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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Chemistry and Biology 2025

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 2–15 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.

Merit

TOTAL 14

QUESTION ONE

Low-density polyethylene (LDPE) is a type of polymer that can be used to make the body of a kayak.

(a) Define the term polymer.

A polymer is a 2d
macromolecule that is
shaped in a chain formation
with atoms that are covalently
bonded.

LDPE is widely used due to its versatility, moisture resistance, and low melting point. It is characterised by its low density and flexibility.

A kayak needs to be buoyant and insoluble in water, so it can float on the water with kayakers.

Figure 1: Carbon, C, and hydrogen, H, bonds form long chains and branches in LDPE

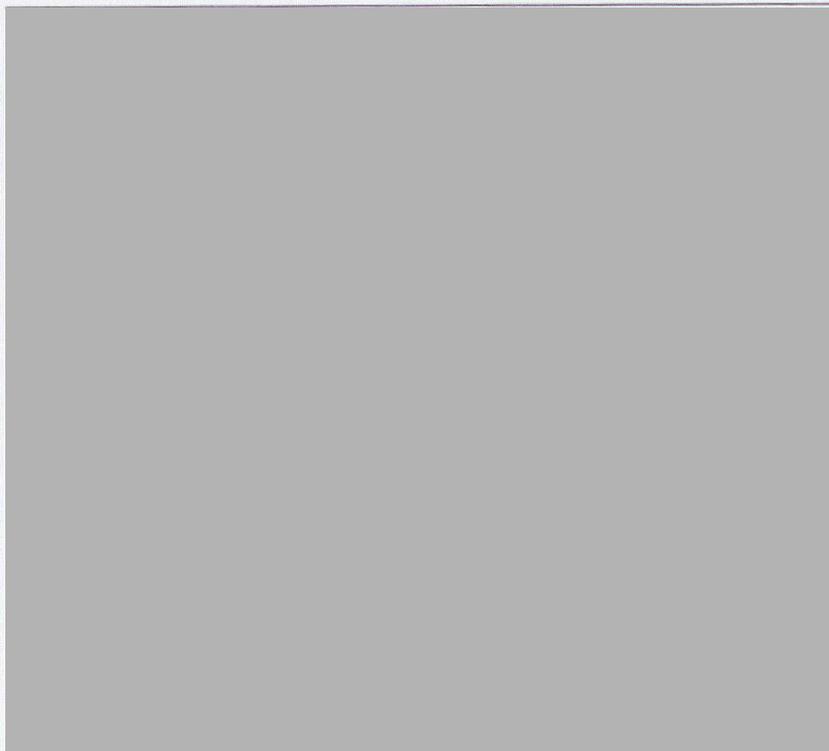


Figure 2: Skeleton structure of LDPE (top) compared with the related high-density polyethylene (HDPE) (bottom)



- (b) Explain how the structure and bonding of LDPE results in a low-density polymer that is suitable for use in kayaks.

LDPE is a 2d macromolecule called a polymer. In the LDPE it has a chain of carbon & hydrogen atoms that are covalently bonded. & also has weak inter-molecular forces. If the LDPE has a low density it means that there is a lot of space between the atoms as the closer they are the more dense the polymer becomes.

↳ Covalent bonds happen when two ~~atoms~~^{elements} ~~are~~ non metals are attracted by the the carbon's nucleus to the hydrogen ~~atom~~ electron & hydrogen nucleus to the carbon's electron. Carbon atoms can have 4 covalent bonds & hydrogen atoms can only have 1 as carbon needs 4 valence electrons to have a full valence shell where hydrogen needs 1.

A kayaker is looking for a new kayak made out of stronger and harder carbon fibre sheets.

Figure 3 shows three layers of carbon fibre sheets, with a close-up of the atomic structure of the planes of carbon atoms that make up these layers.

Figure 3: Layers of carbon fibre sheets, with close-up of atomic structure



(c) (i) Select (✓) the type of material a carbon fibre sheet is.

- covalent network ionic material metallic solid
 molecular substance polymer

(ii) Explain why the structure and bonding within a carbon fibre sheet results in a kayak that is hard and strong.

The carbon fibre sheet is a 2d covalent network called graphite. The carbon atoms are ^{strongly} covalently bonded whereas the layers are held together by weak intermolecular bonds. The ~~fibres~~ fibre sheets are hard & strong due to the strong covalent bonds. Since there strong it takes a lot of energy to break the bond which makes the kayak hard & strong.

QUESTION TWO

The shaft of a kayak paddle is made of aluminium, Al.



(a) (i) Select (✓) the type of material aluminium, Al, is.

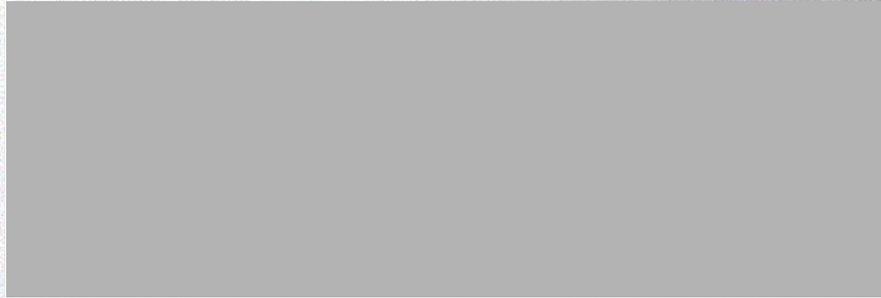
- covalent network ionic material metallic solid
 molecular substance polymer

(ii) How does the structure and bonding of aluminium, Al, allow it to be malleable, forming the long, hollow tube of the shaft of the paddle?

Aluminium is a metallic solid formed in a 3d lattice bonded together by the non directional metallic bond. ~~The atoms~~ This allows the electrons to move freely in the lattice. For Aluminium to be malleable the aluminium atoms in the lattice are able to move & slide over each other where the force happens then it creates a different shape. They are able to do that due to their non directional metallic bond.

Figure 4 shows aluminium, Al, and the alloying of aluminium and magnesium, Mg.

Figure 4: The alloying process of aluminium and magnesium



(b) (i) Define the term alloy.

An alloy is when an ~~metal~~ ^{element} combines with the metal to help strengthen a property.

(ii) Explain how adding magnesium, Mg, to aluminium, Al, to make an alloy, changes the malleability of the material.

Before the aluminium atoms were easily able to slide over each other as they were the same size. As shown in the diagram above the magnesium is bigger than aluminium. This will make it harder for the atoms to slide over each other. So the malleability will be lower as it is harder.

Table 1 shows the physical properties of aluminium, Al, and two different alloys that could be used for a kayak paddle.

The shaft of a kayak paddle is formed of a long, hollow tube. It needs to:

- float if it is dropped into the water
- be hard enough to pull the blades through the water
- be light enough for a kayaker to lift and use.

Table 1: Density and hardness of substances		
Substance	Density	Relative hardness
Pure aluminium	2.7 g/cm ³	Low
Aluminium and magnesium alloy	2.60–2.7 g/cm ³	Medium
Steel (iron and carbon alloy)	7.75 g/cm ³	High

- (c) Using the information in Table 1 and your knowledge of structure and bonding of materials, discuss why an aluminium and magnesium alloy would be preferred over both pure aluminium and steel (iron and carbon alloy) as the material used for kayak paddles.

If we look at the relative hardness of the 3 metals we see that the best option is steel, as it is high, then ~~Al~~ Al alloy then pure Al. But the density of the 3 metals show that steel is very dense with 7.75 g/cm³. This will make it a lot harder to paddle & will tire you out quickly. It also ~~isn't~~ won't be good if you dropped the paddle in the water as it will most likely sink. This means steel isn't the best option. The pure Al & the Al alloy roughly the same density but the Alloy is slightly less dense. Since the alloy is harder than pure Al it makes it the best option for a paddle.

QUESTION THREE

Sea water is made up of water, H_2O , and salt, NaCl . Figure 5 shows the structure and bonding of the individual substances.

Figure 5: Structure and bonding of water, H_2O (left), and salt, NaCl (right)



(a) (i) Select (✓) the type of material water, H_2O , is.

- covalent network ionic material metallic solid
 molecular substance polymer

(ii) Select (✓) the type of material salt, NaCl , is.

- covalent network ionic material metallic solid
 molecular substance polymer

White solid salt, NaCl, is visibly left behind on the surface of the sea kayak. The salt is brittle, and it crumbles easily when touched.

- (b) Explain how the arrangement of particles in salt, NaCl, and the attractive forces between these particles leads to this brittleness.

NaCl is an ionic ~~solid~~ material structured in a 3d lattice bonded together by the ionic bond. The ionic bond is created by the positive cation Na^+ , & negative anion, Cl^- , attracting to each other as positive attracts negative. The brittleness occurs the ions in the 3d lattice move. When a force move the ions move the positive Na are now next to another Na and same force the negative Cl. When ions of the same charge

- (c) Explain how the properties and attractive forces of water, H_2O , and salt, NaCl, allow for water to visibly remove the salt from the surface of the sea kayak. → score paper

~~When~~ if the salt's visibility has been removed then the salt is soluble & has dissolved in water. This happens as the attraction of the water is strong enough to break the ionic bond in the salt. So the positive Hydrogen ^{ion} attracts the negative ~~the~~ Chloride ion & the negative oxygen ion attracts the positive sodium ion. This then breaks the ionic bond & dissolves the salt into the water without seeing it.

Question Three continues
on the next page ➤

A plastic bottle floats on the sea water. The plastic bottle contains both air and fresh water. Table 2 shows the density of each of the materials.

	Types of material			
	Sea water	Fresh water	Plastic bottle	Air
Density	1.02–1.03 g/cm ³	~1 g/cm ³	0.94–0.965 g/cm ³	0.0012 g/cm ³
Arrangement of particles	Mixture containing both sodium chloride and water	Pure substance (water molecules)	Pure substance (long chain molecules)	Mixture (gaseous molecules and atoms)

- (d) Using the information in Table 2 and your own knowledge of properties of materials, explain why the plastic bottle containing both air and fresh water floats on sea water.

Firstly for the plastic bottle to stay together without dissolving means it has to be insoluble in water. This means that the attracted forces of the water molecules aren't strong enough to break the strong covalent bonds in the 2d macromolecule polymer. Then, as show in the table, we see that the sea water is the most dense material on the table but the fresh water & the plastic bottle are very close. The salt in the sea water make it more dense. Since everything else is less dense than the sea water it makes it harder for it to sink & the bottle will just float.

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

Question 3 (b)

are together they repel each other which
breaks the ionic bond. This is how the
salt is brittle.

Merit

Subject: Chemistry and Biology

Standard: 92023

Total score: 14

Q	Grade score	Marker commentary
One	A4	The candidate was awarded A4 as they identified the covalent bond in the polymer. In part (c), the covalent network was stated with weak attraction between the layers and large amount of energy needed to break the strong covalent bonds.
Two	M5	The candidate was awarded M5 as they linked non-directional metallic bond to atoms being able to slide over each other when force is applied. In part (b), the candidate defined an alloy and noted that the alloy is less malleable due to different sizes of atoms making it harder for them to slide over each other.
Three	M5	The candidate was awarded M5 because they identified the substance types and explained the ionic solid structure and bonding. They linked the application of force to same-charged ions lining up, repelling each other causing the solid to shatter.