

MYP Interdisciplinary learning

On-screen examination, May 2023

Example marked student responses

This document contains example material which demonstrates how the markscheme was applied to six student responses for the May 2023 session. The grades awarded are shown below. Two students were awarded grade 7, two were awarded grade 4, two were awarded grade 3.

Teachers should consider the application of the markscheme and in particular the assessment of longer, open-ended responses. Teachers may wish to mark the student response themselves using the published markscheme and then compare their marking to the standard demonstrated in this document.

Grade	Descriptor
7	Produces high-quality, frequently insightful work. Communicates comprehensive, nuanced interdisciplinary understanding of concepts and contexts through effective exploration of real-world issues, ideas and/or challenges. Consistently demonstrates sophisticated critical and creative thinking to synthesize and create new understandings and reflect on personal development. Frequently transfers interdisciplinary knowledge and discusses action taken or to be taken in unfamiliar situations.
4	Produces good-quality work. Communicates basic interdisciplinary understanding of most concepts and contexts through appropriate exploration of real-world issues, ideas and challenges, with few misunderstandings and minor gaps. Often demonstrates critical and creative thinking to make connections between disciplines, create new understandings and reflect on personal development. Transfers some interdisciplinary knowledge and outlines action taken or to be taken in familiar situations.
3	Produces work of an acceptable quality. Communicates basic interdisciplinary understanding of many concepts and contexts with occasional evidence of appropriate exploration of real-world issues, ideas and challenges, with occasional significant misunderstandings or gaps. Begins to demonstrate some basic critical and creative thinking to make connections between disciplines, create new understandings and reflect on personal development. Begins to transfer interdisciplinary knowledge and outlines action taken or to be taken with little insight.

Example 1: Grade 3

Student 1

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

For the cost part, solar car is more expensive than hydrogen car, that is \$178 500, the hydrogen car is \$68 500, so solar car need \$90 000 more than hydrogen car. Although the cost of buy a solar car is more expensive, it don't need to go somewhere for charge, so it safe the time for charge.

Both of solar car and hydrogen car have no emmision of CO₂, the strength of solar car is that solar car don't use charges, if sun light is enough, it can work for very long distance, the averange range of solar car is 750m/ 1 200km. On the other hand, it also can be the weakness of solar car, when the weather is not good enough you need to find other way to charge your car or choose other transport.

Hydrogen car's avrange range is not as long as solar car, it just have 300m/ 480km, but it's refuelling time is just 5 minutes. the only thing waste by product is just water, you can say it don't have emissions because water drop go on the floor will become cloud and rain that we can use.

after compare both of care, the Solar car is good for place that have lots of sunshine, although it has higher cost, but it can travel longer distance. the Hydrogen car is easier to affore, the speed of refuelling is also fast, but maybe the cost of hydrogen will be high, better than solar car in place that usually raining.

Markscheme

Strand 1: 0

Strand 2: 0

Strand 3: 4–6 Conclusion

Best fit: 1 mark

Grade 3

As the response focuses on the cars and not the brochures, there is a limited understanding of the context.

Example 1: Grade 3

Student 1

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

In my mind, scenario 2 is the best scenario. It is because of scenario 2 has the most budget in all three scenarios, in all types of transport budget, it always in the second place that is near to first place, it don't have types very weak.

The second reason i choose scenario 2 is because od carbon emissions per 100cars/ tonnes CO₂ of scenario 2 is even less than 100% in first 12 years and until 20 years it still very close to the scenario 3. It means the emissions of scenario 2 is very low, so it can safe the environment better. It is also means scenario 2 is a good scenario can sustainable.

Last but not least reason, the power outage od scenario 2 is about $\frac{1}{3}$ of scenario 3, it shows that scenario 2 can safe more power because of low frequency of outage.

because all of these reasons, i think scenario 2 is the best scenario of all three scenarios.

Markscheme

Strand 1: 4–6

Strand 2: 1–3

Strand 3: 4–6

Best fit: 4 marks

Grade 3

There is a basic understanding of the concepts demonstrated here, allowing for a comparison to be made. The response begins to demonstrate critical thinking as a result of the comparisons.

Example 1: Grade 3

Student 1

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5. In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

The first challenge for the self-employed delivery driver is that she cannot afford the cost whatever for more taxes or an electric truck that is double price as a normal one, and the second challenge is even the nearest charging station is very far from her home, and it need to take very long time for fully charge every day.

In my mind, the best solutions is that if government wants to let more people use electric car to decrease emissions, they should let the cost of get an electric car decrease so they can afford the cars, when there are more electric car in the city, of course the charging stations will increase by the companies for the car owners.

there is an example as I said in the material, the conscientious consumer said because of their government reduce the price of each electric car by 20%-30%, their city already has 30% electrification of all vehicles. We can see that if government give subsidy for electric car, the speed of people change car to electric is much faster than only let people pay more taxes.

Markscheme

Strand 1: 1–3

Strand 2: 3/4

Strand 3: 4–6

Best fit: 4 marks

Grade 3

Basic understanding of concepts in context. Beginnings of creative thinking demonstrated. Use of the pre-release material demonstrate and ability to transfer knowledge to unfamiliar contexts.

Example 2: Grade 3

Student 2

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

In the brochure of the solar car, math have been used to determine the charges required for 16000 km, also distance travelled by an solar car without a single charge. Science have been used to determine the CO₂ emissions by the solar car. In the brochure of the hydrogen car, math have been used to determine the average range of the car, science have been used to arrange the different components of the car and show the working of the hydrogen car and also to determine whether the car emits any CO₂ or not, the refueling time.

Strengths:

- Solar car can run for 10000 miles with only 20 charges.
- Solar car can travel twice the distance of an electric car.
- Solar car and hydrogen car has 0 grams of CO₂ emissions.
- Hydrogen car takes only 5 minutes to refuel where as an electric car takes 45 minutes even with power charging.

Weakness:

- Solar car is expensive

Solar car is a better option then the hydrogen car since it uses oxygen from the atmosphere, where already people are facing problem to get fresh air, but buying a solar car is also not in everyone's capability as it is a very expensive car, where not everyone is financially stable.

Markscheme

Strand 1: 1–3

Strand 2:

Strand 3: 4–6 (low, as not relevant)

Best fit: 2 marks

Grade 3

There is a basic understanding of concepts in the first paragraph.

Example 2: Grade 3

Student 2

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

In scenario 2, the total budget is \$21 billion dollars, \$2 billion more than in scenario 3 and \$4 billion dollars more than in scenario 1. The total budget is spread out almost equally in scenario 2, where in scenario 3 there is only \$2 billion dollars for public transport and in scenario 1 only \$3 billion dollars for electrification infrastructure and research. In scenario 1, the relative frequency of monthly power outage at average in span of next 10 years is 0.13, in scenario 2, the relative frequency of monthly power outage at average in span of next 10 years is 0.18. In scenario 1, the average carbon emissions are 1176 tonnes per 100 cars in next 10 years, where as in scenario 2, the average carbon emissions are 881.55 tonnes per 100 cars in next 10 years.

According to the above calculations, scenario 2 is the best case scenario as the total budget is equally distributed in the maintenance of the roads, public transport, the electrification infrastructure and research and new highways compared to scenario 1 and 3. Stability of electricity supply in scenario 1 is best as the average frequency of a monthly power outage is 0.13 in next 10 years but the average carbon emissions are 1176 tonnes per 100 cars in next 10 years, which can affect the environment very easily, and increase the greenhouse gases effect. In scenario 3, the average carbon emissions in next 10 years are lower than in scenario 2, but the budget available for public transport is \$2 billion dollars only, which is very low in comparison of scenario 1 & 2, where not everyone is financially stable to buy a good electric vehicle.

Markscheme

Strand 1: 4–6

Strand 2: 0

Strand 3: 0

Best fit: 2 marks

Grade 3

A lot of the response is just providing information from the references and not answering the question. The first paragraph includes a description of information from the resources and very basic communication of concepts. The second paragraph is beginning to demonstrate critical thinking.

Example 2: Grade 3

Student 2

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5. In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

Two challenges faced by the self-employed delivery driver are:-

1. The self-employed delivery driver needs to drive the delivery truck in the whole city every day of the week to deliver the goods, and doesn't earn enough to buy the groceries for his family, where the government is asking the driver to switch to an electric vehicle, or else the driver may pay higher taxes.
2. An electric truck costs double the price of an ICE truck and an used electric vehicle is mostly not available for sale. Also a self-employed delivery driver lives in a apartment where installing a power charging grid for charging an electric vehicle is expensive and the nearest charging station for the driver is 1 hour away from his apartment, and it will take a up to 8 hours to charge the electric truck.

The solutions for the above challenges can be that:-

1. The government should introduce schemes and give subsidies on electric vehicles like government pays a certain percent of the original price of the car when someone buys a new electric vehicle.
2. The government should introduce a fast charging cable which can charge fully within an hour.
3. The government and private companies should collaborate and develop the infrastructure of the charging stations so people who can't afford the power charging grid in their apartment can charge their vehicle nearby easily.
4. Reduce the taxes for those who own an electric vehicles so that the ones who are financially unstable can afford the daily requirements for their families.

Markscheme

Strand 1: 4–6

Strand 2: 4–6

Strand 3: 4–6 low

Best fit: 5 marks

Grade 3

There is basic understanding of the issues in the challenges section. The solutions demonstrate the beginnings of creative thinking.

Example 3: Grade 4

Student 1

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

To begin I would like to add that the 2 big differences in these sales brochures is that the solar car brochure it mainly talks about what the car can do , for example "Charges twice as fast as a standard electric car" or " The average distance traveled is twice as far as a standard electric car", whilst the hydro car brochure tells you about the car, explains how it works, and even tells you the waste by-product which is water by the way. As far as I can see both car share one similarity which is they both have 0 CO₂ emissions which means they both are non-air polluting cars, which is great for the environment.

What I like and what I dislike about both brochures is that the solar car only seems to boost and hype the car and doesn't tell us more about the car itself and how it works, although I dislike that about the solar brochure it's quite the opposite with the hydro car since it's doesn't really give you information about the ability of the car.

In conclusion although both cars sale impressed me I would like to see more information on both that could really persuade me like maybe if they told us if the car parts are sustainable and non-flammable in order not to cause any problems after the cars are discarded or if any of the material in the car can have the environment and what there planning to do about that, but in the end that's just my opinion.

Markscheme

Strand 1: low 4–6 (not always relevant to the disciplines)

Strand 2: 1–3

Strand 3: 6

Best fit: 4 marks

Grade 4

There are many instances where the student demonstrates an understanding of the concepts.

Example 3: Grade 4

Student 1

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

In my opinion I believe that electrifying 100% of electric cars is the better scenario.

To justify my reasoning lets look at the facts although in the total budget it seems that 40% has a better total budget which sits at 17 billion \$ compared to 100% which its at 19 billion \$ this is due to the fact that 40% spends most of its budget on public transport rather than maintenance of the road which is only 3.5 billion \$ compared to 100% with 4.5 billion \$ which makes it a 1 billion \$ difference.

Secondly for the 70% if you look at the total budget you'll find that it is exceeding the 20 billion \$ Budget meaning that for the 70% 1 billion \$ will be taken out of the budget for the environment.

Thirdly lets look at the Stability of the electric supply you will see that at 100% there is a relatively high number of power outages with an average of 0.34 compared to 40% which has an average of 0.09.

Although 100% seems to be lacking in the stability of electric supply it makes up for it if the carbon footprint since over time all in the long term of 20 years 100% has a record of 1410 cumulative carbon emissions compared to 40% which has a record of 2930 cumulative carbon emissions per 100 cars, making the 100% of electric cars a better ecological and non-air pollution solution.

Markscheme

Strand 1: 7–9

Strand 2: 7–9

Strand 3: 0 (credit cannot be given for the last paragraph for both strand 2 and 3)

Best fit: 6 marks

Grade 4

The response has many instances of critical and creative thinking combined with basic understanding of concepts.

Example 3: Grade 4

Student 1

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5. In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

Whilst reading the self-employed delivery driver's opinion I realized that she is right due to the fact that the electric car is a complicated and relatively new car the price will 30-40% more expensive (reference 2) and as she also stated there is not as many electric charging station compared to the regular petrol stations especially in apartment buildings.

What I would personally like to do is ask the owner of the apartment to implement a new regulation where people are able to build more electrical charging station so that the tenants have an opportunity to use it for charging their car overnight, and not just 1 electric car station but many so that people have access.

As for the first problem was the pricing I believe once electric cars become more popular after mass selling since it will be so common it's basically like clothes, for example if you go to the store on a big holiday and you find a brand new top, but it ends up being expensive but then a week later you go back to the same store and now that shirt is being discounted, in my opinion it's practically the same with cars you wait a bit until the price starts dropping than either buy a new one or get second hand if the price is still too expensive.

Markscheme

Strand 1: 1–3

Strand 2: 4–6

Strand 3: 4–6

Best fit: 4 marks

Grade 4

In the first paragraph there is transfer of knowledge in the situation. In the second and third paragraph there is creative thinking.

Example 4: Grade 4

Student 2

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

In the first brochure, The Solar Car, mathematics was used to get the distance travelled and the average number of charges per mile and kilometres, which is a good way to include mathematics and give facts about the car. There was barely any science facts in this brochure, where it just stated "0 grams, CO₂ emitted", which doesn't tell people exactly how the car works using solar electricity. The strength of the brochure is that we have exact details on the averages of the car's charge and distance travelled. The weakness is that there is barely any scientific information on the brochure.

The second brochure, "The Hydrogen Car", there were many information and facts stated, as of the mathematics section, the brochure stated the average range of the car and the refueling time. As for the scientific section, the brochure gives as an image of the process of how the car works, as the audience is able to know exactly what happens in the process. It is also stated that "0 emission" which tells us that this product is safe for the environment. The strength of this synthesis is that there isn't carbon emission produced. The weakness is that the brochure is kind of loaded, and the image lines need to be a little bit neater looking.

In conclusion, I think that the second brochure is better, as it has information on both the mathematical and scientific part. In addition, it tells us in details how the electricity is generated with the image of the process and steps.

Markscheme

Strand 1: 1–3

Strand 2: 1–3

Strand 3: 4–6

Best fit: 4 marks

Grade 4

There are several instances of basic understanding in the first and second paragraph.

The conclusion demonstrates critical thinking and application of knowledge to the context.

Example 4: Grade 4

Student 2

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

The best scenario is the second scenario, as 70% of the cars will be electrified, and it will cost 21 billion which is 1 billion over the budget. The scenario 2 is effective to the environment as the cumulative carbon emission will be 1587.5 in 20 years, and the scenario 3 will be 1410 which is close numbers. The scenario 1 is 2930 in 20 years, which is good but not as effective as scenario 2 and scenario 3. The second scenario's relative frequency of monthly power outage will be 0.05 in 20 years, while the third scenario's monthly power outage will be 0.6 in 10 years and then drop to 0.3 in 20 years. This is because there are many cars so more electricity will have to be generated, which will make the stability of power supplies decrease, this electricity power can be generated unsustainably.

Scenario 3 is having 100% electrified cars and in the budget of 20 billion. The high amount of electricity that will be generated can come from many different sustainable ways like wind turbines and solar panels. These sources are renewable, meaning we will never run out of them, so we will still be able to generate more electricity through sustainable ways that doesn't require the damage of the environment.

In my opinion, I think that the third scenario will be the best one to choose if we stick to generating electricity through renewable resources and avoiding to burn fossil fuels and generate electricity.

Markscheme

Strand 1: 4–6

Strand 2: 4–6

Strand 3: 4–6

Best fit: 6 marks (Even though opinions contradicted, the reasoning leads to the conclusion)

Grade 4

In the response we see an understanding of the concepts and the context, as well as some critical thinking and transfer of concepts to the situation. There are connections between disciplines and an understanding of the challenges/issues.

Example 4: Grade 4

Student 2

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5. In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

Two challenges the self-employed delivery driver is facing is that she is facing finical issues due to the goverment demanding for higher taxes if she doesn't switch to an electric car. In addition, the nearest charging stations for electric cars is far way from her apartment.

Due to the lack of electric cars charging station in the country, the goverment should create more charging stations in thy city and near compounds before giving consequences for those how don't own an electric car. As the Transport Ministers siad " I have real concerns about the lack of electric car charging infrastructure in this country". This quote clearly suggest the country to create more charging stations, which will solve one of the self-employed delivery driver's problem. The other problem the delivery driver is facing, is that she wont be able to buy an electric car with a low income " Electric cars are 30 -40% more expensive to buy than petrol cars" from refernece 2 , but the goverment should help low income employee by giving them time to be able to buy an electric car. In additon, the conscientious consumer stated " which reduces the price of each electric car by 20- 30 %." so with enough time and a 30% off the car's price, the delivery driver would be able to buy an electric car. The cheapest car in the market is 18 500\$, and with the 30% off discount the price of the car will be 12 950\$, which means the the delivery driver would be able to save 5550\$ from the discounts.

Markscheme

Strand 1: 1–3

Strand 2: 4–6

Strand 3: 4–6

Best fit: 4 marks

Grade 4

There are several sections that demonstrate creative thinking.

Example 5: Grade 7

Student 1

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

In the above sales brochures, there are many similarities and differences between the way both brochures have approached the synthesis of mathematics and science. In this text, I will be comparing and contrasting the synthesis of mathematics and science in the above brochures, analyzing the use of mathematics and science in each, explaining the strengths and weakness of each synthesis, and providing an evaluative conclusion.

To begin with, let us analyze the use of mathematics and science in both brochures. In "The Solar Car" brochure, an important point mentioned regarding science is the mass of Carbon Dioxide emitted per 1200 kilometers, being at a low zero grams per 1200 km. Similarly, a very important point mentioned in "The Hydrogen Car" brochure is that there are zero carbon dioxide emissions at all times. However, unlike the Solar Car brochure, the Hydrogen Car brochure delves deeper into the usage of science by mentioning exactly how the car is powered by Hydrogen using a chemical reaction which leaves water as the sole byproduct using a diagram and labels. In terms of the usage of mathematics, the Hydrogen Car brochure mentions the refuelling time, being at 5 minutes, and the average distance driven before needed to refuel, being at a distance of 480 kilometers. Similarly, in the Solar Car brochure, a very important point which is repeatedly mentioned is the distance driven before requiring to charge, being at roughly 1200 kilometers per charge. Despite not mentioning the recharge time like in the Hydrogen Car brochure, the Solar Car brochure chooses to lean towards a more mathematical approach rather than the Hydrogen Car brochure's scientific approach. In the Solar Car brochure, statistics such as the average number of charges required per 16,000 kilometers are provided to the viewer, the average distance travelled compared to other vehicles are also provided, and the speed of the Solar Car is also compared to other vehicles in the brochure.

While both approaches towards the two brochures come with many of their own respective positive aspects, this does not mean that they do not lack any negative aspects alongside the positive aspects. To begin with the positives a scientific approach, it enables the viewer to fully understand exactly how the processes which benefit the consumer work in the vehicle. A consumer who fully understands the product they are researching is more likely to purchase it as it is a safer option. Furthermore, this scientific approach will appeal to a large and growing community of technologically-savvy people. However, the drawbacks of neglecting to include much mathematics and instead focus on a scientific approach are as apparent as the positives. To begin with, important details such as average distance driven before needing to recharge, price of charging, and speed may not be included in brochures which focus on a scientific approach. Details such as these are important as people require certain specific details in their vehicles, and not mentioning these important details in vehicles simply means making the viewer have to do extra research. Furthermore, this does not appeal to the wide mass of consumers looking for practicality in a vehicle, as the scientific approach focuses mainly on how the benefits work and not what the benefits will do or how many benefits there are. Now, in terms of the mathematical approach, there are many positives which present themselves alongside it. To begin with, key details which many viewers would instantly look for such as speed, price of charging, average distance driven before recharging, etc. are mentioned very clearly. This enables the viewers to fully understand exactly what benefits the vehicle will provide for them. Furthermore, a mathematical approach will greatly appeal more to consumers seeking practicality in their vehicle of choice as mathematical approaches focus on what the benefits of the vehicle are. However, mathematical approaches are not free of any drawbacks. To begin with, while consumers will know what the benefits are, they will not understand how the benefits work. This means that the vehicle will not appeal to the large and growing community of technologically-savvy people around the world. Furthermore, the lack of providing scientific information on how the vehicle works could lead to lawsuits as many could claim that the mathematical approach to the brochure was misleading.

From the above information, it is clear that both brochures synthesize mathematics and science together. However, it is also clear that the Solar Car brochure leans mainly towards mathematics, and the Hydrogen Car brochure leans mainly towards a scientific approach. While both approaches have their many respective positive aspects, we must also shed a light on the negative aspects of the imbalance of the synthesis of mathematics and science in both. In this text, I compared and contrasted the synthesis of mathematics and sciences in the above brochures, analyzing the use of mathematics and science in each, explaining the strengths and weaknesses of each synthesis, and providing an evaluative conclusion.

Markscheme

Strand 1: 10–12

Strand 2: 10–12

Strand 3: 7–9

Best fit: 10 marks

Grade 7

The response clearly demonstrates a comprehensive understanding of the relevant concepts and context. There is also some sophisticated critical thinking with some insightful work in the second paragraph.

In the third paragraph there is critical thinking as well as transfer of knowledge to the unfamiliar context. There is also insightful work relating to the overall purpose using the disciplines. There is sophisticated and nuanced analysis for the use of disciplines in the synthesis.

Example 5: Grade 7

Student 1

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

Recently, three scenarios for the electrification of vehicles have been provided to the department of transport which depict the expected outcomes of different percentages for vehicle electrification, being at 40%, 70%, and 100%. I believe that scenario 2, being the electrification of 70% of vehicles will be the best scenario for our community. In this text, I will be justifying why scenario 2 is the best by providing evidence supporting it using mathematical and scientific reasoning, providing a response to the evidence against scenario 2 using mathematical and scientific reasoning, and I will be providing an evaluative conclusion.

To begin with, scenario 2, being the electrification of 70% of vehicles in the community, will be the best scenario for our community as it will significantly lower the communities vehicular carbon footprint. According to the above graph, scenario 2 will have the lowest cumulative carbon emissions per 100 cars for the next 9 years. While scenario 3 will have lower cumulative carbon emissions from year 11 to year 20, the difference between the cumulative carbon emissions between scenario 2 and scenario 3 will not be significantly different, never exceeding a difference of 100 tonnes of Carbon Dioxide. Comparing the cumulative carbon emissions of scenario 2 to scenario 1 simply displays how effective scenario 2 will be at lowering our cumulative carbon emissions. In the 20th year, the cumulative carbon emissions in scenario 2 will be roughly 1500 tonnes of carbon dioxide. In scenario 1, the cumulative carbon emissions will be double of the cumulative carbon emissions in scenario 2, sitting at roughly 3000 tonnes of carbon dioxide. Another point which needs to be raised is the stability of electricity supply. In scenario 2, the instability of electricity supply will slightly increase, however, compared to the massive increase in scenario 3, which is sometimes over double or even triple in relative frequency of a monthly power outage, scenario 2 simply displays exactly how there will be a lesser effect on the stability of electricity supply. Finally, in scenario 2, more money would be used for building new highways and electrification infrastructure and research while keeping the money spent on public transport and maintenance of roads balanced.

There are many arguments which have been brought up against scenario 2. To address the main argument, many people claim that scenario 2 will be harmful to the environmental department as it costs 21 billion dollars compared to the 20 billion dollar budget. This means that the remaining billion dollars will be taken from the environmental departments budget. While this may seem like a great negative, I believe it is fully justified as the money spent on the electrification of 70% of vehicles will have a positively massive impact on our communities carbon emissions, as a lot of the cumulative carbon emissions in general come from petrol cars. Furthermore, many people claim that the decreased budget for public transport in scenario 2 will greatly affect many peoples daily lives. However, this could not be farther from the truth. Since electric vehicles are much cheaper to maintain compared to petrol cars, such as requiring a lot less money on charges and being able to drive longer distances, while being at roughly the same purchasing price of petrol cars, more people will be encouraged to purchase their own electric vehicles, which decreases the demand for public transport. Since there will be a decreased demand for public transport, it is only logical to lower the budget on public transport and simply use the finances gained from this move to focus on more important things such as electrification infrastructure and research.

All in all, I believe that scenario 2 will be the best scenario for our community to approach, as it will decrease our communities vehicular carbon footprint while not severely impacting stability of electricity supply and balancing the budget for matters such as maintenance of roads and construction of highways. In this text, I justified why scenario 2 is the best scenario by providing evidence supporting it using scientific and mathematical reasoning, providing a response to the evidence against scenario 2 using scientific and mathematical reasoning, and I provided an evaluative conclusion.

Markscheme

Strand 1: 10–12

Strand 2: 10–12

Strand 3: 7–9

Best fit: 10 marks

Grade 7

The concepts are clearly understood and communicated in a way that demonstrates application of the student's knowledge to this context.

The student is able to find a creative solution to a real-world problem utilizing complex information.

Example 5: Grade 7

Student 1

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5. In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

Recently, many people have been criticizing the swift introduction of electric vehicles to the global world. A specific group which are especially critical towards electric vehicles are self-employed delivery drivers, such as the one in reference 5. In this text, I will be discussing the challenges and related solutions that electric vehicles present for self-employed delivery drivers such as the one in reference 5.

To begin with the challenges faced by self-employed delivery drivers, an important point often mentioned by them is the price of purchasing an electric truck. Electric trucks are very expensive vehicles which cost double the price of a petrol truck. While this is not a problem for some individuals of higher class, it most certainly is a problem for middle and working class individuals, mainly working class. It is unfortunately true that most self-employed delivery drivers, such as the one in reference 5, are of working class, and can barely afford to purchase basic necessities. To quote the self-employed delivery driver in reference 5, she states: "I barely make enough money to pay for groceries for my family". The challenge of suddenly having to switch from a petrol truck to an electric truck which is double the price of the petrol truck may cause immense stress for any individual in her financial situation. In addition, another major challenge faced by self-employed delivery drivers is the lack of infrastructure which support electric vehicles. Due to the sudden shift in the country's perspective towards electric vehicles, a lot more electric vehicle charging stations are needed, and the country simply does not have enough of electric vehicle charging stations available for use. According to the self-employed delivery driver in reference 5, "There are some charging stations in my city, but the nearest one is an hour away from my home." She also cannot simply drive the electric truck everyday to a charging station to charge her vehicle then return, as according to reference 2, a limitation of electric vehicles is that they "can take several hours to charge", which means that she simply cannot drive to the nearest charging point, charge, then drive back. Furthermore, even the transport minister in reference 5 has stated that "... we only a fraction of the charging stations needed to charge electric cars." Which simply contextualizes the immense brick wall in front of the self-employed delivery driver who would need to drive an hour and back every day if she had an electric truck.

While many challenges are sprung up by the swift introduction of electric vehicles into the country for self-employed delivery drivers such as the one in reference 5, there are also many solutions which could address both challenges. To begin with solutions for the first challenge of the price of the electric truck, while the electric truck costs double the price of a petrol truck, electric trucks require a lot less maintenance compared to petrol trucks as they simply have fewer parts. According to reference 2, a major positive of electric vehicles is that "maintaining an electric car is much cheaper than a petrol car, because there are fewer routine checks needed." Furthermore, charging your electric vehicle is much cheaper than refueling a petrol vehicle. This disparity in price will be much more apparent in the future as oil prices continue to rise exponentially globally, meaning that switching to electric vehicles will enable to you spend less on charges right now and in the future. Finally, the increased price of purchasing an electric truck is not unjustifiable, as it comes with many benefits. To begin with, according to reference 2, another major positive of electric vehicles is that "transitioning to electric cars will reduce noise disturbance." In addition, electric cars are more environmentally friendly compared to petrol cars. According to reference 2, a positive of electric vehicles is that "Electric cars can lower CO₂ emissions by more than 40% compared to petrol cars." To address the second challenge, while it is true that the country currently lacks infrastructure to support electric vehicles, such as charging points, it does not mean that rapid developments are being made all over the country to develop our infrastructure to make it more hospitable for electric vehicles. In fact, many more charging points are being installed all over the country in all regions, from urban regions, to suburbs regions, and to rural regions. With the rapid development of our countries infrastructure to make it more hospitable for electric vehicles by building new highways and installing more charging points, the transition from petrol vehicles to electric vehicles will be a lot smoother than what many, such as the self-employed delivery driver in reference 5, would expect.

While there are many challenges faced by self-employed delivery drivers such as the one in reference 5 due to the country's sudden shift in perspective towards electrification of vehicles, it does not mean that there are many already pre-existing solutions or solutions that are in development that render these challenges are solvable right now or in the near future. In this text, I discussed the challenges and related solutions that electric vehicles present for self-employed delivery drivers such as the one in reference 5, explaining two challenges that self-employed delivery drivers such as the one in reference 5 may face and explaining multiple solutions which address both challenges.

Markscheme

Strand 1: 10–12

Strand 2: 4–6

Strand 3: low 10–12

Best fit: 9 marks

Grade 7

The response shows comprehensive understanding and transfer of knowledge in the context.

The student uses creative thinking to find solutions, utilizing information from a variety of sources and synthesizing to form a coherent argument.

Example 6: Grade 7

Student 2

Question 1 [12 marks]

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in "The Solar Car" and "The Hydrogen Car" sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

The above brochures show the synthesis of two sustainable cars that don't require petroleum to function. "Sustain" is a solar powered car while "Infinity and Beyond" is fueled on hydrogen.

Both of the two posters employ mathematics and science to provide understanding of the two cars. "Sustain" which is a solar powered car utilizes the sun's rays as its main source of energy through the use of solar panels. Since the car runs on solar, it does not require active charging. The brochure states that the car does not emit CO₂, which allows it to be a greener and more sustainable transport option. Through experimentation and trials, it is mentioned in the brochure that the "Sustain" car charges twice as fast as a normal car, alongside this, the average distance covered by it is also twice that of a standard electric car, below that the poster mentions the sustain car requires only 20 charges while a standard electric car needs 60 per 10000 miles. All this information must have been gained through scientific testing, after obtaining this information, it was important to compare the performance of the "Sustain" car to standard electric cars. Through this the production company employed mathematics and science to promote the purchase of their car and backed up the claims with tested statistics.

Similarly, "Infinity and Beyond" which is a hydrogen power car also has similar claims to that of the "Sustain" car. The hydrogen car does not emit any CO₂, making it greener and more sustainable. However, instead of being a no charge car, "Infinity and Beyond" requires five minutes of fueling time. The average distance that it can cover is 300 miles, which is significantly lower by 9700 miles compared to the solar car, which covers an average distance of 10000 miles. The hydrogen car brochure depicts, through a diagram, the internal parts of their car. The diagram shows the circuit through which the car functions, the brochure also explains, step-by-step the functioning of the car and how it runs on hydrogen. This information allows consumers to form strong arguments about the most suitable car for them. Through the use of science, the functions of the car are made to be clear, alongside this, the statistics mentioned above, like the average distance that the car can cover is calculated through multiple trials and applied mathematics.

The difference between the two car brochures is that the "Sustain" car brochure shows more statistics about the performance of the car, it provides information about the performance mathematically, for instance, most of the information on the "Sustain" car brochure is about the statistics of the car rather than how it functions. Contrastingly, the hydrogen car brochure makes it a priority to explain how the car functions internally through the use of science, rather than statistics the brochure focuses more on explaining how the car runs on hydrogen and the science behind it.

Though the two posters are different, both have a set of strengths and weaknesses. As observed in the first brochure, it is based majorly on statistics rather than the scientific explanation of how the car functions on solar, or why it covers a longer distance than standard electric cars. Through the statistics provided, the consumers are able to make their decision on which car would be the most suitable for them, however, through that is a strength the poster has, it is also important to put emphasis on the functions of the car. Another smaller discrepancy the brochure had was, on the side it mentioned the car required no charges, however, in the main body of the brochure it claimed the amount of charges required by "Sustain" which is 20 to the charges required by standard electric cars, this might create confusion in the consumers. Since the brochure is promoting a sustainable and green car, it is important to mention how and what makes the car sustainable. If the mathematical statistics are not supported by scientific explanations, they become less valid.

The second poster of the hydrogen car has a minimal yet informative poster. It is easy to understand and provides most of the information that is needed for a consumer. The brochure also includes a diagram that provides the consumers with a visual of all the functions that are taking place internally in the car. The aim with the brochure was to provide and educate consumers about why they should be purchasing a hydrogen car, however, the brochure lacked mathematical statistics. Other than the average distance traveled by it, the brochure only focused on the science of the car, which made the explanations baseless as consumers would not know the features and potentials of the car. Hence it is important to balance out scientific explanations with mathematical statistics and vice versa.

In conclusion, it is important, when making a brochure, to provide well-rounded information and explanation. In the case of the two car brochures, it was important to provide claims and support these claims with both mathematics and science, since the making of the car heavily involves the two streams. Both posters had information, however, they lacked balance, therefore the use of both streams with balance was crucial in this situation.

Markscheme

Strand 1: 10–12

Strand 2: 10–12

Strand 3: 7–9 Conclusion vague.

Best fit: 10 marks

Grade 7

The student demonstrates comprehensive understanding, along with some sophisticated critical thinking. The fourth paragraph is concise, but demonstrates an understanding of the disciplinary concepts, transferring knowledge to the unfamiliar situation. The fifth paragraph relates to the overall purpose of the synthesis and has some insightful work. Excellent critical thinking and transfer of knowledge to the context.

Example 6: Grade 7

Student 2

Question 2 [12 marks]

You need to prepare a proposal justifying which scenario is best. By applying your knowledge of science and mathematics, **justify** which scenario is best. In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

The department of transport is making a proposal to completely electrify all cars over a period of 10 years under the budget of \$20 billion. Through this proposal, the department of transport would discuss and clarify concerns about budgeting, power supply and carbon emission as the main concerns. Alongside this, though long calculations and scientific reasonings, the department would put this proposition into action as soon as it is approved as part of our 10 year action plan for a greener, more sustainable future.

When observed above, the bar graph shows the budget that would be spent on this long term project. With \$4.5 billion used for road maintenance, \$3.5 billion used for new highways, \$2 billion for public transport and \$9 billion for electrification and infrastructure research, with the total money being spent would be \$19 billion, which remains under the budget which \$1 billion left to transfer to the environmental budget. Through this proposal, we aim to reduce carbon emission significantly, and all while staying under budget.

As mentioned above, one of the main concerns and aims with this project would be to reduce carbon emissions. As observed in the line graph, if all the transports are electrified, the carbon overall carbon emission would significantly plummet to a high of 1410 cumulative carbon emission per 100 cars in only 20 years, when compared to other scenarios, the carbon emission as a result of our proposal are the lowest, again, allowing for a better and more green environment, which is also one of the aims for the proposal. If nothing was to be done about the carbon emission that cars produce, the overall high would be 5900 cumulative carbon emission per 100 cars, which is approximately 79% more than what the car emissions would be with all 100% of the vehicles being electrified.

Since conversion of all vehicles to electric would require the government to install well placed and distanced charging stations, it would take a toll on the power supply of the area. This would make the probability of power outages higher than when none, 40% or 70% of the vehicles were electric. Though this could pose as an issue in the beginning, as a part of our action plan, the department of transport has made sure to take into consideration, the effects of switching to all electric vehicles. When the switch to electric vehicles is in transit, we plan on investing the \$1 billion that was left over from the overall budgeting to install a stronger power supply that will be able to handle the new energy requirements. Through this, we are able to stay within our set budget while also resolving issues that may involve the switch to all electric vehicles. As observed in the graph above, the highest power outage frequency is 0.6, however, as the years pass it is seen to be lowering as it reaches year 20 with a frequency of 0.3, though the power outage frequency will eventually go down, through our plan of installing a new stronger power supply, the effect would be faster and more efficient.

Overall, making the switch to using all electric vehicles has mostly benefits, with the disadvantages being taken into consideration by the department of transport. While staying within the budget we hope to go through with our action plan and abide by the statistics mentioned above. All the statistics that have been collected, were collected through scientific and mathematical judgement, hence, with that information, we hope to solve the power outage issue and maintain the carbon emission levels to the minimum. The department of transport hopes to have this proposal approved.

Markscheme

Strand 1: 10–12

Strand 2: 10–12

Strand 3: 7–9

Best fit: 10 marks

Grade 7

The second and third paragraph demonstrates a comprehensive understanding of the concepts and context.

In the fourth paragraph there is understanding of the context, using critical thinking to articulate how the issue will be overcome and some creative thinking.

Overall, there is a clear, comprehensive understanding of the concepts and context, demonstrating critical thinking to assess what the information means. The response demonstrates transfer of interdisciplinary knowledge to this context.

Example 6: Grade 7

Student 2

Question 3 [12 marks]

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5.

In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

As a self employed delivery truck driver, having to switch to an electric vehicle can pose as an issue due to various reasons. As a delivery truck driver, the income is only enough to "get by", and most people consider a high-tech item like an electric car a luxury, on that the self employed delivery truck drivers cannot afford. Alongside this, the truck driver would be required to purchase a large vehicle rather than a standard size one due to the nature of their job, making it even more challenging to invest in such a an expensive purchase. Now that the government has made it required to own electric vehicle, the delivery truck driver is facing a dilemma on how to approach the situation.

Since the income of the delivery truck driver is low, it is extremely challenging to make a large purchase with the current amount of money she is earning. An electric car is 30% to 40% more expensive than a standard petrol car, which is a major hike in price. The cost of these electric cars start from the cheapest being a bifuel car at \$18500 to the most expensive being the solar car at \$178000. When put into perspective, if a smaller everyday use passenger car cost this amount, a large delivery truck would have an even higher cost quotation. Alongside the most noticeable struggle with the price of the car, the charging situation would also be an issue for the delivery truck driver. As she is currently residing in an apartment with no charging stations, she would have to drive all the way to her nearest charging station, which she mentions to be a hour drive away. Even if she was able to purchase the truck she would have to drive all the way to the charging station, and wait 8 hours for her truck to fully charge which limits sustained long distance travels and would be an inconvenience to do every single day.

Since the government is mandating her to purchase an electric vehicle that is out of her budget range, she would be eligible to apply for a loan in accordance to her yearly income. Along with a loan, if discussed with government officials, she might also be accepted to be aided by the government when purchasing the car. Instead of paying double the taxes every month, she could set out a sum of her income to pay off her loan at her own pace. Throughout the duration she owned a petrol car, she must have experienced malfunction and repair requirements. When she is able to apply for a loan to purchase an electric car, the money she had to invest in repairs would significantly reduce as electric vehicles are cheaper to maintain in comparison to petrol running vehicles. Having a loan on purchasing a car would simplify her situation immensely as she will be in control of how much money she is investing in the car and she is able to do it in her own time.

Though she will be able to purchase an electric car, her issue with charging would still remain. However, as mentioned previously, there are multiple options to alternatively powered vehicles. Those include, hydrogen powered, solar powered, and bionic fuel powered. Bionic fuel being the cheapest, it is one of the best options she could invest in. However, if the government is requiring her to own an electric car particularly, there are options that could resolve her charging issue. When purchasing an electric car, she should invest in one that includes a charging set up. As electric cars become more common, a smaller version or an average charging set up is included with the car. Though it might be expensive, since she had the option to use a loan, investing in a charging dock will make her job more convenient.

Finally, another solution that would resolve all her issues would be to sign with a delivery service agency. Though it may be a drastic solution to her problems, signing with an agency would mean that the agency would cover for all the costs that come with owning an electric vehicle, perhaps, the agency might also provide her with one.

To conclude, though the governmental policy of switching to electric vehicles or facing consequences of paying double the taxes is extreme and incomprehensible for those that are not able to afford purchasing electric vehicle, the above solution may provide the self employed delivery driver with some alternative options to her problems that are preventing her from abiding by the governmental policy and purchasing an electric delivery truck.

Markscheme

Strand 1: 7–9

Strand 2: 7–9

Strand 3: 7–9

Best fit: 9 marks

Grade 7

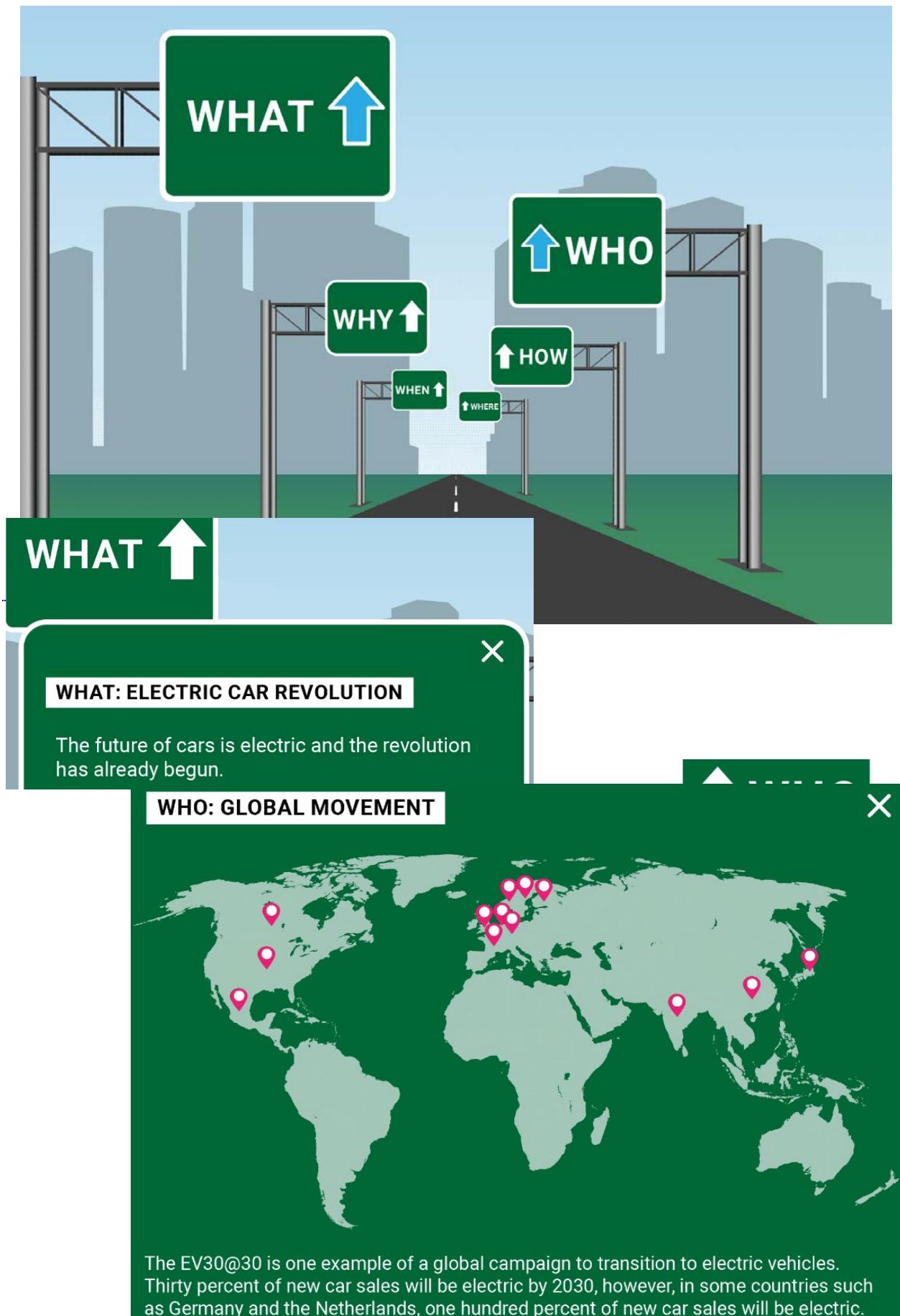
In the second paragraph the student shows transfer of knowledge from the pre-release material/another question to this context. This is a demonstration of creative thinking. In the third paragraph the student applies critical thinking to the context to provide a good explanation of the issues being faced overall.

In the fourth paragraph critical and creative thinking are used to arrive at viable solutions.

This question is complex, requiring significant application of conceptual understanding utilizing a variety of different information sources. This response synthesizes these aspects together, demonstrating independent transfer of knowledge and skills.

Reference 1: Road map for the global transition to electric vehicles

This media is interactive. Click on the arrows in the sign posts.



WHY ↑

WHY: GREENER FUTURE

Electric vehicles will soon be much more affordable, easier to charge, able to drive distances over 1000 km on one charge. Most importantly, they will considerably reduce air pollution and our dependence on fossil fuels.

↑ HOW

HOW: RECHARGEABLE BATTERIES AND ELECTRICITY SUPPLY

Due to a need to generate more electricity, the supply of electricity will need to be “smarter” and more flexible so that supply matches demand in order to reduce the need for additional peak capacity.

Electric cars run on rechargeable batteries rather than using petrol or diesel. The lifetime of a rechargeable battery is currently eight years with predictions that batteries will last 20 years in the future.

WHEN ↑

WHEN: ELECTRIC CARS RULE THE ROAD

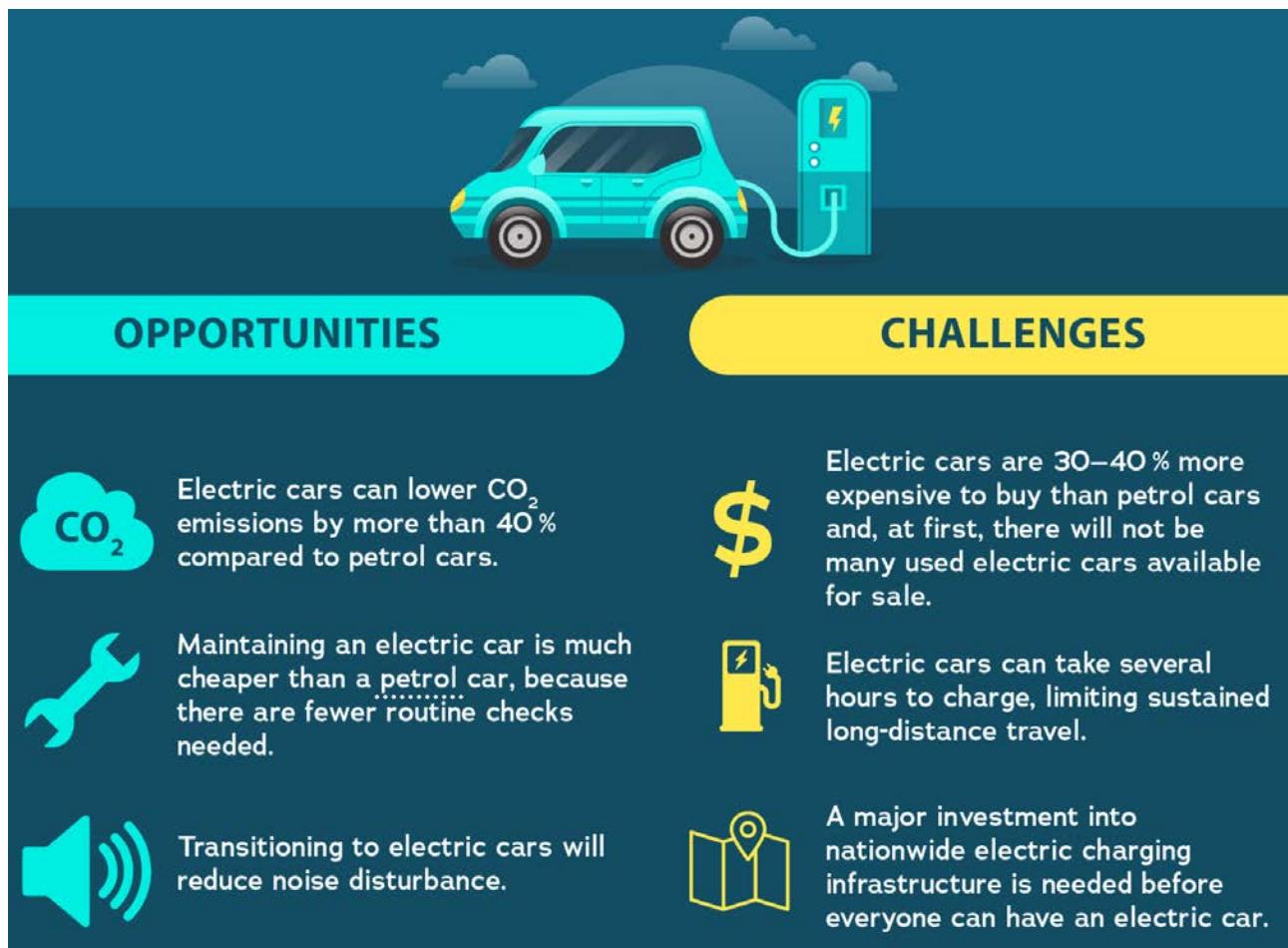
Projected global sales for new electric vehicles



↑ WHERE

WHERE: CHARGING NETWORK INFRASTRUCTURE

Countries will need to invest in a national charging network. For example, London (UK) already has more than 500 rapid charge points and 7000 residential charge points. In the US, where many houses have garages, 80 % of electric vehicle owners charge their cars at home.

Reference 2: The opportunities and challenges of electric vehicles

Reference 3: Brochure specifications for alternatively fuelled vehicles

This media is interactive. Click on each car for more information.

ALTERNATIVELY FUELLED VEHICLES

BIONIC
The Biofuel Car LPG
From \$18 500

SUSTAIN
The Solar Car
From \$178 500

Terawatt
2023 Edition
The Electric Car
From \$38 000

INFINITY & BEYOND
The Hydrogen Car
From \$68 500

BIONIC

THE BIOFUEL CAR
LPG



From
\$18 500



- 1.0 litre turbocharged dual-fuel engine, combining petrol and LPG capabilities, with an LPG-only mode
- Choose both LPG and petrol on the move, for a combined range of more than 600 miles/960 kilometres
- Reduce global warming with CO₂ reductions in LPG mode
- Save up to 10% on your CO₂ emissions, which for the average driver is half a tonne of CO₂ a year
- Less air pollution by reducing harmful NOx emissions
- LPG biofuel is approximately half the price of petrol
- Save over \$800 on your yearly fuel cost
- Servicing and maintenance times are identical to that of a conventional petrol car

Terawatt

2023 Edition

THE ELECTRIC CAR



From:
\$38 000

260 horsepower (hp)

320 lb·ft max. torque

0-60 mph (0-100 km/h) in 5 seconds

140 mph (225 km/h) top speed

260 miles/418 kilometres electrical range



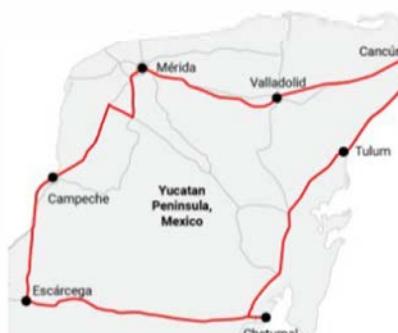
SUSTAIN THE SOLAR CAR



HEAD TO THE LIGHT AND REDUCE THOSE ENDLESS CHARGES

FROM \$178 500

SUSTAIN YOUR DREAM ROAD TRIP



The average distance travelled is twice as far as a standard electric car.

Average number of charges per 10 000 miles/16 000 kilometres:

- Sustain Solar Car: 20*
- Standard electric car: 60

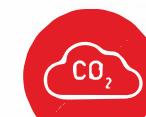
* based on an average of 12 daylight hours of which 6 hours are direct sunlight.

DISTANCE TRAVELED 750 MILES/ 1200 KILOMETRES	0 GRAMS CO₂ EMITTED
0 CHARGES	

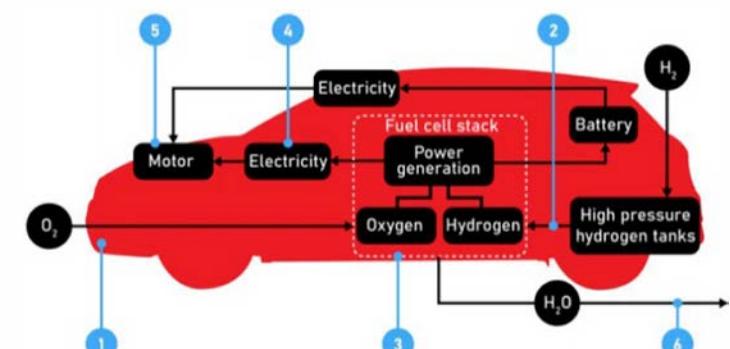
INFINITY & BEYOND THE HYDROGEN CAR



From \$68 500

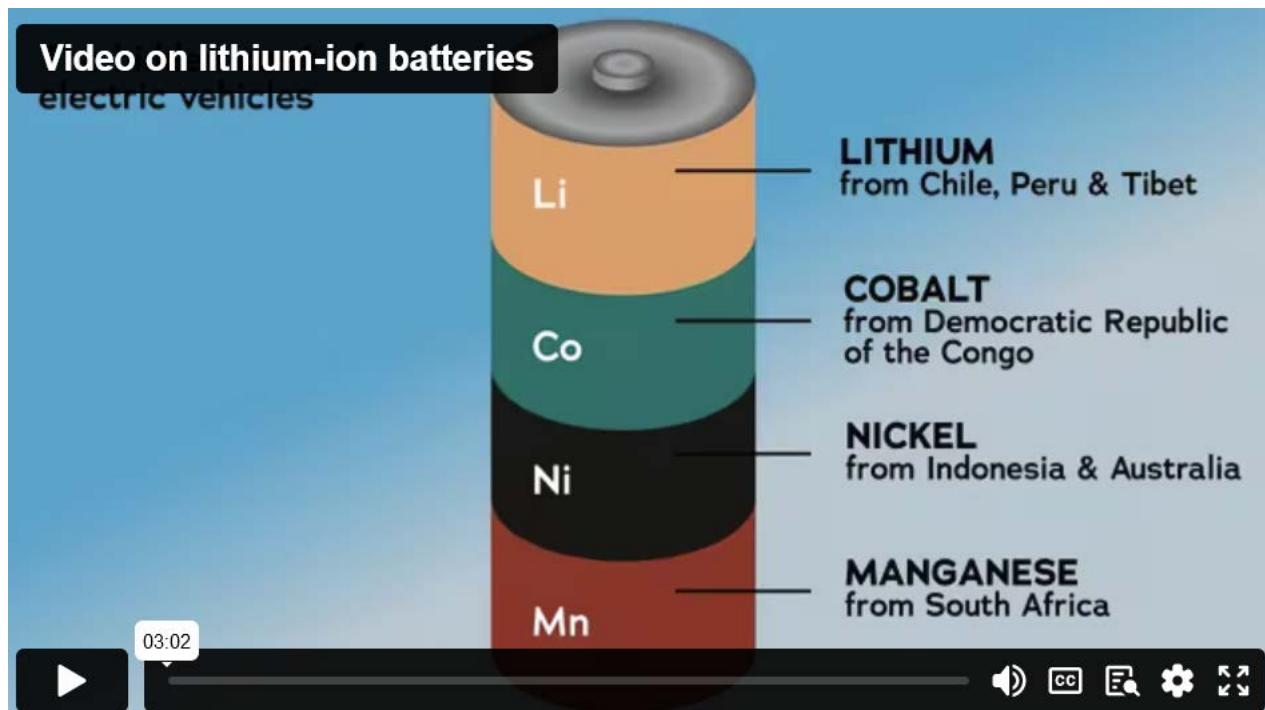


0 emissions

Refuelling time
5 minutesAverage range
300 miles/480 km

- 1 Oxygen from the atmosphere enters the car's air vent.
- 2 Hydrogen is transitioned to the fuel stack.
- 3 A chemical reaction generates electricity and water.
- 4 The electricity powers the motor.
- 5 The motor enables the vehicle to move.
- 6 The only waste by-product is water.

Reference 4: Video on lithium-ion batteries



©

Video script:

Lithium-ion rechargeable battery technology is responsible for innovations in technology such as smartphones, tablets and laptops and electric vehicles.

Electric vehicles are the globally accepted transport of the future, but there is an environmental cost to this battery-powered innovation.

The lithium-ion battery technology aspires to a fossil fuel-free society. However, lithium-ion batteries are made with metal components such as cobalt, nickel and manganese.

Most cobalt is mined in the Congo. Human-rights groups have exposed severe ethical and environmental issues in mining operations, such as child labour and pollution.

Fatal accidents in informal mining practices and human exposure to cobalt dust makes the process of mining cobalt hazardous.

Also, the extraction of cobalt requires a process called smelting, which emits sulphur oxide and other harmful air pollutants.

Another important component of these batteries is lithium. More than half of the world's lithium supply comes from the arid salt flats of the Atacama Desert.

The process to extract lithium uses significantly large amounts of groundwater, resulting in a decreased water supply and less accessible water for local agriculture. In the Atacama Desert, lithium mining companies have used 65 % of the region's water supply.

Lithium mines can also be found in Tibet. In 2016, there was a large chemical leak at a lithium mine in the Tibetan highlands.

As a result, the river was severely polluted and several fragile ecosystems on the Tibetan plateau were devastated.

Thousands of animals, including fish and local wildlife, which relied on the water from this river were killed.

Many of the components of an old lithium-ion battery in a smartphone or laptop cannot easily be recycled and most end up in landfill. The components are highly flammable and are responsible for fires and contamination of local environment at waste facilities.

However, the news is not all bad. Old lithium-ion car batteries from electric vehicles have the potential to be repurposed. Research facilities are already working together to repurpose old lithium-ion car batteries in other applications.

Car manufacturers are developing cost-effective technologies to recycle 100 % of the components from lithium-ion car batteries.

As demand for electric vehicles continues to increase, waste lithium-ion car batteries have the potential to become a serious environmental problem.

A sustainable solution to the problem of repurposing and recycling lithium-ion car batteries could be the next big innovation.

Reference 5: Multiple perspectives on the transition to electric vehicles

Transport minister



I have real concerns about the lack of electric car charging infrastructure in this country. At the moment, we only have a fraction of the charging stations needed to charge electric cars. The average distance between charging stations in the countryside is about 50 miles, this just isn't practical for most electric car owners.

Conscientious consumer



I still can't believe that so many people still drive petrol cars. In my country, we are already at 30 % electrification of all vehicles. This is because our government subsidises ownership of electric cars, which reduces the price of each electric car by 20-30 %. Let's get rid of these dirty fossil-fuel cars right now!

Self-employed delivery driver



I drive my delivery truck in the city every day, all day long. Now the government is telling me I have to pay higher taxes if I don't switch over to an electric truck. I barely make enough money to pay for groceries for my family, and now I'm expected to pay double the price for a new electric truck. We live in an apartment with no way of charging an electric vehicle. There are some charging stations in my city, but the nearest one is an hour away from my home. Even if I were to take the truck to that charging station every day, it would still take 8 hours to fully charge the vehicle.

Automotive engineer



Electric cars are better than their petrol equivalents in a number of ways. Electric vehicles produce zero direct emissions, are 30 % quieter, and have higher energy efficiency than petrol. Electric vehicles are easier to maintain; with fewer parts, they break down less often than petrol cars, and will be on the road for more years than a petrol car.

SUSTAIN

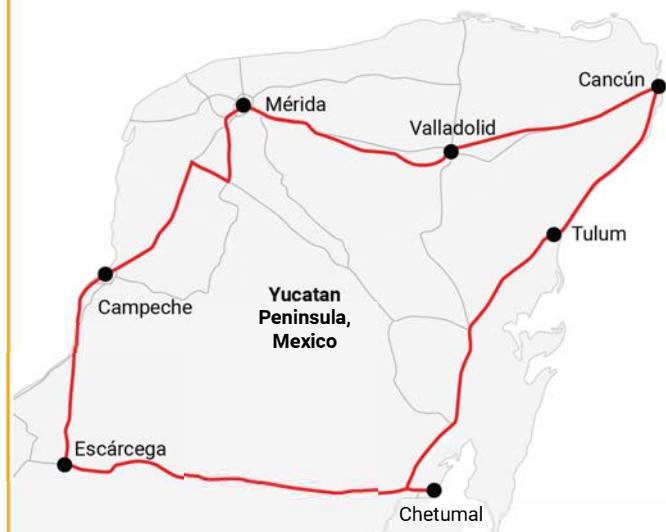
THE SOLAR CAR



HEAD TO THE LIGHT AND REDUCE THOSE ENDLESS CHARGES

FROM \$178 500

SUSTAIN YOUR DREAM ROAD TRIP



**DISTANCE
TRAVELED
750 MILES/
1200
KILOMETRES**

**0 GRAMS
CO₂ EMITTED**

0 CHARGES

Sustain Solar Car charges twice as fast as a standard electric car.

The average distance travelled is twice as far as a standard electric car.



**Average number of charges per 10 000 miles/
16 000 kilometres:**

- Sustain Solar Car: 20***
- Standard electric car: 60**

*** based on an average of 12 daylight hours of which 6 hours are direct sunlight.**

INFINITY & BEYOND

THE HYDROGEN CAR



From \$68 500



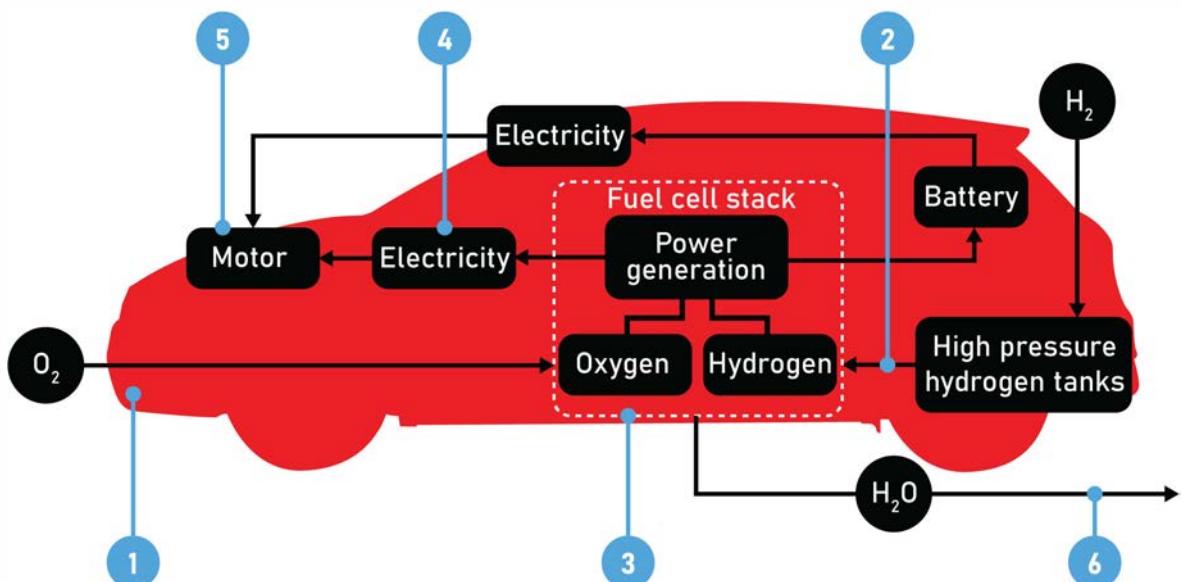
0 emissions



Refuelling time
5 minutes



Average range
300 miles/480 km



- 1 Oxygen from the atmosphere enters the car's air vent.
- 2 Hydrogen is transitioned to the fuel stack.
- 3 A chemical reaction generates electricity and water.
- 4 The electricity powers the motor.
- 5 The motor enables the vehicle to move.
- 6 The only waste by-product is water.

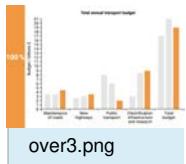
Question 1 (12 marks)Overview Content**Evaluating**

In this task (question 1), you will be assessed using **criterion A** (Evaluating) for sciences and mathematics.

Compare and contrast sales brochures of different vehicles.

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in “The Solar Car” and “The Hydrogen Car” sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

Question 2 (12 marks)Overview Content**Synthesizing and reflecting**

In this task (questions 2 and 3), you will synthesize your knowledge from sciences and mathematics to determine the best scenario for introducing electric vehicles and you will reflect on the impact on an individual. You will be assessed using **criterion B** (Synthesizing) and **criterion C** (Reflecting).

Review different scenarios for the introduction of electric vehicles into society.

You are a government official working for the department of transport. Your department is overseeing the transition to electric cars over a 10-year period.

The total budget for transport is \$20 billion. If the project costs more than \$20 billion, the extra budget funds will be taken from the budget for the environment.

The interactive media below shows the projected outcomes for three transition scenarios: 40 %, 70 % or 100 % electric vehicles.

This media is interactive

Click on the coloured tabs for each scenario and hover over the graph points for more detail.

You need to prepare a proposal justifying which scenario is best.

By applying your knowledge of science and mathematics, **justify** which scenario is best.

In your answer you must include:

evidence supporting your choice using mathematical **and** scientific reasoning

a response to the evidence against your choice using mathematical **and** scientific reasoning

an evaluative conclusion.

Scenario 1

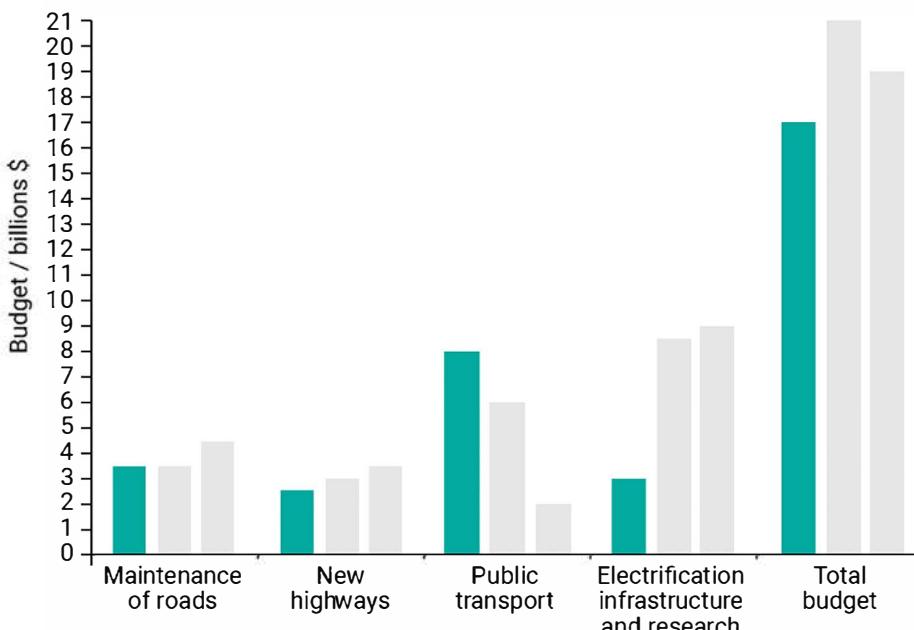
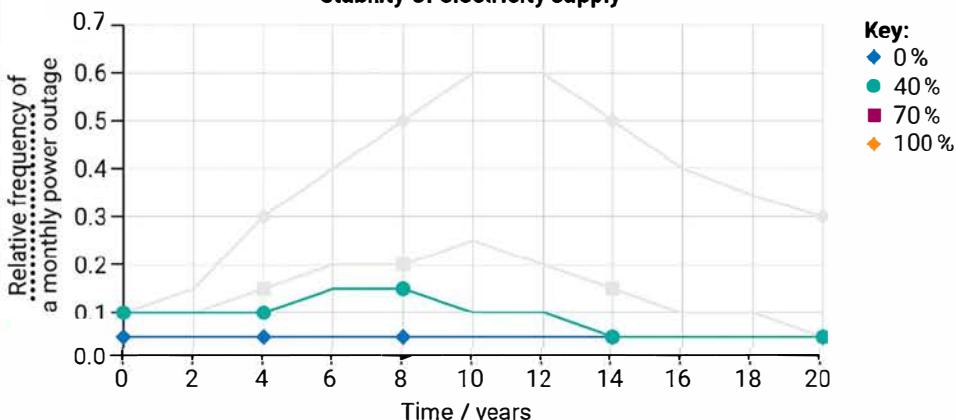
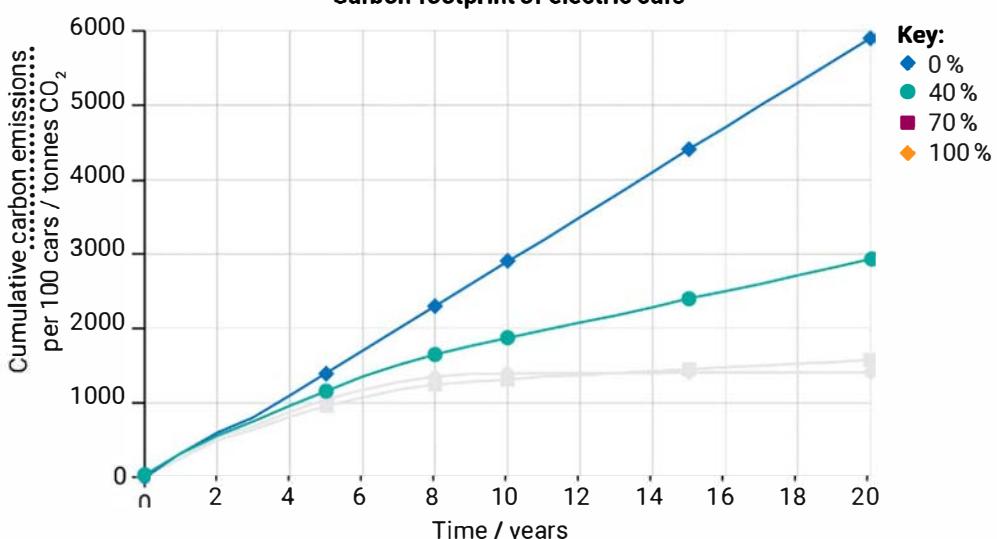
Percentage of cars electrified:
40 %

Scenario 2

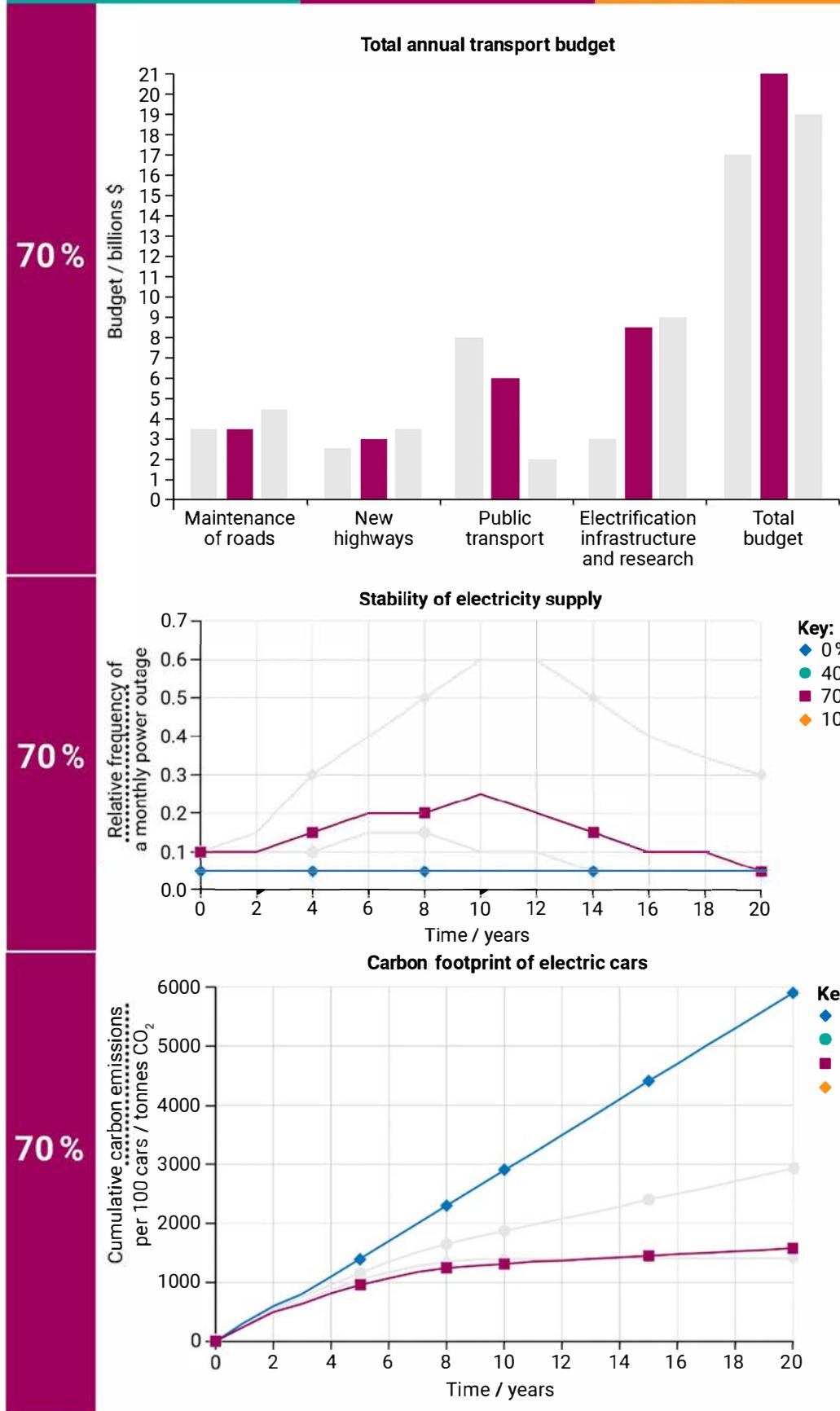
Percentage of cars electrified:
70 %

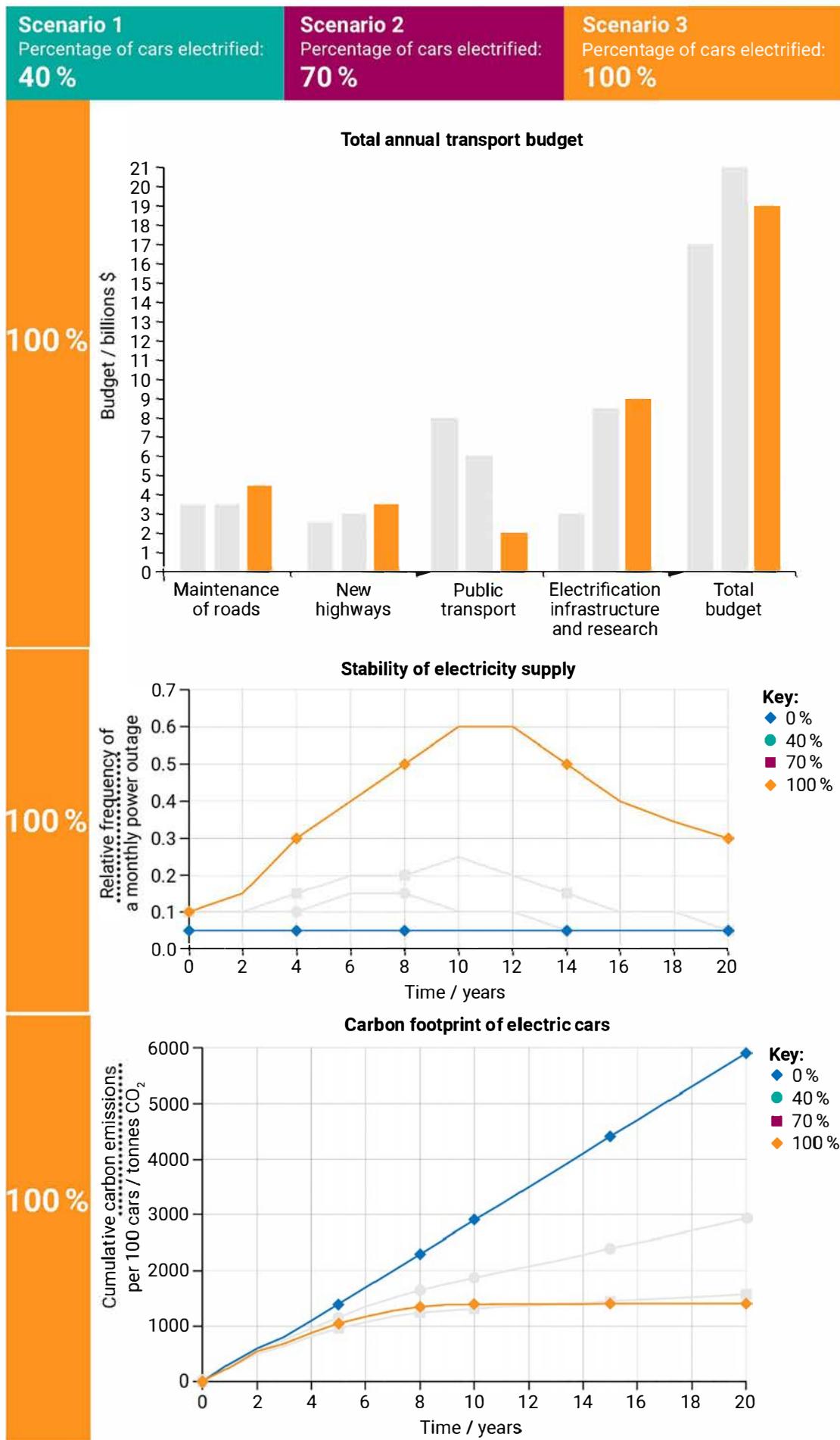
Scenario 3

Percentage of cars electrified:
100 %

40 %**Total annual transport budget****40 %****Stability of electricity supply****40 %****Carbon footprint of electric cars**

Scenario 1	Scenario 2	Scenario 3
Percentage of cars electrified:	Percentage of cars electrified:	Percentage of cars electrified:
40 %	70 %	100 %





Self-employed delivery driver

I drive my delivery truck in the city every day, all day long. Now the government is telling me I have to pay higher taxes if I don't switch over to an electric truck. I barely make enough money to pay for groceries for my family, and now I'm expected to pay double the price for a new electric truck. We live in an apartment with no way of charging an electric vehicle. There are some charging stations in my city, but the nearest one is an hour away from my home. Even if I were to take the truck to that charging station every day, it would still take 8 hours to fully charge the vehicle.

**Question 3 (12 marks)**

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5.

In your answer you must:

explain **two** challenges

explain solutions to address **both** challenges

include evidence from the pre-release material to support your arguments.



Markscheme

May 2023

Interdisciplinary learning

On-screen examination



This markscheme is **confidential** and for the exclusive use of examiners in this examination session.

It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Global Centre, Cardiff.

Best fit approach

'The approach used in assessment in the application of assessment criteria is a "best fit" model. The examiner or teacher applying an assessment criterion must choose the achievement level that overall best matches the piece of work being marked. It is not necessary for every detailed aspect of an achievement level to be satisfied for that level to be awarded but it must reflect the balance of student achievement against the markband. For example, if student work matches two of the three requirements within a markband but one is seriously lacking, the student should be awarded for the strands that have been met well, but the mark awarded should be at the lower end of the markband to compensate for what is lacking in one strand. If the level of student work spans multiple markbands, compensation depends on the performance in the higher order skills. It is worth noting that the highest level of any given criterion does not represent perfection'

Note: Before marking, please familiarize yourself with the [pre-release material](#), all sources, the questions and the markscheme.

*These are the command terms used throughout the markscheme.

Command term	Definition
State*	Give a specific name, value or other brief answer without explanation or calculation.
Outline*	Give a brief account or summary.
Describe*	Give a detailed account or picture of a situation, event, pattern or process.
Explain*	Give a detailed account including reasons or causes.
Compare and contrast	Give an account of the similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.
Discuss	Offer a considered and balanced review that includes a range of arguments, factors or hypotheses. Opinions or conclusions should be presented clearly and supported by appropriate evidence.
Justify	Give valid reasons or evidence to support an answer or conclusion. (See also "Explain".)

Question 1

Refer to the two sales brochures in the tabs above. **Compare and contrast** the synthesis of mathematics and science in “The Solar Car” and “The Hydrogen Car” sales brochures. In your answer you must:

- analyse the use of mathematics and science in each brochure
- explain the strengths and weaknesses of each synthesis
- give an evaluative conclusion.

(12 marks)

Note: Responses must refer to the brochures use of mathematics and science, not the cars themselves. If a response only compares the cars, then students score 0 for the first two strands. The conclusion can still gain marks.

Note: Responses should not be two separate lists about each brochure or discuss each brochure separately. The command term is Compare and Contrast and responses must therefore refer to similarities and differences of the brochures together. If there is no comparison or contrast for the first two strands, highest band available for this strand is 1-3

Note: To be valid, examples must reference an element of the brochures.

Marks	Descriptor
0	The student does not achieve a standard described by any of the descriptors given below.
1-3	<p>The student:</p> <ul style="list-style-type: none"> • states how each brochure uses mathematics and science • states a strength and weakness of each syntheses.
4-6	<p>The student directly compares and contrasts each brochure by:</p> <ul style="list-style-type: none"> • outlining how each brochure uses mathematics and science • outlining the strengths and weaknesses of the syntheses • attempting a conclusion.
7-9	<p>The student directly compares and contrasts each brochure by:</p> <ul style="list-style-type: none"> • describing how each brochure uses mathematics and science • describing the strengths and weaknesses of the syntheses • giving a conclusion.
10-12	<p>The student directly compares and contrasts each brochure by:</p> <ul style="list-style-type: none"> • explaining how each brochure uses mathematics and science • explaining the strengths and weaknesses of the syntheses • giving an evaluative conclusion.

Question 2

You need to prepare a proposal justifying which scenario is best.

By applying your knowledge of science and mathematics, **justify** which scenario is best.

In your answer you must include:

- evidence supporting your choice using mathematical **and** scientific reasoning
- a response to the evidence against your choice using mathematical **and** scientific reasoning
- an evaluative conclusion.

(12 marks)

Note: Do not credit any scientific information that is not from the examination or pre-release material.

Note: Mathematical calculations are not required and are therefore to be ignored. Credit is to be awarded for demonstrating and understanding of mathematical concepts.

Marks	Descriptor
0	The student does not achieve a standard described by any of the descriptors given below.
1-3	<p>The student justifies by:</p> <ul style="list-style-type: none"> • stating evidence using mathematical or scientific reasoning • stating a counter argument using mathematical or scientific reasoning.
4-6	<p>The student justifies by:</p> <ul style="list-style-type: none"> • outlining evidence for their choice using mathematical or scientific reasoning • outlining a counter argument using mathematical or scientific reasoning • attempting a conclusion.
7-9	<p>The student justifies by:</p> <ul style="list-style-type: none"> • describing their choice using mathematical and scientific reasoning • describing a counter argument using mathematical or scientific reasoning • providing a conclusion. <p>or</p> <ul style="list-style-type: none"> • Describing their choice using mathematical or scientific reasoning • describing a counter argument using mathematical and scientific reasoning • providing a conclusion.
10-12	<p>The student fully justifies by:</p> <ul style="list-style-type: none"> • explaining their choice using mathematical and scientific reasoning • explaining a counter argument using mathematical and scientific reasoning • providing an evaluative conclusion.

Question 3

Self-employed delivery driver


I drive my delivery truck in the city every day, all day long. Now the government is telling me I have to pay higher taxes if I don't switch over to an electric truck. I barely make enough money to pay for groceries for my family, and now I'm expected to pay double the price for a new electric truck. We live in an apartment with no way of charging an electric vehicle. There are some charging stations in my city, but the nearest one is an hour away from my home. Even if I were to take the truck to that charging station every day, it would still take 8 hours to fully charge the vehicle.

Using your new interdisciplinary understanding, **discuss** the challenges and related solutions that electric vehicles present for the self-employed delivery driver in reference 5.

In your answer you must:

- explain **two** challenges
- explain solutions to address **both** challenges
- include evidence from the pre-release material to support your arguments.

(12 marks)

Note: best fit each strand separately and then best fit all three strands.

Note: Please familiarise with yourself with the pre-release material

Note: Reference to the delivery driver does not gain credit for the third strand as reference to the pre-release material

Marks	Descriptor
0	The student does not achieve a standard described by any of the descriptors given below.
1-3	The student discusses by: <ul style="list-style-type: none"> • stating two challenges • stating two solutions
4-6	The student discusses by: <ul style="list-style-type: none"> • outlining two challenges • outlining two solutions • attempting to use evidence from the pre-release material.
7-9	The student discusses by: <ul style="list-style-type: none"> • describing two challenges • describing two solutions • using evidence from the pre-release material.
10-12	The student fully discusses by: <ul style="list-style-type: none"> • explaining two challenges • explaining two solutions • using relevant evidence from the pre-release material.

Appendix 1: For use with question 1

The table below is taken from reference 3 in the pre-release material.

Name	The Solar car	The Hydrogen Car
Model	Sustain: Sustain your dream road trip	Infinity and Beyond
Price	From \$178 500	From \$68 500
Range	<p>750 miles / 1200 kilometres - Distance travelled.</p> <p>The average distance travelled is twice as far as a standard electric car.</p> <p>Sustain Solar car charges twice as fast as a standard electric car.</p>	300 miles / 480 kilometres- Average range
Emissions	Zero grams CO ₂ emitted	Zero - Emissions
Savings	Zero charges	Not mentioned
Other information	<p>Average number of charges per 10 000 miles / 16 000 kilometres:</p> <ul style="list-style-type: none"> - Sustain Solar Car: 20* - Standard electric car: 60 <p>* based on an average of 12 daylight hours of which 6 hours are direct sunlight.</p>	<p>5 minutes - Refuelling time</p> <p>Oxygen from the atmosphere enters the car's air vent.</p> <p>Hydrogen is transitioned to the fuel stack.</p> <p>A chemical reaction generates electricity and water.</p> <p>The electricity powers the motor.</p> <p>The motor enables the vehicle to move.</p>

Appendix 2: For use with question 2

The interpretations below are from the charts. The converse interpretations can also be made. Students will use their own language to communicate them and may also include values from the charts:

The total budget:

The total budget for 70% is higher than the total budget for 100%

The total budget for 70% is higher than the total budget for 40%

The total budget for 100% is higher than the total budget for 40%

The stability of electricity:

There are a higher number/frequency of power outages with 100% compared to 70%

There are a higher number/frequency of power outages with 70% compared to 40%

There are a higher number/frequency of power outages with 100% compared to 40%

70% has better stability of electricity than 100%

40% has better stability of electricity than 70%

40% has better stability of electricity than 100%

The Carbon footprint of electric cars:

The cumulative (or total) emissions for 70% is higher than for 100%

The cumulative (or total) emissions for 40% is higher than for 70%

The cumulative (or total) emissions for 40% is higher than for 100%

Total annual transport

Area	Budget / billion \$		
	40 %	70 %	100 %
Maintenance of roads	3.5	3.5	3.5
New highways	2.5	3	3.5
Public transport	8	6	2
Electrification infrastructure and research	3	8.5	9
Total Budget	17	21	19

Stability of electricity supply

Time in years	Relative frequency of a monthly power outage High relative frequency = high number of power outages Low relative frequency = low number of power outages		
	40%	70%	100%
0	0.1	0.1	0.1
4	0.1	0.15	0.3
8	0.15	0.2	0.5
14	0.05	0.15	0.5
20	0.05	0.05	0.3

Carbon footprint of electric cars

Time in years	Cumulative carbon emissions per 100 cars / tonnes CO ₂		
	40%	70%	100%
0	0	0	0
5	1168	963.4	1044
8	1656.4	1247.5	1356
10	1879.6	1315.3	1394
15	2400.8	1455.2	1410
20	2930	1587.5	1410