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NZQA

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.

Achievement

TOTAL 12

Page 1

Make sure you have the paper Resource Booklet 92023R.

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.

Polymers are made of long chains of big molecules. The molecules are held together by strong covalent bonds. In between the chains are weak intermolecular forces. Polymers are insoluble. Polymers are malleable because of the weak intermolecular forces.

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

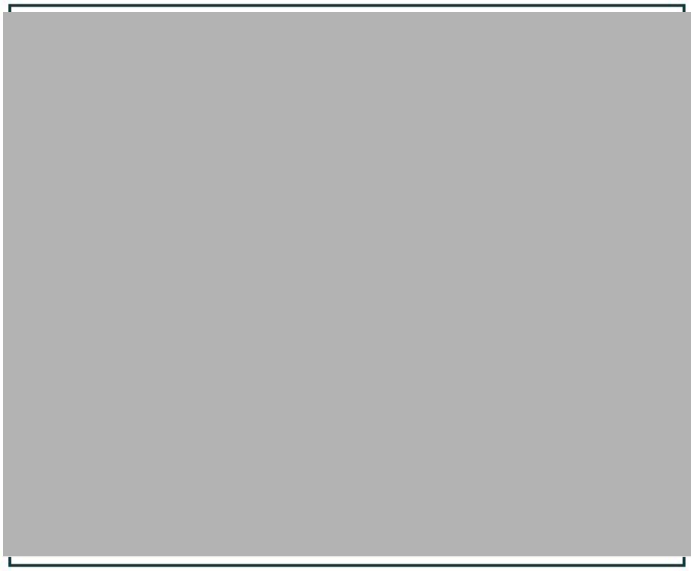

Figure 2: Skeleton structure of LDPE (top) compared with the related high-density polyethylene (HDPE) (bottom)

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

The skeleton structure of LDPE has many branches and space between atoms resulting in it being a low-density polymer. The bonding of LDPE provides space between atoms and is not compact making it less dense. It is important for the kayak to not be dense so that it is buoyant.

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.

Carbon fibre sheets have strong covalent bonds between carbon atoms making the kayak strong. It also has weak intermolecular forces between sheets to hold them together. The structure of carbon fibre sheets have many layers that are held together making it hard.

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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. Metallic solids are made of cations and delocalised electrons. The cations are held together by strong electrostatic forces in a regular 3D lattice structure. The aluminium cations are able to slide over each other allowing it to be malleable. The aluminium must be malleable to be made into the shaft of the paddle.

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.

Alloys are materials made up of to different elements. Alloying makes a material stronger.

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

Adding magnesium to aluminium makes the structure of the alloy irregular. This makes the material less malleable because the atoms cannot slide over each other as easily.

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.

An aluminium and magnesium alloy would be preferred for a kayak paddle shaft because it is less dense than pure aluminium and steel but still has medium hardness. The magnesium and aluminium alloy has a low density because when the magnesium is added it makes the material less compact compared to pure alluminium. The electrostatic boding of the aluminium and magnesium alloy makes the substance hard because it requires a lot of energy to break these bonds apart.

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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.

Ionic substances have strong ioninic bonding between cations and anions. Between these ions are weak intermolecular forces which can easily be broken apart making the salt brittle.

(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.

Salt is soluble in water which means the ions are more attracted to the water molecules than each other. This means that when the water comes into contact with the salt, the salt breaks apart dissolving into the water.

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.

Table 2: Density and arrangement of particles of 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.

All three materials fresh water, the plastic bottle and air are less dense than sea water making them float. The plastic that the bottle is made out of is insoluble keeping the sea water out of it and stopping it from floating.

Achievement

Subject: Chemistry and Biology

Standard: 92023

Total score: 12

Q	Grade score	Marker commentary
One	A4	The candidate was awarded A4 as they defined a polymer, identified strong covalent bonds, linked branched chains to low density, and identified the covalent network solid.
Two	A4	The candidate was awarded A4 as they identified a metallic solid, defined alloy, and noted alloy was less malleable than aluminium as atoms cannot slide easily.
Three	A4	The candidate was awarded A4 as they identified the molecular and ionic substances, stated that salt is soluble, and that the sea water is denser than the plastic bottle.