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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 1 Chemistry and Biology RAS 2023

**92023 Demonstrate understanding of how the
properties of chemicals inform their use in a
specific context**

EXEMPLAR

Achievement

TOTAL 04

Page 1

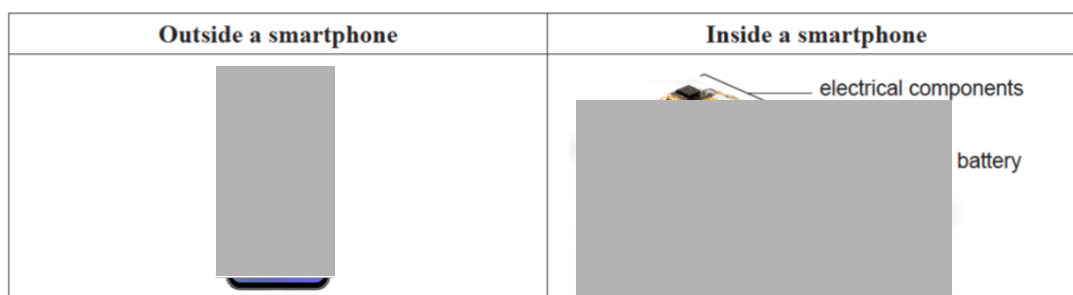
Make sure you have the paper Resource Booklet 92023R.

TASK

Elements in a smartphone

A smartphone is an electronic device that contains a lot of circuitry (electrical components).

The smartphone shown contains the elements copper (Cu), gold (Au), and tin (Sn).



- (a) Use your knowledge of the physical properties of chemicals to explain why ALL of the three elements are suitable for use as electrical components in a smartphone.

In your answer:

- Identify the ONE type of chemical structure from the list below that copper (Cu), gold (Au), and tin (Sn) all share.
- Identify TWO key physical properties from the list below needed for copper (Cu), gold (Au), and tin (Sn) to be used for electrical components.
- Discuss the structure of the elements and the two physical properties you have chosen, and link these to their use as an electrical component in a smartphone.

Type of chemical structure (choose ONE):

- ☐ covalent network ☐ ionic ☒ metallic ☐ molecular

Key physical properties (choose TWO):

- ☐ boiling point ☐ density ☒ electrical conduction
☐ heat conduction ☒ malleability ☐ melting point
☐ solubility in water

Discussion:

B I U    

Copper, gold and tin are all metallic compounds, made of a 3D lattice structure and the forces of attraction are metallic bonds. Metallic compounds can conduct electricity because of the presence of freely moving charged particles, this is important for compounds used in a smartphone because it is necessary in order to be able to operate the phone.

Metallic substances are also malleable, this means that atoms and electrons in the 3D lattice structure can move past one another without disrupting and breaking the structure, this is important because it means these metallic compounds can be molded into whatever shape is required.

- (b) One of the electrical components in a smartphone is a **heat sink**. The heat sink draws heat away from the electrical components in the smartphone to prevent the phone overheating.

Table A: Properties of chemicals

Substance	Melting point °C	Electrical conductivity, σ (1 / ohms m)	Thermal (heat) conductivity, k (W / mK)
Copper	1084	5.96×10^7	413
Gold	1063	4.52×10^7	319

Note: $10^7 = 10\,000\,000$

Use **Table A** to discuss which of the two elements above (copper or gold) would be the most suitable as a **heat sink**.

Most suitable element:

☒ copper ☐ gold

Discussion:

B *I* U

Copper would be more efficient as a heat sink because of its higher melting point and thermal heat conductivity, this means that the copper would be able to withstand and hold more heat before melting and you would not require as much of it.

- (c) Solder is a combination of metals, mainly tin (Sn). Solder is used to join the electrical components of the smartphone together. Solder does this by **melting** then **cooling**, forming a **solid** join connecting the electrical components together.

Table B: Properties of chemicals

Substance	Melting point °C	Electrical conductivity, σ (1 / ohms m)
Copper	1084	5.96×10^7
Gold	1063	4.52×10^7
Tin	232	9.17×10^6

Note: $10^7 = 10\,000\,000$ and $10^6 = 1\,000\,000$

Use your analysis of the information in **Table B** to discuss why solder is mainly made of tin.

B *I* U

Tin is mainly used because of its low melting point and high electrical conductivity, high electrical conductivity is important because it means no power will be lost on the joins of the wire, and low melting point is important because it requires less energy to break the metallic bonds to form the metal into liquid and mold it to the wire.

The battery of a smartphone



Interior view of smartphone showing the lithium ion battery

For electricity to flow, substances need charged particles, either electrons or ions. The electrons or ions require two terminals (+ and -) for the battery to work.

(d) Both graphite and diamond are forms of carbon (allotropes).

Discuss why graphite is used as part of a smartphone battery (terminal) to conduct electricity rather than diamond.

In your answer refer to the:

- type of chemicals graphite and diamond are
- structure of the graphite and diamond
- relevant physical properties of graphite and diamond.

B <i>I</i> <u>U</u>
Graphite and diamond are covalent network substances, this means that they are extremely dense materials because of their unique structure. Graphite was chosen because diamond is incapable of conducting electricity, this is because the 4 potential bonds on each carbon atom are all linked to other carbon atoms, this means there are no freely moving charged particles. The carbon present in graphite leaves potential bond which is left free for electrons and ions to use, which means that it can conduct electricity.

In a smartphone's lithium ion battery, ions can be used to carry a charge (conduct) between the battery terminals.

A salt is a metal ion joined to a non-metal ion (e.g. sodium chloride).

(e) Use your knowledge of the physical properties of chemicals to discuss why a **lithium salt solution** is a more suitable source of lithium ions than a **solid** lithium salt.

In your answer include the:

- type of chemical that lithium salt is
- physical property that a solid salt must have to be able to dissolve into a liquid to form a solution.

B <i>I</i> <u>U</u>
Lithium salt is a ionic compound made of a 3D lattice structure and held together by positively and negatively charged ions, these ions are attracted to each other and hold together forming strong ionic bonds. Because the 3D lattice is such a strong structure, while in a solid state there are no freely moving charged particles which means that it cannot conduct electricity. When lithium salt is placed in water the positive and negative attractive forces in the water overcome the ones which are holding the solid lithium salt together and make it dissolve, this means that the structure is broken and the lithium salt solution now has freely moving charged particles and can conduct electricity.

(f) Analyse the information provided in Table C.

Table C: Properties of aluminium alloys





Substance	Melting point °C	Density kg / m ³	Malleability (GPa)
Alloy 1	635	2810	70
Alloy 2	649	2640	68

Note: A more malleable metal / alloy has a lower GPa value.

Use the information to discuss which alloy would be most appropriate as a battery cover for a smartphone.

In your answer:

- state what an alloy is
- compare the physical properties of the alloys and link these to their suitability as a battery cover in a smartphone.

B *I* U    

An alloy is a substance made of two metals, these are made to potentially obtain benefits from both metals. Alloy 2 has a higher melting point and is a more malleable substance which would make it better for shaping around the battery. Alloy 1 is more dense which would provide more protection to the battery, and the difference in malleability and melting point is not that much which is why I think alloy 1 would be more suitable as a battery cover.

Source:
Outside a smartphone: www.noelleeming.co.nz/p/samsung-galaxy-a54-5g---awesome-graphite/N218021.html
Inside a smartphone (adapted): www.counterpointresearch.com/odms-contributed-23-global-smartphones-shipped-cy2017/
Lithium ion battery (adapted): www.reliancedigital.in/solutionbox/better-understanding-of-batteries-li-ion-vs-li-po/

Achievement

Subject: Chemistry and Biology

Standard: 92023

Total score: 04

Q	Marker commentary
(a)	Gold, copper, and tin are identified as metallic chemical. Metals have free-moving particles. The structure of metal allowing conduction and is malleable has been omitted.
(b)	Copper is identified as the most suitable metal for a heat sink, with reference to copper's high melting point and high thermal conductivity. An explanation of how heat energy is related to the melting point or what high thermal conductivity means in relation to a heat sink may have led to a higher grade. Electrical conductivity was not mentioned.
(c)	Comparison of the melting points of gold, copper, and tin and stating that tin has the highest conductivity may have led to a higher grade.
(d)	Correct chemical type stated. Candidate states that "diamond is incapable of conducting electricity ... no free moving charged particles". Graphite description included "electrons and ions" plus explanation of both structures in relation to particles and forces but there was no link to use.
(e)	The correct chemical type is identified. Well written response as to why an ionic solid cannot conduct. The candidate added that ions are "fixed" so unable to conduct charge. While the response as to why a solution can conduct is good, it is not linked to use in a battery.
(f)	The definition is incomplete. There is no link stated between density and use in a battery cover for alloy 1.