away from the pin or paperclip. Observe the effect this has on the floating pin or paperclip. If the paperclip is still floating, then add a couple of drops of detergent on the other side of the paper clip or on the clip. Record your observations. |
| <http://magic.about.com/od/science-magic-tricks/ss/Floating-Metal-Science-Magic-Trick.htm> |  |

|  |  |
| --- | --- |
| **Untitled-2**  <http://www.exo.net/~pauld/summer_institute/Nano%20Institute/Day1%20Scale/selfassemblyFloatingCoins.html> | 1. Take a fresh tray of water and some 5-cent pieces. Place a 5-cent piece onto a plastic fork. Carefully slide the 5-cent piece into the tray of water. Keep the coin level. Then slowly remove the fork so that the coin floats. 2. Now carefully add another 5-cent piece carefully so that it floats. Continue until the next one sinks. Record how many 5-cent pieces you were able to float. |
|  |

|  |  |
| --- | --- |
| **Discussion questions**  **insect** | 1. Explain why objects are able to float on water.   ………………………………………………………………………………………………………………………………………………………………………………………………………………………………   1. Explain why adding a few drops of dishwashing detergent affects the way an object floats on water.   ………………………………………………………………………………………………………………………………………………………………………………………………………………………………   1. Why do the particles at the surface of a liquid behave differently from those in the bulk of the liquid?   ………………………………………………………………………………………………………………………………………………………………………………………………………………………………   1. Some insects are able to excrete an oily substance which coats the fine hairs on their legs. Explain how this prevents these insects from sinking in the water.   ……………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

|  |  |
| --- | --- |
|  | **SEND Practical exercise 3:**  **Investigate the wetting properties of water** |
| *This experiment can be done at home.* |

|  |  |
| --- | --- |
| **Aim** | To investigate the degree of wetting of different surfaces by water. |

|  |  |
| --- | --- |
| **Materials** | \* Several different surfaces such as   * Dinner plates: one washed, the other greasy * Non-stick cooking surface * Waxed surface such as a car bonnet * Plant material such as a plant leaf or petal   \* fresh water in a beaker or glass  \* dropper or teaspoon |

|  |  |
| --- | --- |
| **Background** | Wetting refers to the amount of contact between a liquid and a solid surface.  If water spreads over a surface without beading it ‘wets’ the surface. |

|  |  |
| --- | --- |
|  | The degree of wetting can be judged by the contact angle between a drop and the surface.  The relationship between wetting and contact angle is shown in the diagram below. |
|  | Good Moderate Poor  Liquid  Surface  Wetting Partial wetting Non-wetting |

|  |  |  |
| --- | --- | --- |
| **Method** | **1.** | Arrange the surfaces to be tested.  Using a dropper or teaspoon sprinkle an amount of water onto the first surface. Observe whether the water beads or coats the surface.  Estimate the contact angle of drops that form on the surface.  Estimate the degree of wetting of the surface.  Record your observations in the table on the next page. |
|  | **2.** | Repeat step 1 for the remaining surfaces. |

**Table of Observations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Surface tested** | **Observation** | **Estimate contact angle.** | **Estimate degree of wetting.** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

|  |  |
| --- | --- |
| **Discussion** | Based on your observations, rank the surfaces you tested in order from poor wetting surface to good wetting surface. |
|  |  |

|  |  |  |
| --- | --- | --- |
| **Questions** | **1.** | Why does water wet some surfaces better than others? Use your observations to explain your answer.  …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |
|  | **2.** | From the surfaces that you tested, which had the highest surface energy? Which had the lowest? Explain why.  …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

|  |  |  |
| --- | --- | --- |
|  | **Emulsions** | *This lesson is optional for CORE-PLUS students* |

We know that oil and water don’t mix. They stay as two separate layers with a clear boundary between them.



Oil and water are immiscible (don’t mix)

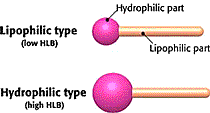
Two liquids which don’t mix are called **immiscible.**

For example, a salad dressing of oil and vinegar forms separate layers. If we add some mustard the dressing remains mixed.

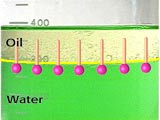
One end of the mustard particles attracts the water particles and the other end attracts the oil particles. This stops the separate layers forming. The mustard is called an **emulsifying agent**. Many different emulsifying agents are used in manufactured food to stop vegetable oils and water forming separate layers.



Milk is another emulsion of fat droplets dispersed in water. The milk is mechanically stirred and emulsifying agents are added to maintain the emulsion. Without an emulsifying agent the fat droplets, would form a layer on top.

**How does an emulsifier work?**

An emulsifier consists of a water soluble **hydrophilic** (water-loving) part and an oil-soluble **lipophilic** (oil-loving) part within it.

When an emulsifier is added to a mixture of water and oil, the emulsifier anchors its hydrophilic part into water and its lipophilic part into oil.

The surface tension between the two layers is reduced by the emulsifier,  
allowing the oil and water layers to mix.

|  |  |
| --- | --- |
| There are two types of emulsions | |
| Oil-in-water (O/W) emulsions  Water continuous phase  Suspended  oil drops | Water-in-oil (W/O) emulsions  Oil continuous phase  Suspended water drops |
| The oil droplets are dispersed in a continuous phase of water. The most familiar examples of oil in water emulsions are salad dressings or milk. | The water droplets are dispersed in a continuous phase of oil. Many medicinal creams and butter are water in oil emulsions. |

Sources: <http://www.kitchencritic.co.uk/upload/2009/04/salad-sunrise-oil-vinegar.jpg>

<http://www.photographersdirect.com/buyers/stockphoto.asp?imageid=641936> <http://www.takelifeon.co.uk/img/ss_breakfast_milk.jpg>

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|  | **Go to Chapter ten in your textbook, and read…** |
| To find out more about emulsions read the section *Emulsions* on pages 234 to 236 of your textbook*.* |

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|  | **SEND** | **Practical exercise 4:**  **Investigate emulsions of household products** |
| **This experiment is optional for CORE-PLUS students**  **and can be done at home.** | |

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| **Aim** | To investigate the labelled emulsions of household products. |
| **Method** | Go to your kitchen cupboards and bathroom cabinet and look for bottles, jars or tubes of mixtures which use water or oil as the main ingredient.   * Identify the type of emulsion: oil in water or water in oil. * Name a key property of each product that identifies it as oil in water or water in oil. (For key properties see Table 10.2, p.236 in your textbook). * Look at the labels and see if you can identify the emulsifier. * Show your findings in a table similar to the table shown below. A few examples will do. Send in your finished table. |

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| --- | --- | --- | --- |
| **Product** | **Type of emulsion** | **Key properties** | **Emulsifier** |
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| **Discussion questions** | **1.** | Butter is a water in oil emulsion, but milk is an oil in water emulsion. Draw a diagram to show how an emulsifier stabilises each type of emulsion. |
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|  | **2.** | Based on the properties of emulsions, name four tests that could be used to test for the type of emulsion in hair care products.  …………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………… |

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| **LESSON 3** | **Nanotechnology** |



**You may have heard of tennis racquets reinforced with carbon nanotubes or transparent sunscreens that contain nano sized particles.**

**This is nanotechnology…the application of nanoscience to make useful items.**

**Nano-science is the study of nanoparticles and their properties.**

**Nanoparticles are extremely small particles: A nanometre is a "billionth" of a metre.**

**It’s hard to imagine particles that small!** **Let’s see an example of the nano scale.**

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| Zooming in…. | | |
| ex1 | | |
| 1. Look at your hand. At the 10 cm scale (10−1 meter) we can clearly see fingers and skin. | 1. At the 1cm scale (10−2 meter) we can see the structure of skin | 1. At the 1 mm scale (10−3 meter) we can see cracks in the skin. |

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| ex2aex2b | | |
| 1. At the micron level,   1 millionth of a metre (10−6 meters), cracks look like deep crevices. | 1. At 10 microns we can see individual cells, such as the white blood cell above. | 1. At 1 micron, we begin to see individual DNA strands that exist within the nucleus of the cell. |

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| ex3b | | |
| 1. At the nano level, 1 billionth of a metre (10−9 meters)… | 1. …we can see double helix that make up DNA. | 1. At 1 nanometre, we begin to see individual atoms that make up the DNA strand. |

Source: <http://nanosense.sri.com/activities/sizematters/>

**How can we see something as small as a nanoparticle?**

The prefix “nano” comes from a Greek word “***nanos***” meaning dwarf.

A nanometre is a "billionth" of a metre. It's easy for us to visualize a meter, but a "billionth" of that? Such a scale eludes most of us. Advances in microscope technology allows us to see particles as small as nanoparticles.

1. **The light microscope**

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|  | red blood cells  magnification 400 times. |
| A human hair is about 50-100 microns (about 0.1 millimetres) thick.  The naked eye can see to about 20 microns in width.  Light microscopes magnify about 1000 times, letting us see up to about a micron.  At this magnification we can see images of particles like red blood cells. | |

1. **The electron microscope**

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|  |  |  | red blood cells  magnification 4000 times. |
| Scanning electron microscopes (SEMs),were invented in the 1930s.They let us see objects as small as 10 nanometers. They work by bouncing electrons off surfaces to create images.  The small size of electrons allows greater resolution than light microscopes.  At this magnification we are able to see things like blood cells in greater detail. | | | |

Sources: <http://www.biotech.iastate.edu/facilities/BMF/images/SEMFaye1.jpg> <http://cgee.hamline.edu/see/questions/dp_cycles/cycles_bloodcells_bw.jpg>

1. **Modern microscopes**

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| <http://www.answers.com/topic/scanning-tunneling-microscope> | Modern microscopes give us a new way to “see” at the nano scale. We these microscopes can see extremely small things, like atoms.  **Scanning probe** microscopes scan the surface of a sample with a beam of electrons and were developed in the 1980s.  **Atomic Force** microscopes create an image of the atomic surface in response to the electromagnetic forces between the atoms of the surface.  **Scanning Tunneling** microscopes apply a flow of electricalcurrent to create an image of the atomic surface from the strength of the current. |

**Things change at the nano scale**

Nanotechnology is a field of research and innovation used to create new materials on the scale of atoms and molecules.

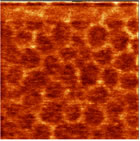
A nanometre is one-billionth of a metre: ten times the diameter of a hydrogen atom.

The diameter of a human hair is, on average, 80,000 nanometres.

To imagine this scale, consider walking for a day. Every step you take is about a meter. Let’s say every step you took was a nanometer. It would take you a day to walk across a hair. That’s the scale we are talking about.

Gold at the nano scale

is red in colour

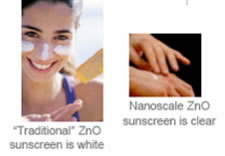
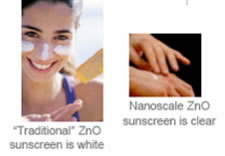


At such scales, the ordinary rules of physics and chemistry no longer apply.

Characteristics, such as colour, strength, conductivity and reactivity, can differ substantially at the nano scale.

For example, particles of gold metal in the nano scale range don’t look gold anymore… they look RED! In fact, depending on size, they can turn red, blue, yellow, and other colors. Why? Because different thicknesses of materials reflect and absorb light differently.

The colour of gold is one example of the effect of particle size on optical properties.



Traditional ZnO sunscreen is white.

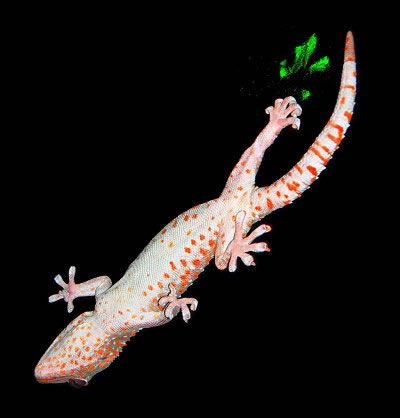
Nanoscale ZnO sunscreen is clear.

Another example is nano sunblock. Zinc oxide, ZnO, is the key ingredient in sunblock. It is a thick white paste that blocks UV light and scatters visible white light.

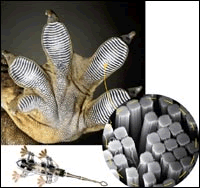
Nano sunblock contains nano sized zinc oxide particles. Nano sunblock still blocks UV light, but the particles are so small that it appears clear, not white.

This is because the nano sized particles are so small compared to the wavelength of visible light that they don’t scatter it.

**Why do properties change at the nano scale?**

Nanoscale objects have a far greater amount of surface area compared to their volume, so surface effects are far more significant than for larger particles.

Examples of surface effects are found in nature. Geckos have an amazing ability to walk on even the most slippery surface and to stick upside down to ceilings even by only one leg. It appears that geckos have lots of very fine hairs that make very effective contact with surfaces.

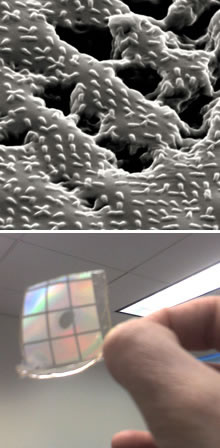
Scientists only recently worked out how the microscopic adhesive hairs – or setae – that cover the animals’ feet work.

Gecko toes are sticky because they are covered with millions of flexible **nanopillars**, giving them a very large surface area.

It turns out Van der Waals’ forces are the key forces at work behind the nanopillars adhering to a surface.

Source: <http://kitup.military.com/2007/10/coming-soon-100.html>

Adapting gecko-like properties for medical applications has resulted in a medical adhesive, called **gecko tissue tape**. It is a very sticky tape that could replace sutures in medical procedures.



Gecko tissue tape has new applications in medical procedures.

The adhesive is inspired by geckos' feet, which allow the reptiles to walk along the ceiling and up and down smooth walls.

The adhesive gecko tape relies on nanoscale pillars, just like geckos, combined with chemical glue. It is the first such tape to show good adhesive strength and safety.

The nanotechnology in gecko tissue tape has the following properties:

* the adhesive sticks once and strongly in a wet environment
* is biocompatible (that does not cause inflammation),
* is biodegradable (dissolves over time without producing toxins)
* is elastic (in order to suit the bonded tissues and stretch with them).

Gecko tissue tape is just one example showing why nanotechnology is so important. Nanotechnology is a way of increasing the surface area of a material by building it with nano sized particles, rather that breaking down large particles into smaller ones.

Source: <http://www.technologyreview.com/biomedicine/20301/>

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| ***Quick Check***  **Exercise 2** | **A space elevator from carbon nanotubes** |
| *Answers are on pp.28 – 29* |  |



Carbon is a versatile element.

Carbon has four bonding electrons, so it can bond in several different ways.

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| Structures of carbon can be very strong | | |
| diamond | buckyballs | nanontube… graphite rolled into a tube |
| diamond | bucky | graph roll roll |

|  |  |
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| **DVD** | **Carbon nanotubes and space elevators** |
| Watch the movie, [***Space elevator***](Interactives/SpaceElevator/SpaceElevator.html), on the Chemistry CD in Further Resources. Then fill in the missing words below. |

|  |  |
| --- | --- |
| elevator  **Word list:**  research  acetylene  ribbons  buckyballs  steel  attraction  iron  one thousandth  carbon  billions  nanotubes  Van der Waal’s  ½ billion  centimetres  diamond  space shuttle  22 000 miles | A space shuttle costs ……………….dollars each trip.  Scientists dream of a space elevator ……..… ………. long to replace the ……….… ………….  Structures of carbon can be very strong: ………………. , ………………., or nanontubes: graphite rolled into a tube.  Nanotubes only a few ………………. long have been produced, so how to produce one 22 000 miles long?  A process was discovered where a silicon plate coated with ………………. reacts with a gas containing ……………….and ………………..  The reaction releases carbon atoms that form ……………….of ………………..  The nanotubes tend to stick together due to a ……………….force of ……………….between them.  The force of attraction allows the nanotubes to be drawn out into fine ………………., each less than ……………….the thickness of a human hair.  Although the ribbons are stronger than ………………., whether they are strong enough for a space elevator cable requires further ………………….. |

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| **SEND Carbon nanotubes and ‘smart’ bridges** |



**Carbon nanotubes can improve the strength and safety of bridge structures.**

**Read the background below, watch the movie, *Smart Bridge*, on the Chemistry CD, then complete the exercise on the next page.**

|  |
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| **What is a carbon nanotube**?  A carbon nanotube is a large molecule made of carbon atoms. The atoms are arranged in hexagons, much like chicken wire, the same arrangement as in graphite.  However, in graphite this 'chicken wire' lies in flat sheets on top of each other.  In a nanotube the sheet is curled up into a tube. |
| tube fold  A sheet of graphite…. folded to form a carbon nanotube. |

Source: <http://research.ncku.edu.tw/re/articles/e/20071026/5.html>

|  |  |
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| nanotube1 | Nanotubes are 100 time stronger than steel but 6 times lighter.  Like graphite they can conduct electricity.  They are also very flexible and extremely thin.  The diameter of a carbon nanotube is about 10,000 times smaller than a human hair.  If nanotubes are added to other materials they increase strength and flexibility.  All of these properties mean that carbon nanotubes can make the things we use stronger and safer. |

**Carbon nanotubes and bridges**

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| When a bridge collapses it occurs suddenly with very little warning. | Bridge joints can break suddenly after years of stress and corrosion inside the joint. | Collapses could be avoided if we could monitor the interior of the joints **before** cracks begin. |
| collapse  A bridge collapse | shear  The broken bridge joint | joint crack  A bridge joint starting to crack. |

|  |  |
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| **DVD** | **SEND Carbon nanotubes and ‘smart’ bridges** |
| Watch the movie, [***Smart Bridge***](Interactives/SmartBridge/Smart%20Bridge.html), on the Chemistry CD, in Further Resources. Then fill in the missing words below. |

|  |  |
| --- | --- |
| **joint2**  **Word list:**  high resolution  high frequency  steel  conduct electricity  sensors  chemistry  nanotech skin  current  carbon nanotubes  conducting nanoskin  piezoelectric  ultrasonic  electrical properties  Sonar  electrical current  audible signal | Bridge collapses could be avoided if it was possible to monitor the bridge joints for signs of stress before cracks begin.  …………….. technology is being trialled used to find cracks in bridges. The sensors are called …………….. sensors. They send and receive …………….. …………….. tones through the bridge. The sonar waves are …………….. and are converted into an …………….. …………….. . The signal from a bridge with a cracked section is different to the signal from a bridge with no cracks.  The …………….. can be placed at strategic places on the bridge to monitor the condition of the metal.  Researchers have developed a …………….. …………….. which can sense damage to metal beneath the surface when a …………….. is passed through it.  The secret of this ‘sensing skin’ are …………….. ……………...  Carbon nanotubes are not only several times stronger than …………….. but they can …………….. ……………...  The …………….. …………….. of the nanotubes allow detection of damage beneath its surface.  A …………….. …………….. map on a computer shows any areas of damage.  It is hoped a …………….. …………….. material could be sprayed or glued over key bridge components. The nanoskin would be able to detect where fractures have occurred.  When damage starts to form the skin’s …………….. …………….. changes its flow causing a change in the computer ‘map’ of the bridge.  By altering the …………….. of the nanoskin allows it would be possible to identify different types of damage to the bridge underneath the skin. |

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| **LESSON 4** | **How could nanotechnology affect the way we live?** |

Let’s look at several examples of how new innovations in nanotechnology might change the way we live. A few of these products are starting to become available, but most are still being researched.

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| **Materials** | **Nanopaint** for cars.  Nanopaint is lot more durable and resistant to rock chips and scratches.  **Stain resistant** or **self-cleaning** clothes is another possible innovation. |

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| **Health care** | **Detecting disease earlier**- Using nanotechnology, we could detect cancer much earlier, which means more successful, easier treatment.  **Preventing viruses from infecting us-** If we could cover the protein that exists on the influenza virus, we would prevent the virus from recognizing and binding to our body cells. We would never get the flu! |

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| **The environment**    A Nanosolar cell | **Nano solar cells** – Nano solar cells mixed in plastic could be painted on buses or roofs.  **Nanopaint** on buildings could reduce pollution – nanobased paint contains titanium dioxide (TiO2) nanoparticles. When nanopaint is exposed to Ultraviolet light, the nanopaticles in the paint breake down organic and inorganic pollutant that wash off in the rain. |

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| **Technology** | **A DVD that could hold a million movies.**  Current CD and DVD media have a storage capacity scale in micrometers. New nanomedia has a storage capacity scale in nanometers. That is 1000 times more storage along each dimension (length, width) or 1,000,000 times greater storage density! |

**What does nanotechnology have to offer that existing technologies do not?**

* Nanoscale particles have fundamentally different optical and reactive properties that larger particles do not.
* Recently identified nanostructures such as carbon nanotubes have fundamentally different mechanical and electrical properties.
* Nanoscale particles have a much higher likelihood of being taken up in biological systems than larger particles due to their size.

**Potential risks of Nanotechnology**

#### Health issues

There are several potential entry routes for nanoparticles into the body. They can be inhaled, swallowed, absorbed through skin, deliberately injected during medical procedures or released from implants.

How these nanoparticles behave inside the organism is one of the big issues that needs to be resolved.

The behaviour of nanoparticles is a function of their size, shape and surface reactivity with the surrounding tissue. They could cause overload on phagocytes, cells that ingest and destroy foreign matter, thereby triggering stress reactions that lead to inflammation and weaken the body’s defences against other pathogens.

Apart from what happens if non-degradable or slowly degradable nanoparticles accumulate in organs, another concern is their potential interaction with biological processes inside the body. Because of their large surface, nanoparticles on exposure to tissue and fluids will immediately adsorb onto the surface of some of the macromolecules they encounter. This may, for instance, affect the regulatory mechanisms of enzymes and other proteins.

**Environmental issues**

Not enough data exists to know for sure if nanoparticles could have undesirable effects on the environment.

Two areas are relevant here:

In free form nanoparticles can be released into the air or water during production (or production accidents) or as waste by-product of a production process, and ultimately accumulate in the soil, water or plant life.

In fixed form, where they are part of a manufactured substance or product, they will ultimately have to be recycled or disposed of as waste.

We don’t know yet if certain nanoparticles will constitute a completely new class of non-biodegradable pollutant. We also don’t know how such pollutants could be removed from air or water because most traditional filters are not suitable for such tasks (their pores are too big to catch nanoparticles).

**Social risks**

Societal risks from the use of nanotechnology have also been raised.

On the instrumental level, these include the possibility of military applications of nanotechnology.

Source: <http://en.wikipedia.org/wiki/Nanotechnology>

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| j0360668 |  |
| **SEND A brief summary of some new products of**  **nanotechnology** |

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|  | **Go to Chapter ten in your textbook, and read…** |
| Pages 237 to 247on *nanotechnology.* Thencomplete the following table that summarises some new products of nanotechnology. |

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| **Nanothechnology** | **How does it work?** |
| Transparent sunscreen | The conventional sunscreen contains up to 50% w/w ZnO (zinc oxide) where as nanomodified sunscreen contains only 2% w/w ZnO. By decreasing the size of ZnO particles, the surface area to volume ratio increases largely.  So ZnO surface acts the UV filter. |
| Self cleaning and non fogging glass |  |
| Stain resistant fabric |  |
| Water repellent coating |  |
| Designer drugs |  |
| Potential risks: health, environmental and social. |  |

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| j0360668 |  |
| **SEND Theory questions:** |
|  |

**Question 1**

* + - * 1. Briefly explain the meaning of surface energy using an example from everyday life to illustrate your answer.
        2. Explain why copper has a higher surface energy than gold, even though they are both metals.
        3. Explain why water has a higher surface energy than paraffin wax, even though water is a liquid, and paraffin wax is a solid.

**Question 2**

Label the hydrophobic and hydrophilic ends of the following molecules:

1. CH3(CH2)12COO−Na+
2. CH3C(CH3)2NH3+
3. CH3(CH2)4Cl
4. CH3(CH2)17COOH
5. CH3(CH2)16N+(CH3)3

|  |  |
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| j0234700 |  |
| **Answers to Exercises** |

**Quick check exercise 1**

* + - 1. **The energy needed to create a new surface by breaking bonds within the substance is referred to as the surface energy. e.g. the amount of energy needed to split a log of wood.**
      2. **Paraffin wax is a non-polar compound with dispersion forces. But water molecules held together by stronger hydrogen bonds. Therefore, the force of attraction between water molecules is greater than the bond strength between paraffin wax. Therefore, water has a higher surface energy than paraffin wax.**
      3. Ethanol has a lower surface energy than glass and will therefore wet it since there is a smaller downward force acting on the ethanol in the thinner tube the ethanol will rise higher in this tube than in the wider tube.

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| capillarytubes2 | The diagram on the left shows the capillary action in four tubes of different diameter  Source:[www.physics.montana.edu/.../capillaryaction.html](http://www.physics.montana.edu/demonstrations/video/2_fluidmechanics/demos/capillaryaction.html) |

* + - 1. Particles in detergent solution have equal attraction to the bulk of the liquid and glass**.**
      2. silicon dioxide (covalent network lattice)> nickel ( metallic) > phosphorus trichloride ( dipole-dipole forces) > decane ( liquid, long molecules, dispersion forces) > liquid oxygen ( small molecules, dispersion forces)

**Quick check exercise 2**

* + - 1. A surfactant is a ‘surface active agent’ that changes the properties of surfaces from being hydrophilic to hydrophobic, or vice versa. It is able to do this due to its characteristic hydrophilic, water loving ‘head’ and hydrophobic, water-hating ‘tail’.
         1. The high surface tension of water behaves like a’ skin’, preventing the needle from sinking.
         2. The needle sinks, since surface tension of water has been lowered.
      2. Liquid particles in the bulk of a liquid are surrounded by liquid, thus only liquid/ liquid interactions are possible. Particles at the surface of a liquid may react with other liquid particles or particles in the air and may consequently experience liquid. Liquid as well as liquid /air interactions.
      3. a. The secretion of oil enables insects to stay above the watersince the oil will not mix with, or dissolve, in the water, i.e. oil will not ‘wet’ the water so the insect remains on the surface.

1. Standing on fewer legs; coating feet with a surfactant before walking on water.

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|  |  | Checklist |
|  | ***This week you should have sent the work shown below to your teacher.***  Tick the items you have sent and keep this as your record. |
|  |  | * Theory Questions 1 and 2 on page 27. * The completed paragraphs on carbon nanontubes and ‘smart’ bridges on page 23. * The completed table on page 26, ‘*A* *summary of some new products of nanotechnology’.* * Practical Exercises 1and 2 on page11. * Practical Exercise 3 on pages 13 – 14 * CORE-PLUS students also do Practical Exercise 4: Emulsions of household products, on page 16. |