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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Chemistry and Biology 2024

92023 Demonstrate understanding of how the physical properties of materials inform their use

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of how the physical properties of materials inform their use.	Explain how the physical properties of materials inform their use.	Evaluate how the physical properties of materials inform their use.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Pull out Resource Booklet 92023R from the centre of this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

Do not write in the margins (). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 10

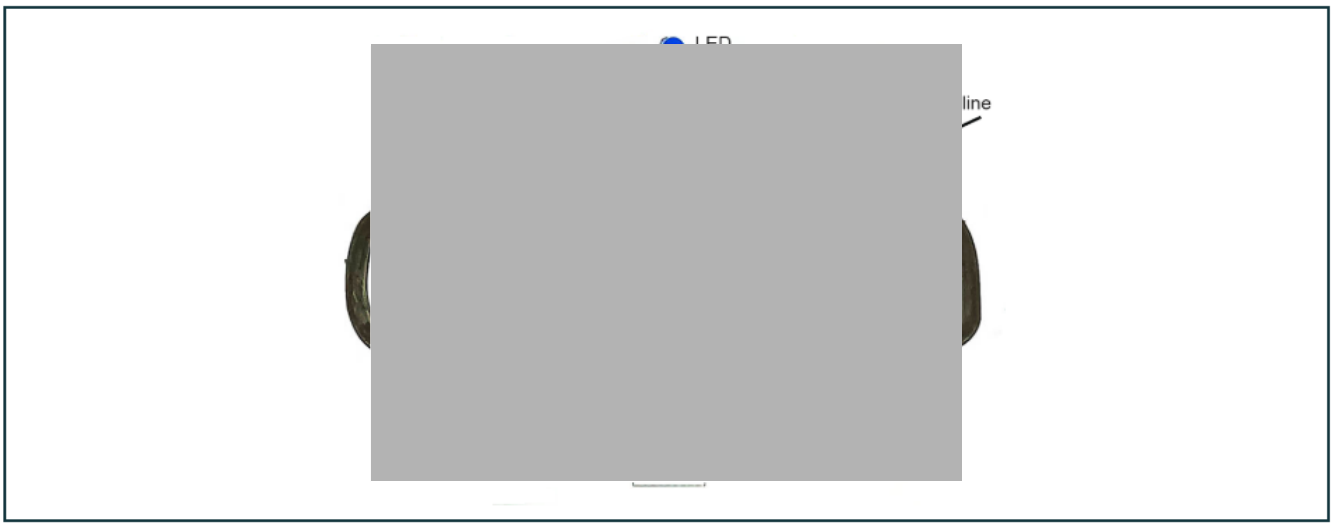
Page 1

Make sure you have the paper Resource Booklet 92023R.

QUESTION ONE: Paper electrical circuits

A pencil containing graphite (carbon), C, has been used to draw an electrical circuit, which is an outline of a car.
A 9V battery and light-emitting diode (LED) are also part of the circuit.

Table 1: Physical properties of graphite (carbon), C		
Physical property	**Numerical values**	**Comment**
Melting point	3 650 °C	Very high
Solubility in water	-	Insoluble
Electrical conductivity	3×10^5 σ (S / m) at 20 °C	Good
Malleability	4.80 GPa	Brittle
Hardness	1 to 2 Moh	Soft



(a) Describe TWO physical properties of graphite (carbon) and link these two physical properties to their use in drawing and creating an operating electrical circuit.

Graphite (Carbon) has two very important physical properties that make it good for usage in drawing and creating an operating electrical circuit. Firstly, properties such as high melting point, at 3650 Degrees Celsius, allow for no melting during electrical current processes. When the current is being carried along this path, it will not reach a temperature high enough to melt the surrounding area or the graphite, so it is efficient for this. Following this, its other properties also help in making an electrical circuit. As we can see from the graph, graphite has been classified as having a 'good' electrical conductivity, meaning it also will be good for the conduction of electricity in a police car diagram, as delocalized valence electrons allow it to carry the current of electricity through and up to the LED diode, and back down again for a continuous cycle.

(b) Explain these TWO physical properties with reference to the structure and bonding of graphite (carbon).

Graphite (Carbon) has two important physical properties, melting point, (In which it is high) and electrical conductivity (In which it is good). The structure of carbon remains in a honeycomb pattern throughout, with a high amount of free, delocalized electrons, classified as valence electrons. These electrons are what help carry the current through the structure, and out the other end, meaning this makes a structure perfect for carrying current. The melting point, being high, means that the bonding is not as strong as that of other harder materials, but does not melt under much heat, but can also carry heat and energy through a circuit to create light. These two properties are very good for the usage in police car diagrams which contain a battery and light.

(c) Evaluate how graphite (carbon) will behave when used to draw and create an operating electrical circuit by linking the TWO physical properties to the structure and bonding.

When graphite (Carbon) is used to create an operating electrical circuit in a police car diagram, it will behave as follows:
When the battery is inserted, and the path is linked up to the LED Diode light, graphite will keep at a steady temperature and will not melt, due to the high melting point caused by is stable level of bonding, meaning it will be able to carry heat and electrical current, but will not melting it deform under the pressure. Secondly, graphite will (assuming the path is linked correctly and done in a way that works best) carry the electrical current of free, delocalized valence electrons, up through its path toward the light, and almost immediatly begin a cycle of negative and positive electron flow, meaning the light will work effeciently. This shows that its supposed 'good' electrical conductivity, is correctly established, and so for as long as the diagram is intact, and the graphite lines are present, the light will continue to work until the battery runs out, assuming the graphite is of the right thickness, and its the correct temperature.

Source (adapted)

Car: Steam Powered Family. (2024). *Simple curcuit project* [Image]. steampoweredfamily.com/paper-simple-circuit-project

Arrow: [Vector image]. stock.adobe.com/770919389

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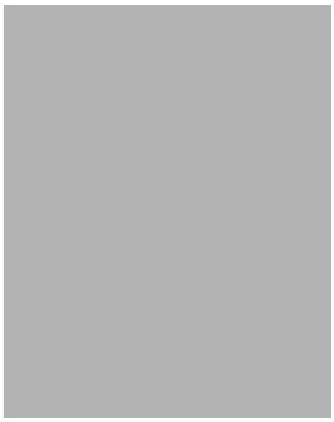
QUESTION TWO: Electrical fire

Carbon dioxide fire extinguishers can be used safely to put out electrical fires. These extinguishers are filled with non-flammable carbon dioxide, CO_2, gas.

Table 2: Physical properties of carbon dioxide and air		
Physical property	**CO_2**	**Air**
Density at 20 °C (kg/m^3)	1.98	1.20
Electrical conductivity	Insulator	Insulator



A carbon dioxide fire extinguisher

(a) Describe TWO physical properties of carbon dioxide and link these two physical properties to the safe use of carbon dioxide to prevent oxygen in the air from fuelling a fire.

Carbon Dioxide, as used in fire extinguishers, have two main physical properties that make it effecient and safe for putting out electrical fires. Fire extinguishers have a electrical conductivity that is classified with the word "insulator", in short terms, this means a material that completely cuts of the electrical current of a active electrical source. This could be compared to standing on a plastic stool when touching an electric fencing system, but the plastic, cuts of the current as it is a hard and strong structured material. Carbon Dioxide, being dense and holding NO delocalized electrons, makes it an insulator, good for usage in stopping electrical fires as when ignited and sprayed directly at the fire, the strong structure will cut it off. Another property, Density, also helps this matter. Carbon Dioxide has a high density at 1.98, meaning that air which fuels and is contained in fires, at 1.20, is no match to the high density of carbon dioxide. So therefore, when a highly dense substance and a lower dense substance meet, known as carbon dioxide being applied to oxygen in a fire, the fire will be overpowered and covered by the dense substance, and therefore be forced to completely cut off its oxygen (air) flow and electrical current.

(b) Explain these TWO physical properties, with reference to the structure and bonding of carbon dioxide.

Density and electrical conductivity both come into play in carbon dioxide fire extinguishers. These fire extinguishers have a high amount of carbon dioxide, and density is created by how strong the structure and bonding is. The higher the density, the more likely the structure has very strong bonding with little to NO valence (delocalized electrons). These delocalized electrons are only present in things with a high electrical conductivity, and therefore, an insulator such as carbon dioxide, has a strong structure and bonding, compacted tightly and densly, making it not allow for electrical current altogether. Its density also applies. We know that if something has a good electrical conductivity, it must be less dense and things must more easily flow through it, helping it carry current. Because carbon dioxide is an insulator, it means that its high density at 1.98, stops any kind of electrical current from passing through, and gives it an advantage in also cutting off current.

(c) Evaluate how carbon dioxide will behave when used as a fire extinguisher by linking the TWO physical properties to the structure and bonding.

When carbon dioxide is being used as a insulator, and in a fire extinguisher, it will behave as follows:
During putting out the fire, the dense gas will come out in a thick and overpowering cloud, this shows that the carbon dioxide is dense and thick, and will begin to cut off the flow of the fire as it burns. Whilst it does this, by itself, the carbon dioxide will spread quickly, moving through the fire and multiply, giving off a possibly strong smell. Its density will cut off the atmosphere in that specific area, and cloud the room as it works as an insulator. Its strong structure and bonding, help with this. Its little to NO amount of delocalized electrons, help it cut off any flows that are already apparent within the fire, and any bonds will also be cut off during this time. When the fire is completely out, the carbon dioxide gas will linger, but will remain steady and clouded as to keep the fire down any further.

Source

Extinguisher: [Photograph]. stock.adobe.com/204932761

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QUESTION THREE: Harakeke

Harakeke (New Zealand flax) has long upright leaves that can grow up to four metres (4 m) in length. When the green flesh is removed by scraping, a long, white fibre (**polymer**) called **muka** is revealed. This fibre can be spun or plaited.

Muka fibre is a natural polymer material.

The spun muka can be used for many things, including making a kupenga (fishing net). Kupenga could then be weighed down with stones so that the kupenga would sink.

Harakeke leaves (green) and muka fibres (white)

Kupenga made by knotting muka fibres together

Table 3: Young's modulus and solubility of various materials

Material	Young's modulus* GPa	Solubility in water
Muka	8.6	Insoluble
Hemp	11.8	Insoluble
Wool	2.3	Insoluble
Glass	70–100	Insoluble

* A high value of Young's modulus means that a material is brittle

(a) Describe TWO physical properties of muka and link these two physical properties to their use in making a working kupenga.

Muka, a flax product, and a natural polymer, is great for use in kupenga, a natural fishing net used for catching fish. Using muka is effecient, as properties such as its malleability and solubility in water, help it work for making a kupenga. For being a kupenga, muka must have a low solubility, and must not dissolve or break down when placed in water for long periods of time to catch fish. The table shows that muka is insoluble in water, which means that when used as a kupenga, it will not dissolve in water and stays intact when braided together tightly, allowing for it to be used for long periods of time. Other properties, such as its malleability, are essential for muka to be knotted into a kupenga form. Malleability allows it to bend and be molded as a natural polymer, so that it can be tied without breaking. It also has a mid level Young's modulus, which means it works well against glass, something with a high young's modulus. Other materials, also do not have the malleability for a kupenga, and would be hard to shape into a net.

(b) Explain these TWO physical properties, with reference to the structure and bonding of muka.

Muka, with properties such as a high malleability and insolubility, are due to many aspects of its structure and bonding. Muka, with its high malleability, are due to its free structure, consisting of a honeycomb lattice, which allows it to bend and shape, to suit the person braiding it into shape. Its insolubility, is due to its ability to allow water around it, but not into its structure, as it moves freely with the water particles, and holds shape due to its strongly bonded layers. Perfect for usage as a polymer in making kupenaga due too these two aspects.

(c) Evaluate how muka will behave when used as a kupenga by linking the TWO physical properties to the structure and bonding.

Firstly, when muka is stripped from the harakeke plant and is beginning to be braided, its malleability due to its strong honeycomb lattice will move and allow the muka to form and shape the braids within the kupenga shape, so that as it is braided, it will not break but will remain bendy and easy to form. Secondly, when the kupenga has been created and the muka structure is lowered into the ocean to catch fish, and weighed down by the rocks placed on top of it, it will not break or dissolve as its structure moves with the water, and its electrons are packed snugly, meaning it keeps its shape and its insolubility will stop it from dissolving. Therefore the muka will react positively in terms of behavior in the water, and with allow for many fish to be caught and lifted from the water.

Achievement

Subject: Chemistry and Biology

Standard: 92023

Total score: 10

Q	Grade score	Marker commentary
One	A3	Electrical conductivity and melting point have been described as the two physical properties needed for the operation of the circuit. Stated that the delocalised electrons help carry the current through the structure. Not identified the type of material or the structure and bonding of the material.
Two	A4	Density and lack of electrical conductivity have been described as the two physical properties needed for the operation of the fire extinguisher. Linked poor electrical conductivity to the lack of delocalised electrons. Noted carbon dioxide will overpower and cover the flame.
Three	A3	Malleability and insolubility have been described as the two physical properties of muka. Explained that the muka being insoluble will not dissolve the kupenga when placed in water.