

This assessment is based on a now-expired version of the achievement standard and may not accurately reflect the content and practice of external assessments developed for 2024 onwards. No part of the candidate's evidence in this exemplar material may be presented in an external assessment for the purpose of gaining an NZQA qualification or award.



Level 1 Chemistry and Biology RAS 2023

92022 Demonstrate understanding of genetic variation in relation to an identified characteristic

EXEMPLAR

Achievement

TOTAL 04

Student answer**Question 1**

In this assessment I will be discussing Homo sapiens and Cystic fibrosis. You either have Cystic fibrosis or normal mucus. Cystic fibrosis is thick mucus. Cystic fibrosis is caused when you have a different allele which makes you a thick mucus characteristic. Cystic fibrosis is really bad because your mucus is so thick it clogs up your airways sometimes. You get Cystic fibrosis if you inherit 2 recessive Cystic fibrosis alleles.

Genetic variation makes a species survive because if everyone was the same and had the same genes then the species would probably get wiped out fast. Because if a disease or something kills the species then there would be nothing to counter the disease.

Genetic variation comes about sexual reproduction and mutation. Sexual reproduction is when a sperm meets an egg and then they fertilize. This makes genetic variation because the offspring inherits different genes from the mum and dad. And they get 23 chromosomes from mum and 23 chromosomes from the dad. This causes genetic variation because the mum and dad's genes mix to make a new combination of genes.

A mutation is when there is a change in the DNA sequence causing genetic variation.

Phenotype is when someone has the specific gene, and you can see that they have that gene. And a genotype is when you can't see you have the specific gene, but you have it and could be a carrier. So, the Cystic fibrosis phenotype would be that you can see someone with Cystic fibrosis. You will be able to see if they have thick mucus. While if someone has the Cystic fibrosis genotype you wouldn't be able to see if they had the Cystic fibrosis gene. They could just be a carrier of that gene.

Genetic variation is important to the population of homo sapiens because if everyone had the same genetics it wouldn't be good because if something like a disease were to spread around the Homo sapiens species we wouldn't be able to study what gene could be immune to it. And genetic variation is important to Homo sapiens because these different genes allow us to tell each other apart which makes it unique.

Question 2

I think it was important for the scientist to have genetic information on the Kakapo because the kakapo were endangered, so then they could use that information on their genetics to see how to get them to breed and create genetic variation within the endangered species so they could repopulate. I think Richard Henry had a big impact on the genetic variation since his genes were different to the Kakapo. So when he was breeding with another Kakapo him and the other Kakapo were creating an offspring with a new combination of genes.

Achievement

Subject: Chemistry and Biology

Standard: 92022

Total score: 04

Q	Grade score	Marker commentary
(a)	A4	<p>Overall, this script sits at the Achievement level as it contains accurate definitions and descriptions. For example, the candidate has identified that genetic variation is important for survival of a population in relation to disease.</p> <p>The candidate has defined sexual reproduction, describing a sperm fertilising an egg, i.e. genetic material from each parent.</p> <p>The candidate has defined mutation.</p>
(b)		<p>The candidate has identified that breeding kākāpō that are as genetically different as possible is important for conservation of the species.</p>

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EXEMPLAR

Merit

TOTAL 06

Part A:

Sexual reproduction is when a female gamete (egg) is fertilized by a male gamete (sperm) and become a zygote, this process combines genetic material from two different individuals (23 chromosomes from father and 23 from mother), leading to siblings with a unique combination of alleles. Mutation is when the DNA sequence is changed, it can happen by errors in DNA replication, viral infection and chemical or radioactive substances or other things and they are the source of new genetic information.

Mutation introduces new genetic variations through changes in DNA sequence, such as point mutations, insertions, deletions, and gene duplications. Sexual reproduction combines genetic material from two parents through processes like cell division, and random fertilization, resulting in unique combinations of alleles in offspring. Both mutation and sexual reproduction contribute to genetic diversity within populations, contributing to evolution and adaptation.

The genotype in humans refers to the genetic information an individual inherits from their parents. It consists of the specific alleles (versions of genes) present in an individual's DNA. These alleles determine the potential traits an individual can express, genotype is not directly observable. The phenotype in humans is the observable physical and functional traits of an individual, resulting from the interaction between their genotype and environmental factors, in the genotype we can have dominant genes or recessive genes, when you have recessive gene and one dominant your phenotype will be of this dominant gene, you only would have a recessive gene in your phenotype if your genotype genes were two recessives. Phenotypes can include traits such as hair colour, height, and susceptibility to certain diseases. An example of this variation is my father because his mother has green eyes (represented as "bb"), but his father has brown eyes (could be represented as "Bb" or "BB", but in his case my grand grandparents' had brown eyes, so it is "BB"), as the genes of brown are dominant and the genes of green eyes are recessive his phenotype is for brown eyes, but in his genotype we will find the genes of green eyes (represented as "Bb"), so if his father had green eyes too, he would have green eyes because would be two recessive genes.

Genetic variation helps populations survive and flourish. When environments change, some individuals with certain traits can have better chances of surviving and reproducing. This ensures that the population can adapt over time. Additionally, genetic diversity helps in the fight against diseases. If everyone had the same genetic makeup, a single disease could affect everyone the same way. But with variation, some individuals might be naturally resistant, which helps prevent widespread outbreaks. This could be seen in the Pandemic of Coronavirus where some people were asymptomatic, and others died or had severe health problems.

Part B:

The genetic information obtained from the kakapo population is highly significant for several critical reasons. By studying their genetic makeup, scientists can gain a deep understanding of the extent of genetic diversity within the population. This knowledge is essential for designing effective conservation strategies that aim to prevent inbreeding and ensure the long-term survival of a healthy population. Understanding the genetic composition not only helps to prevent inbreeding, which occurs when closely related individuals reproduce, but also reduces the risk of decreased genetic diversity and the resulting emergence of genetic disorders. This data is crucial for developing breeding programs that often play a key role in boosting the populations of endangered species. These programs are guided by genetic information, assisting in the selection of suitable breeding

pairs to maximize genetic diversity while avoiding the mating of closely related individuals. Moreover, by examining the DNA of kakapos, it becomes possible to identify increased vulnerability to specific pathogens, empowering conservationists to take proactive measures against disease threats.

The genetic relationships highlighted by this data are pivotal in shaping the breeding program. By assessing the level of inherent genetic diversity within the species, steps can be taken to prevent health problems and diminished fitness resulting from inbreeding. This involves purposeful breeding of kakapos like Richard Henry, who exhibited genetic variations distinct from other individuals. This approach ensures reduced relatedness and enhances genetic diversity, which are critical for maintaining the species' resilience. Additionally, individuals well-suited for breeding may possess genetic markers associated with disease resistance and other favourable traits. This guides the selection of mating pairs, strengthening the overall health of the population while avoiding the transmission of harmful genetic traits.

For the next steps of kakapo conservation, I would recommend regularly monitoring the species' genetic diversity and overall health remains crucial. This enables conservationists to make informed decisions based on updated genetic insights. The ongoing execution of the breeding program, utilizing the wealth of genetic data, should consistently prioritize breeding pairs that optimize genetic diversity and minimize the risks of inbreeding. Public awareness initiatives are pivotal, emphasizing the importance of kakapo conservation in broader communities. Furthermore, conservation strategies should remain adaptable, evolving alongside emerging genetic information. It's important to recognize that the genetic diversity fostered through the breeding program enhances the species' ability to adapt, helping against extinction. The most important goal is to reintroduce the species to its natural habitat for sustained and self-sufficient survival.

Merit

Subject: Chemistry and Biology

Standard: 92022

Total score: 06

Q	Grade score	Marker commentary
(a)	M6	This response sits at Merit level because the candidate accurately defines key ideas (e.g. sexual reproduction, mutation, genotype / phenotype), and has explained how genetic variation occurs and the implications of this.
(b)		The candidate has explained how information from genetic relationships can inform the breeding programme. They explain that information about relatedness can inform the breeding of individuals that are less closely related, with the intention of reducing in-breeding in this small population.

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Level 1 Chemistry and Biology RAS 2023

92022 Demonstrate understanding of genetic variation in relation to an identified characteristic

EXEMPLAR

Excellence

TOTAL 08

Write your answers below:

Genetic variation is the difference between individuals within a population. It has different sources, which include sexual reproduction and mutation. Genetic variation is important for a species's survival, as differences among individuals means an increased chance that the species will survive through environmental change.

Genetic variation is the result of sexual reproduction and mutations. The physical appearance, phenotype, of an individual is determined by their genotype, their genetic information. A segment of DNA is called a gene, which codes for certain proteins. There can be variations of genes, alleles, which result in different phenotypes. An individual's alleles depend on their parents. Chromosomes, packages of DNA, are inherited. This means that an individual will inherit two versions of every allele, one paternal and one maternal. Fertilisation, where the egg and sperm cell fuse, results in randomly paired gametes with unique alleles. Before this, there is another source of variation. Meiosis involves a single cell dividing to create four unique gametes. They are unique because of three processes. Crossing over is a process where homologous chromosomes- of the same type- exchange information so that every chromosome will have a unique combination of alleles. On top of this, independent assortment aligns chromosomes randomly, and segregation ensures they are randomly separated into two nucleuses. These processes result in individuals having unique allele combinations.

On top of this, mutations can cause variation. These are changes in the base sequences within a genetic code, which alter protein production. They can be silent and not change anything, or they can be nonsense mutations, and cause change. Just one base pair change can cause a mutation. Mutations vary in their effect on the species. They can be harmful, neutral, or beneficial. As well as this, mutations can only be passed if they affect sex cells. Any changes to somatic - body - cells, will not be inherited by offspring.

Genetic variation is seen everywhere around the world. An example is Sickle Cell Anaemia. Within humans, there is a mutation, the sickle cell mutation, which leads to variation within the protein haemoglobin. Haemoglobin is a protein that carries oxygen around the body. The mutation causes misshapen proteins which impacts oxygen absorption. This disease reduces life expectancy. This allele has three phenotypes depending on the genotype. Homozygous dominant has no disease, homozygous recessive has the disease, and heterozygous genotypes have the sickle cell trait, which has no symptoms but allows that person to pass on the gene. This is why the mutated allele is continuing in the population, despite those with the disease not reaching child bearing age. Punnett squares are a good method of predicting the genotypes of offspring. While these are probability based, therefore not completely accurate,

ANSWER DOCUMENT

they still provide an idea of the chances. For example, two carriers have a 50% chance of having carrier offspring, and 25% chance of both disease and no disease offspring.

Carrier/carrier			Carrier/No disease			Carrier/disease		
	R	r		R	r		R	r
R	RR	Rr	R	RR	Rr	r	Rr	rr
r	Rr	rr	R	RR	Rr	r	Rr	rr

The sickle cell carrier has been found to provide resistance to malaria. This advantage against malaria has led to the favourable trait (Sickle cell carrier) being found in high percentages in high malaria risk zones. This was found using gene tracking studies, such as DNA fingerprinting. This is because the people who carried the sickle cell allele were more likely to survive malaria, and continue to reproduce and pass on the mutation. This has led to the heterozygous genotype being common among people with an African background, but less so in other cultures. This shows the importance of genetic variation. By having diversity in the genotypes and phenotypes of people, the overall species responded well to malaria, a threat the environment posed.

The kakapo is another example. At one point, kakapo were incredibly endangered. Scientists used genetic information to decide how to save the species. It was important to have the kakapo's genetic information. This was because the information revealed that there was little variation between individuals. There was only one individual who showed genetic diversity. Scientists started a breeding program with the unique individual, because the lack of variation was hindering their survival. It was important to introduce variation to the population because diversity would better prepare them for environmental change, as the favourable trait would survive and reproduce, allowing for adaptation over time rather than extinction. Genetic data could inform scientists to breed individuals who would introduce more variety and help the species thrive. To maximise variety within kakapo and continue with their conservation, scientists should keep regular records of kakapo genetic information, so any variation or lack thereof can be noted. Genetic information should remain an important tool in the decision of which individuals to breed to promote more variation. By using punnett squares and pedigree charts, genotypes could be predicted and recorded, allowing for a better understanding of how future breeding programmes should be approached.

In conclusion, genetic variation is the differences within a population. It is a result of sexual reproduction and mutations. Variation allows individuals with favourable traits to survive and reproduce, aiding in long term survival. Therefore, genetic diversity is important for the survival of species. Two examples that show how genetic variation can be important are

Chemistry and Biology 1.3 (92022)

Demonstrate understanding of genetic variation in relation to an identified characteristic

ANSWER DOCUMENT

sickle cell mutation, as the heterozygous allele provides malaria resistance, and kakapo, who almost died out from a lack of variation.

Excellence

Subject: Chemistry and Biology

Standard: 92022

Total score: 08

Q	Grade score	Marker commentary
(a)	E8	This response sits at Excellence level because the candidate has evaluated findings when genetic variation has been identified and tracked for the purpose of identifying genetic relationships. The candidate has also defined key biological terms, explained how mutation can be inherited, and has then applied this to the example of sickle cell anemia. They have used Punnet squares to show how genes can be tracked and particular alleles inherited. They have evaluated the usefulness of this information, and identified ways in which people may use it.
(b)		The candidate has evaluated the effectiveness of genetic tracking by linking the purpose of genetic tracking of kākāpō (the conservation effort) to the findings (the genetic differences between birds).

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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

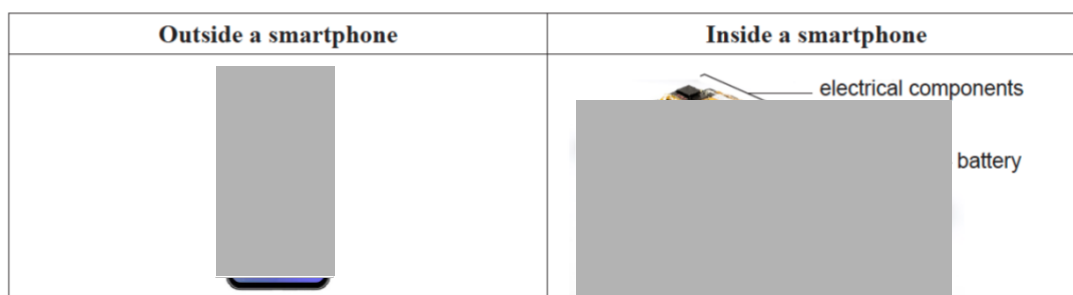
Make sure you have the paper Resource Booklet 92023R.

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* 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* U

Lithium salt is an 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 [List Bulleted] [List Numbered] [Undo] [Redo]

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/

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Achievement

Subject: Chemistry and Biology

Standard: 92023

Total score: A4

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.

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Level 1 Chemistry and Biology RAS 2023

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

EXEMPLAR

Merit

TOTAL 06

Page 1

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TASK

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In your answer:

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- 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 all have a metallic structure. This means that the atoms are all positive ions whose valence electron(s) are delocalised, meaning the electrons are free to move throughout the metal. Attraction between the metal ions and the sea of delocalised electrons is what keeps the metal together. Because of this, the metal ions can be moved without compromising the structure of the metal. In human terms, this means you can bend, squish and stretch the metal, which we call malleability. This is useful for electrical components for a number of reasons. First, it lets you pull the metal into wires, which are a core component of electronics as it lets you easily connect components while using as little space as possible. Second, you can press sheets of metal into very intricate shapes, therefore letting you make the components as small as possible. Smartphones are small, and so have a lot of space constraints, making metal greatly useful for their production. Another useful property of metals for use in electrical components is electrical conductivity. Electricity is the movement of charged particles, and metals contain a sea of delocalised electrons, which are charged particles. For this reason, metals are great conductors of electricity, making them fantastic for use in electrical components in smartphones..

- (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 is more suitable as a heat sink than gold. Heat is conducted when vibrating particles bump into other vibrating particles, transferring some of that energy to the other particles, making them vibrate. Heat is the vibration of particles. Copper has a heat conductivity of 413 k (W / mK), compared to gold's 319 (W / mK). This means copper conducts heat better than gold. The reason for this is that copper atoms vibrate more relative to the distances between atoms with less heat compared to gold, and so have a higher chance to bump into each other, transferring heat easier. This makes copper more suitable as a heat sink than gold as it does a better job of taking heat away from components and transferring it somewhere to be dissipated to the environment. Copper and gold both have similar high melting points, meaning they won't melt under load and one isn't significantly more likely to melt under load. Electrical conductivity has nothing to do with usefulness as a heat sink.





- (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

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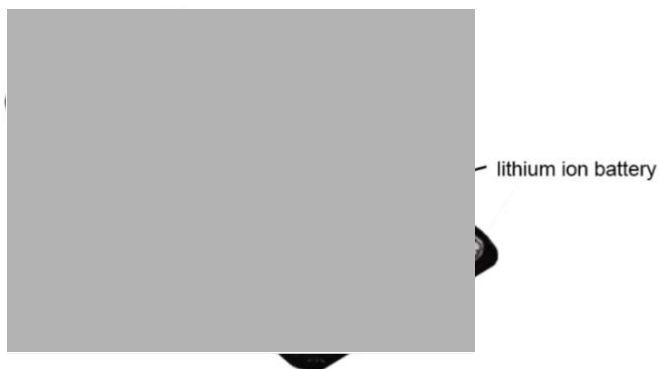
Note: $10^7 = 10\,000\,000$ and $10^6 = 1\,000\,000$

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

B *I* U    

Solder is made to be easily meltable yet decently good at conducting electricity. The bonds holding metals together are between the positive metal ions and the negative sea of electrons surrounding them. Melting is when those bonds are weakened to allow the metal atoms to flow past each other with ease. While copper melts at 1084 degrees celcius, tin melts at only 232 degrees. This is because the bonds holding tin together are weaker than in copper, meaning those bonds are more easily weakened to the point of melting. This lets tin be melted with a simple soldering iron, and applied directly to other metals. Also, because tin has a lower melting point than copper or gold, the molten tin can be cold enough to not melt those other metals. Tin is around five times less conductive than copper and gold, which isn't great, but solder is less to bridge gaps, and more so to hold other metals to each other. However, its relatively high conductivity means that it can make up for any accidental gaps. Electricity is the movement of charged particles, and in metals, there is a sea of electrons which are free to move, letting electricity be conducted. In copper and gold, these electrons move with greater ease than in tin. However, tin still conducts reasonably well. All this lets tin be great for use in solder.

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 U

Both graphite and diamond are examples of covalent networks. This means that the carbon atoms which make up graphite and diamond are sharing electrons between them, causing a very strong bond. In diamond, every possible bond is made, meaning every atom and electron are locked in place. However, in graphite, some bonds aren't made and the atoms are quite aligned as they should. This means there are enough bonds to hold the material together as a solid, however, some electrons are delocalised like in a metal. As electricity is the movement of charged particles, and graphite has moveable charged particles, 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 U

Lithium salts are ionic compounds, where one element has given one or more electrons to the other, causing complete valence shells and stability. An ionic compound is held together by the electrostatic forces between positive and negative ions. When solid, these ions are locked in place and can't move. Because electricity is the movement of charged particles, and solid lithium salts have no moveable ions, and so is not a suitable source of lithium ions. However, when a lithium salt is dissolved in solution, the ions are sticking to the particles in the liquid they're dissolved in and aren't attracted to the other ions. This means those ions can move freely as if liquid. Therefore, dissolved lithium salts are a great source of lithium ions, as those ions can be taken from the liquid.

(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 compound containing at least one metal. An alloy would be more suitable for a smartphone battery cover if it were: more malleable, as that lets it be formed easier; less dense, as that makes the phone lighter. Alloy 1 is more dense than alloy 2. This means that either the atoms are closer together, or whatever was added to aluminium to form the alloys had more particles in each atom for alloy 1 than 2. This makes alloy 2 more suitable. Alloy 1 is less malleable than alloy 2. This means that the attraction between the metal ions and the sea of electrons is stronger in alloy 1, making it harder to move the ions past each other. This makes alloy 2 more suitable. Overall, alloy 2 is more suitable than alloy 1 as it was more malleable and less dense.

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/

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Merit

Subject: Chemistry and Biology

Standard: 92023

Total score: M6

Q	Marker commentary
(a)	<p>The response about the structure of metals and particles is well explained and is linked to the conductivity of metals.</p> <p>The response about the malleability of metals mentions “without compromise” but does not explain what this means in terms of, for example, electrons – positive nuclei / atoms / cations attractions being non-directional, allowing the atoms to roll over each other without breaking the electrostatic forces. Malleability and electrical conductivity are linked to use.</p>
(b)	<p>The candidate recognises copper as a better thermal (heat) conductor compared to gold and links the heat sink to smartphone use.</p> <p>Melting point is not linked to the heat energy that metals can absorb due to the large amount of energy required to break metallic bonds. The candidate states “electrical conductivity has nothing to do with usefulness as a heat sink”. Heat sink is an electrical component, so a requirement is to conduct electricity. Copper is a better conductor of electricity than gold.</p>
(c)	<p>The candidate recognises that tin’s electrical conductivity is low but is still able to conduct reasonably well. Candidate links use of joining other metals rather than components of the smartphone, and the low melting point of tin is related to not being able to melt gold and copper. The link to use in smartphones is missing (i.e. components in smartphones can be damaged by high heat).</p>
(d)	<p>The type of chemical is identified.</p> <p>The candidate discusses the structure of diamond (“atoms and electrons locked into place”) but provides no link between the structure allowing (or not) electrical conduction. Graphite structure misses where the delocalised electrons come from for electrical conduction. No link to use, nor that graphite is a solid.</p>
(e)	<p>Statement for dissolved ions could be strengthened by deleting comment that “[dissolved ions] aren’t attracted to other ions” as this is incorrect.</p>
(f)	<p>The definition of an alloy incomplete. Malleability and density of alloy 2 are identified as properties that are desirable as easier to form and are lighter.</p> <p>To gain excellence, both points need to be linked to use (e.g. lighter means easier to carry).</p>

This assessment is based on a now-expired version of the achievement standard and may not accurately reflect the content and practice of external assessments developed for 2024 onwards. No part of the candidate's evidence in this exemplar material may be presented in an external assessment for the purpose of gaining an NZQA qualification or award.



Level 1 Chemistry and Biology RAS 2023

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

EXEMPLAR

Excellence

TOTAL 08

Page 1

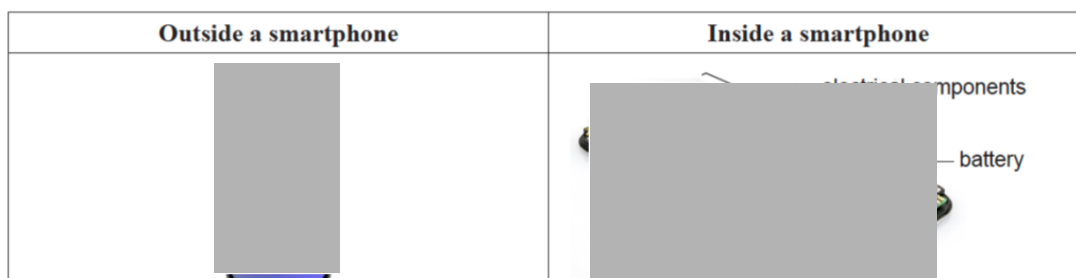
Make sure you have the paper Resource Booklet 92023R.

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 solids. They are made up of positive metal cations which are held in fixed positions in a 3D lattice, surrounded by a 'sea' of delocalised electrons. The metallic solids are held together by strong metallic bonding, which is the electrostatic attraction between the positive metal cations and the negative delocalised electrons. For a substance to be an electrical conductor, it must have free-moving charged particles. The electrons in the metallic solids, are able to move freely throughout the lattice while staying strongly bonded to the metal cations because the bonding is non-directional. Copper, gold and tin are all suitable for use as electrical components because they can conduct electricity because of their free-moving negatively charged electrons. This makes all three metallic solids ideal for use in the electrical components in a smartphone because they can carry a current throughout the phone to power it.

Copper, gold, and tin share the property of very good malleability. When force is applied a metallic solid, it can be reshaped without breaking. This is because when force is applied to the metallic solid, the metal cations in the 3D lattice slide over each other easily, and the solid remains intact because of the strong electrostatic attraction between the cations and the delocalised electrons. This strong metallic bond is non-directional, and the electrons are able to maintain the bond with the cations because they can move throughout the structure. This ability for copper, gold and tin to be easily reshaped when force is applied and remain intact, is ideal for the electrical components in a smart phone because they are able to be easily shaped into small intricate parts that are inside the phone, such as wires.

- (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    

Gold is more suitable as a heat sink because it has a lower thermal conductivity than copper, which means that the positive metal cations are less densely packed in the gold lattice, so when heat is applied and the metal cations start to vibrate, it is harder to transfer the thermal energy to the surrounding cations. This property makes gold a better choice for a heat sink because it is more of a heat insulator than copper and will stop heat being transferred around the phone by absorbing more of it. Gold has also got a high melting point. This is due to the strong metallic bonds between the positive metal cations and delocalised electrons. These metallic bonds take a lot of heat energy to break which is why gold needs such high temperatures to change from solid to liquid. Gold's high melting point means that it can withstand high temperatures as a heat sink while maintaining solid state.

- (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    

Solder is mainly made out of tin because of its lower melting point, and ability to conduct electricity as shown on Table B. Tin is a metallic solid so it is made up of positive metal cations and delocalised electrons in a 3D lattice. Tin's melting point is lower than the other metallic solids because its metallic bonds - the electrostatic attraction between the positive cations and negative electrons, don't take as much heat energy to break as the others. This low melting point is ideal for soldering because the solder must be able to melt easily to join the electrical components. Tin is used for soldering because as it is a metallic solid, it can conduct electricity. The free-moving delocalised electrons can carry a current throughout the lattice, which is ideal for soldering because it connects electrical components, so the current must be able to carry on through the solder.

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 U    

Graphite is a covalent network solid. Graphite has the structure of 2D lattice with layers of bonded carbon atoms held together by weak inter-molecular bonds. Each carbon atom is bonded to 3 others. These carbon atoms are held together by strong covalent bonds, which is the sharing of electrons between atoms. A carbon atom has four electrons in its valence shell, so because each carbon atom is only bonded to three other carbon atoms, there is one delocalised electron for every carbon atom.

Diamond is also a covalent network solid. It is made up of carbon atoms which are bonded by strong covalent bonds. The structure of diamond is a tetrahedral arrangement, because the carbon in diamond is bonded to four other carbons instead of three. As mentioned before, carbon has four electrons in its valence shell, and in diamond all four electrons are being shared with other carbons, leaving no delocalised electrons in the structure.

To conduct electricity, a substance must have free-moving charged particles. Graphite's delocalised electrons can move freely throughout the lattice, whereas in diamond, there are no free-moving charged particles as the electrons are all being shared between carbon atoms. This makes graphite more suitable to be used as a part of a smartphone battery because it can carry an electrical current to charge the battery compared to diamond which cannot.

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.

Lithium salt is an ionic substance. It is made up of positive metal cations and negative non-metal anions, which are held in fixed positions in a 3D lattice when in a solid state. As a solid, the positive metal cations and negative non-metal anions are held together by strong ionic bonding which is the electrostatic attraction between the positive and negative charges of the ions. Lithium salt can be dissolved in a solution of water. Water is made up of polar molecules, meaning that a molecule of H₂O has a slightly positive end and a slightly negative end. This is because the shared electrons between the hydrogen and oxygen atoms, spend slightly more time near the oxygen because of its higher electronegativity. When Lithium salt is added to water, the ions are ripped from the 3D lattice by the H₂O molecules, because the positive end of the molecules attracts negative ions, and the negative end attracts the positive ions. The ions are now able to move freely throughout the solution because the attraction between the water molecules and the ions is stronger than the attraction between the negative and positive ions. A lithium salt solution is a more suitable source of lithium ions than in a solid state, because in solution form they are free to move, thus can successfully carry a charge between battery terminals.

(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.

Alloy 2 would be most appropriate as a battery cover for a smartphone because of its higher melting point, lower density, and more malleability. An alloy is the mixture of two or more elements, one of which is a metal. This makes Alloy 2 a metallic solid. Alloy 2 has a higher melting point because the strong metallic bonds between the positive metal cations and delocalised electrons take more heat energy to break than Alloy 1. This makes Alloy 2 more suitable to be a battery cover because if the battery heats up it is able to withstand higher temperatures than Alloy 1 without changing from solid form. Alloy 2 would also be the better choice for a battery cover because of its lower density. The more dense a substance is, the better it is at conducting heat. This is because when particles are closer together, and heat is applied, the vibrating particles are able to collide with more neighbouring particles and transfer the thermal energy much easier through the structure. Alloy 2 has a lower density than Alloy 1, which means it has worse heat conductivity. This makes Alloy 2 more suitable as a battery cover because if the battery heats up, Alloy 2 will insulate the heat better than Alloy 1, and will not transfer as much heat into the rest of the smartphone, which could cause damage. The third property that makes Alloy 2 more suitable than Alloy 1, is its better malleability. Alloy 2 is made up of positive metal cations and delocalised electrons. The strong metallic bonding means that when force is applied to the structure the cations can slide over each other and the alloy will not break because the strong electrostatic attraction between the electrons and cations is not broken. The metallic bonding in Alloy 2 is stronger than Alloy 1 because Alloy 2's malleability is better. This property of better malleability makes Alloy 2 a better choice as a battery cover because it can be shaped to better fit the battery in the smartphone.

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/

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Excellence

Subject: Chemistry and Biology

Standard: 92023

Total score: E8

Q	Marker commentary
(a)	Complete discussion of the two key physical properties required for a smartphone.
(b)	Copper selected but gold discussed as why it is a good heat sink. The purpose of a heat sink in a smartphone has been misunderstood.
(c)	The candidate explains why tin has a low melting point to join electrical components and tin can conduct electricity allowing electric to pass through the solder joins connecting components. A statement that the low melting point resulted in other electrical components not being damaged by heat was omitted.
(d)	Complete discussion of diamond and graphite linked to use.
(e)	Complete discussion of ionic solid and solution linked to use.
(f)	Complete discussion of three physical properties of alloy 2 linked to use. Only two physical properties required for excellence criteria.