

1(a). The table below gives information about three planets in the solar system.

planet	percentage of carbon dioxide in the atmosphere	density of the atmosphere at the planet's surface (kg/m^3)	distance from the Sun (millions of km)	mean surface temperature ($^{\circ}\text{C}$)
Venus	96 %	120	1.1	470
Earth	0.04 %	1.3	1.5	20
Mars	95 %	0.02	2.3	-60

One astronomer has described the temperatures of these three planets as follows:



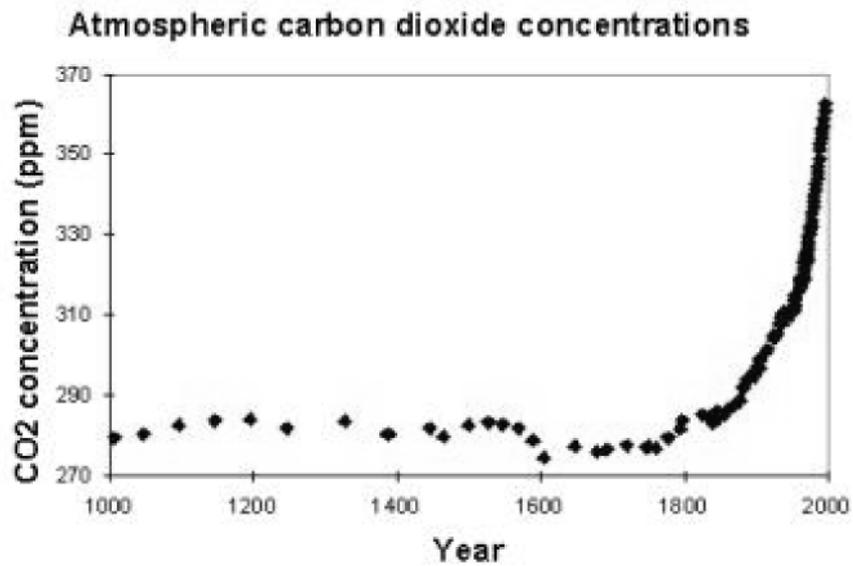
Professor Rubin

The mean temperatures of the Earth, Venus and Mars all correlate with their distances from the Sun, but the temperature differences are not due to the difference in the distances.

Explain what Professor Rubin means and decide whether the data in the table supports her statement.

[4]

(b). Increased levels of carbon dioxide in the atmosphere have been linked to the greenhouse effect. The graph below shows the amount of carbon dioxide in the atmosphere over a 1000 year period.



Many scientists think this is evidence that human activity has had an effect on the amount of carbon dioxide in the atmosphere.

Explain how the graph supports this idea.

[4]

2. This question is about the greenhouse effect and global warming.

The Sun emits radiation with a principal frequency of 600 THz, which corresponds to yellow visible light of wavelength 500 nm.

Which two of the following statements, taken together, **explain** the greenhouse effect?

Put ticks (?) in the boxes next to the **two** correct statements.

Carbon dioxide gas absorbs infrared radiation.

Green plants reduce the amount of atmospheric carbon dioxide.

The Earth emits radiation of principal wavelength longer than 500 nm.

Continued global warming will result in more extreme weather events.

Cutting down forests makes the amount of atmospheric carbon dioxide rise.

[2]

3.

- (i) The Earth and Moon have the same average distance from the Sun over a year. Therefore on average they receive the same intensity of light.

The diameter of the Moon is approximately 3500 kilometres.
The diameter of the Earth is approximately 13 000 kilometres.

How many times more energy is transferred directly by light from the Sun to the Earth than from the Sun to the Moon?

answer = _____ [2]

- (ii) This would result in the Earth and the Moon having the same average temperature.
Suggest why the Earth's average temperature is 15°C and the Moon's is -23°C .

----- [1]

(b). After reading all the advice, Margaret decides she will have some vehicles using each type of fuel.

Which of the following reasons best explains Margaret's choice?

Put a tick (✓) in the box next to the correct answer.

She wants to use the cheapest fuel.

It provides better security of supply.

She wants CO₂ equivalent emissions to be as low as possible.

She thinks nuclear fuel is probably better.

[1]

5(a). This question is about global warming.

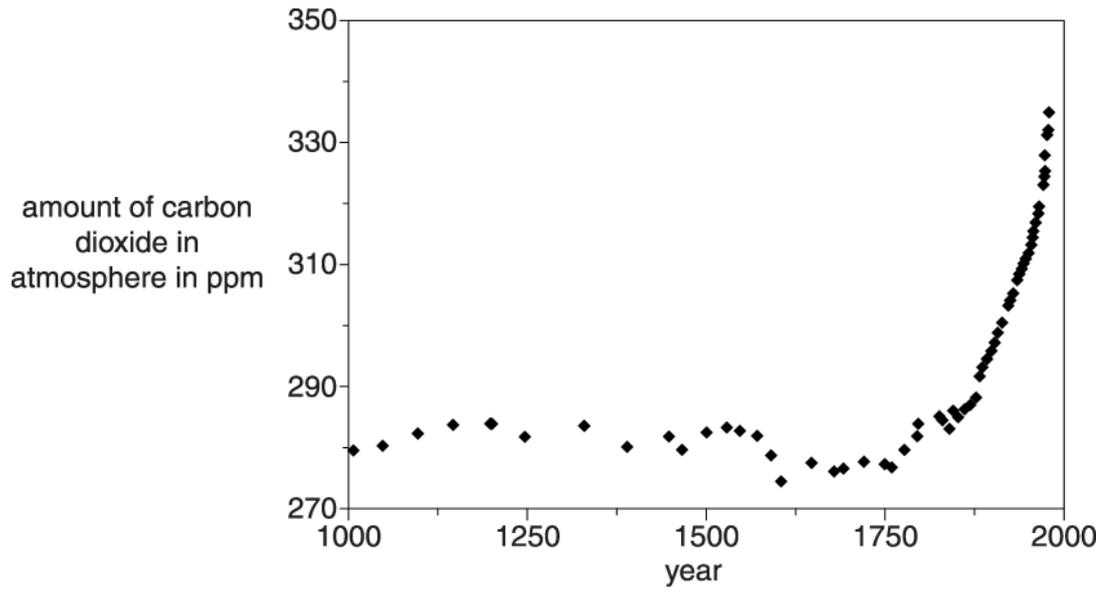
Some of the statements below are true and some are false.

Put a tick (✓) in the correct box after each statement.

	true	false
The atmosphere does not absorb infrared radiation.	<input type="checkbox"/>	<input type="checkbox"/>
The Earth emits infrared radiation.	<input type="checkbox"/>	<input type="checkbox"/>
The Sun does not emit infrared radiation.	<input type="checkbox"/>	<input type="checkbox"/>
The Sun emits radiation equally at all frequencies.	<input type="checkbox"/>	<input type="checkbox"/>
Water vapour is a greenhouse gas.	<input type="checkbox"/>	<input type="checkbox"/>

[2]

6(a). This graph shows the amount of carbon dioxide in the atmosphere over a 1000 year period.



Many scientists think this is evidence that human activity has had an effect on the amount of carbon dioxide in the atmosphere.

Explain how the graph supports this idea.

[4]

(b). Many scientists think that human activity is causing global warming.

What additional evidence would you need to show this causal relationship?

Put ticks (✓) in the boxes next to the correct answers.

A cause for the melting icecaps.

A correlation between global temperatures and atmospheric carbon dioxide levels.

A correlation between global temperatures and sea levels.

A mechanism linking atmospheric carbon dioxide and global warming.

A mechanism linking plant growth and carbon dioxide.

[2]

(c). The consequences of global warming could be very bad for everyone on the planet.

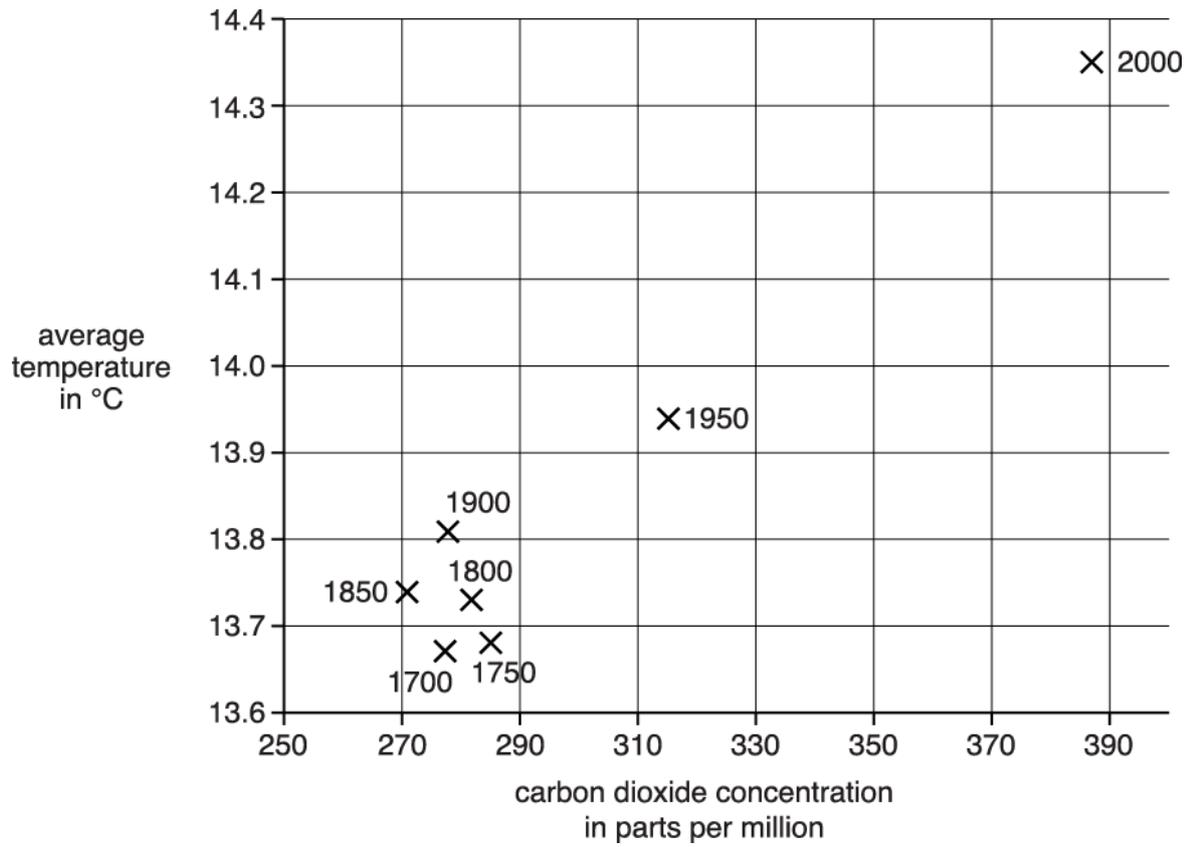
However, most people do very little to change their lifestyle to reduce this risk.

Suggest reasons why people are willing to accept the risks associated with global warming.

[2]

7(a). The graph below shows how the average temperature of the Earth and the concentration of carbon dioxide in the atmosphere have changed over the last 300 years.

Each point is marked with the year the readings were taken.



Five friends have been looking at this graph.



Alice
There is a positive correlation between temperature and carbon dioxide concentration.



Ben
Burning fossil fuels increases the carbon dioxide concentration.



Chandra
Carbon dioxide concentration didn't change much until after 1900.



Debra
I'm worried about the effects of global warming on the environment.

Eddie
Carbon dioxide is a greenhouse gas. It makes the Earth absorb more of the Sun's radiation.



(i) Which two friends are **describing** the data shown in the graph?

Put ticks (✓) in the boxes next to the **two** correct names.

- Alice
- Ben
- Chandra
- Debra
- Eddie

[2]

(ii) Which two friends are **explaining** the data shown in the graph?

Put ticks (✓) in the boxes next to the **two** correct names.

- Alice
- Ben

Chandra

Debra

Eddie

[2]

- (b). The graph opposite, and similar data produced by other scientists, raise concerns about climate change. One such concern is that low-lying land could be flooded.

State and explain **two other** changes that could result from global warming.

[3]

END OF QUESTION PAPER

Question		Answer/Indicative content	Marks	Guidance
1	a	<p>The professor can see a correlation between distance and temperature but doesn't think distance is the cause. (1)</p> <p>Any three from:</p> <p>Combining density and % CO₂ data (1)</p> <p>Venus has much more CO₂ than Earth (1)</p> <p>Earth is warmed by greenhouse effect; Mars hardly if at all; Venus has larger / greater greenhouse effect (1)</p> <p>Sun's radiation gets weaker as you get further from Sun (1)</p> <p>So would expect Venus to be hottest and Mars coolest (1)</p>	4	1st mark for an explanation of the professor's statement
	b	<p>Graph shows (rapid) increase in CO₂ (1)</p> <p>Human activity increased (around this time) / industrial revolution / more factories / population increase (1)</p> <p>Hence correlation (1)</p> <p>Use of fossil fuels / deforestation (produces CO₂) (1)</p>	4	<p>do not allow increase before 1750</p> <p>ignore named examples of human / industrial activity e.g. more cars / more technology</p> <p>must have described graph AND history of human activity for this mark</p> <p>ignore breathing out CO₂</p>
		Total	8	
2		1 st & 3 rd boxes (absorbs IR, Earth emits..)	2	
		Total	2	

Question			Answer/Indicative content	Marks	Guidance
3		i	<p>either calculates the cross sectional area of either the earth or the moon OR calculates the square of the ratio of both earth and moon</p> <p>13.8</p>	2	<p>allow 3.7 or 4 (use of diameters instead of areas)</p> <p>Moon cross sectional area = 9,621,127.5 km² earth cross sectional area = 132,732,289.6 km² moon diameter² = 12,250,000 km² Earth diameter² = 169,000,000 km² accept 130²/35² or 26²/7²</p> <p>correct numerical answer gains both marks accept 13.5 to 14</p> <p>ignore units</p> <p>Examiner's Comments</p> <p>Only a handful of candidates recognised that the ratio of cross-sectional areas was key here. A number of candidates did recognise that a ratio was needed but simply calculated the ratio of the two diameters. Some candidates tried to use energy transferred = power x time.</p>
		ii	<p>the Earth has an atmosphere and this increases the temperature / keeps it warm / OR the greenhouse effect raises temperature</p>	1	<p>ignore references to ozone layer</p> <p>accept consistent albedo argument – the earth reflects less energy back into space and the moon reflects more energy</p> <p>Examiner's Comments</p> <p>Less than half of candidates correctly identified the role of Earth's atmosphere in retaining heat there were a range of incorrect answers e.g. the core of the earth, the ozone layer, that the moon was further away, in the shadow of the earth or that human activity was to blame.</p>
			Total	3	

Question		Answer/Indicative content	Marks	Guidance
4	a	<p>Level 3 Considers all three fuels using all data from table and other information. Considers all three key factors. Draws a clear conclusion based on and consistent with the data considered. Quality of written communication does not impede communication of the science at this level.</p> <p>(5–6 marks)</p> <p>Level 2 Considers all three fuels using some data from table. Considers two key factors. Draws a conclusion based on the data considered. Quality of written communication partly impedes communication of the science at this level.</p> <p>(3–4 marks)</p> <p>Level 1 Considers two fuels using some data from table, considers one key factor. OR Considers one fuel and two factors. Draws a relevant conclusion which may not be based on the data. Quality of written communication impedes communication of the science at this level.</p> <p>(1–2 marks)</p> <p>Level 0 Insufficient or irrelevant science. Answer not worthy of credit.</p> <p>(0 marks)</p>	6	<p>This question is targeted at grades up to C</p> <p>Indicative scientific points may include:</p> <p>key factor – sustainability</p> <ul style="list-style-type: none"> • biogas is renewable* • diesel and petrol are non-renewable*. <p>key factor – economics</p> <ul style="list-style-type: none"> • unit cost of fuel is the same for all • may be expensive to convert vehicles* • may be difficult to find supplies of biogas* • same amount of fuel diesel will go further • replacement costs to replace vehicles* • order of energy efficiency linked to amount used. <p>key factor – environmental impact</p> <ul style="list-style-type: none"> • order of CO₂ equivalent emissions • more CO₂ from diesel or / and petrol than biogas • CO₂ emissions contribute to global warming* • not clear what is meant by 'CO₂ equivalent emissions'. <p>*These are examples of other information beyond that provided in the table.</p> <p>Use the L1, L2, L3 annotations in Scoris; do not use ticks.</p> <p>Examiner's Comments</p> <p>Most candidates were able to make good use of data and present their answers in a clear, well organised way. A few forgot to make a recommendation as asked in the question. A good number of candidates were able to make use of relevant science knowledge in addition to the data given in the question. The most common error was not to adequately describe or include sustainability in their answers. Few</p>

Question			Answer/Indicative content	Marks	Guidance								
					candidates used scientific terms such as renewable and non-renewable. Some candidates attempted to relate sustainability with the amount of carbon dioxide produced and global warming but this was generally done badly.								
	b		<table border="1"> <tr> <td>she wants to use the cheapest fuel</td> <td></td> </tr> <tr> <td>It provides better security of supply</td> <td>✓</td> </tr> <tr> <td>She want carbon emissions as low as possible.</td> <td></td> </tr> <tr> <td>she thinks nuclear fuel is probably better</td> <td></td> </tr> </table>	she wants to use the cheapest fuel		It provides better security of supply	✓	She want carbon emissions as low as possible.		she thinks nuclear fuel is probably better		1	<p>Examiner's Comments</p> <p>This was answered incorrectly by more than half the candidates. The most common incorrect answer was 'she wants carbon dioxide equivalent emissions to be as low as possible' suggesting that candidates had not read the question carefully.</p>
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			Total	7									

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5	a	<table border="1"> <tr> <td></td> <td>T</td> <td>F</td> </tr> <tr> <td>The atmosphere...</td> <td></td> <td>?</td> </tr> <tr> <td>The Earth emits...</td> <td>?</td> <td></td> </tr> <tr> <td>The Sun does not emit...</td> <td></td> <td>?</td> </tr> <tr> <td>The Sun emits...</td> <td></td> <td>?</td> </tr> <tr> <td>Water vapour...</td> <td>?</td> <td></td> </tr> </table>		T	F	The atmosphere...		?	The Earth emits...	?		The Sun does not emit...		?	The Sun emits...		?	Water vapour...	?		2	<p>All correct = (2) three or four correct = (1)</p> <p>Examiner's Comments</p> <p>The objective proved testing: most had two or three of the five true-false choices correct.</p>
	T	F																				
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	b	<p>(Level 3) Describes the generally accepted scientific mechanism for GW, cites correlation between temperature and CO₂ levels as evidence linked to human activity and gives a reason for scientific disagreement on the issue. Quality of written communication does not impede communication of the science at this level. (5–6 marks)</p> <p>(Level 2) May give effects of GW. Links an example of human activity to increased greenhouse gas concentrations. Suggests a reason for scientific disagreement on the issue. Quality of written communication partly impedes communication of the science at this level. (3–4 marks)</p> <p>(Level 1) Links human activity to greenhouse gases and relates to GW OR suggests a reason for scientific disagreement on the issue. May give an effect of GW. Quality of written communication impedes communication of the science at this level. (1–2 marks)</p> <p>(Level 0) Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)</p>	6	<p>This question is targeted at grades up to A* Indicative scientific points related to global warming may include:</p> <p>Global warming:</p> <ul style="list-style-type: none"> • absorption of (infrared) radiation emitted by the warmed Earth by CO₂ / water vapour / methane (greenhouse effect) • CO₂ levels are increasing • global mean temperatures correlate with CO₂ levels in the atmosphere over a considerable time period • computer models correlating with GW effects have been borne out • increased extreme weather events correlate with CO₂ levels. <p>Human activity:</p> <ul style="list-style-type: none"> • increased burning fossil fuels by industrialisation and transport • increased deforestation correlates with CO₂ levels as it is removed by plants. <p>Indicative scientific points related to scientific dispute may include:</p> <ul style="list-style-type: none"> • correlation is not causation • old data may be unreliable • other factors (e.g. variable sun) may cause GW • scientists may find it difficult to abandon own pet theories • scientists may not divorce scientific ideas for e.g. political commitment • might not be qualified in this area of science. <p>Use the L1, L2, L3 annotations in Scoris;</p>																		

Question			Answer/Indicative content	Marks	Guidance
					<p>do not use ticks.</p> <p>Examiner's Comments</p> <p>This question showed how important it is for candidates to read carefully and answer exactly what is asked. The fact that carbon dioxide was not mentioned in the question stem should have triggered an awareness that it should be discussed. Some good candidates understood the mechanism for global warming but made no reference to human activity in their answer, although expressly asked to explain this in the question. Weaker candidates often confused global warming with damage to the ozone layer. Students found it difficult to explain why the opinions of scientists differ on the issue. The most popular comment was to say that some think global warming has natural causes, with more able candidates expanding on this to reference evidence from ice cores and/or examples of natural phenomena, which contribute to greenhouse gas emissions such as volcanoes, or changes in the Earth's orbit, or fluctuations in the Sun's activity.</p>
			Total	8	

Question		Answer/Indicative content	Marks	Guidance										
6	a	<p>graph shows (rapid) increase in CO₂ (1)</p> <p>human activity increased (around this time) / industrial revolution / more factories / population increase / (1)</p> <p>hence correlation (1)</p> <p>Use of fossil fuels / deforestation (produces CO₂) (1)</p>	4	<p>do not accept increase before 1750</p> <p>ignore named examples of human / industrial activity e.g. more cars / more technology</p> <p>must have described graph AND history of human activity for this mark</p> <p>ignore breathing out CO₂</p> <p>Examiner's Comments</p> <p>The most common correct response was recognising that the graph shows an increase in carbon dioxide levels. Many referred to population increase, burning fossil fuels and the industrial revolution. Many correctly quoted figures from the graph to back up what they are saying. The mark most often missed was the one for the correlation between carbon dioxide and human activity.</p>										
	b	<table border="1"> <tbody> <tr> <td>A cause for the melting icecaps.</td> <td></td> </tr> <tr> <td>A correlation between global temperatures and atmospheric carbon dioxide levels.</td> <td>✓</td> </tr> <tr> <td>A correlation between global temperatures and sea levels.</td> <td></td> </tr> <tr> <td>A mechanism linking atmospheric carbon dioxide and global warming.</td> <td>✓</td> </tr> <tr> <td>A mechanism linking plant growth and carbon dioxide.</td> <td></td> </tr> </tbody> </table>	A cause for the melting icecaps.		A correlation between global temperatures and atmospheric carbon dioxide levels.	✓	A correlation between global temperatures and sea levels.		A mechanism linking atmospheric carbon dioxide and global warming.	✓	A mechanism linking plant growth and carbon dioxide.		2	<p>Examiner's Comments</p> <p>This was answered correctly by most candidates.</p>
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	c	<p><i>any two from:</i></p> <p>idea that risk far in future / individual will not be affected (1)</p> <p>idea of keeping current lifestyle / idea of benefits outweighing risk (in the short term) (1)</p> <p>belief that risk is not high (1)</p> <p>idea that they can make no difference / very small effect (1)</p> <p>somebody else's job e.g. the government (1)</p>	2	<p>accept examples of modern conveniences e.g. cars</p> <p>Examiner's Comments</p> <p>Most common correct responses were 'will only be a problem after their lifetime' and 'don't want to change their lifestyles'. The most common insufficient responses were 'they don't care' or 'they will be glad that it will be warmer'.</p>
		Total	8	

Question			Answer/Indicative content	Marks	Guidance																
7	a	i	Alice (1) Chandra (1)	2	one mark for each (unlike 3b) if 3 ticks, deduct 1; if 4 or more ticks, no marks																
		ii	Ben (1) Eddie (1)	2	one mark for each (unlike 3b) if 3 ticks, deduct 1; if 4 or more ticks, no marks Examiner's Comments This question was common with the foundation tier paper, and most candidates scored very highly.																
	b		<table border="1"> <thead> <tr> <th>change</th> <th></th> <th>explanation</th> <th></th> </tr> </thead> <tbody> <tr> <td>Habitat change / desertification / crops may not grow in some regions / species may become extinct</td> <td>(1)</td> <td>due to too hot / cold / dry / wet</td> <td>(1)</td> </tr> <tr> <td>More extreme weather events / drought</td> <td>(1)</td> <td>because of increased convection / more water in atmosphere / more energy in atmosphere or ocean / changes to ocean and atmospheric currents</td> <td></td> </tr> <tr> <td>Species move in to new areas, e.g. mosquitos (malaria spreading northwards)</td> <td>(1)</td> <td>Previously unsuitable habitats become suitable e.g warmer</td> <td></td> </tr> </tbody> </table>	change		explanation		Habitat change / desertification / crops may not grow in some regions / species may become extinct	(1)	due to too hot / cold / dry / wet	(1)	More extreme weather events / drought	(1)	because of increased convection / more water in atmosphere / more energy in atmosphere or ocean / changes to ocean and atmospheric currents		Species move in to new areas, e.g. mosquitos (malaria spreading northwards)	(1)	Previously unsuitable habitats become suitable e.g warmer		3	two marks for suggested changes and one for an appropriate explanation of either change. Examiner's Comments This part was more demanding than part (a), and many candidates clearly did not read 'State and explain two other changes (i.e. other than flooding) that could result from global warming.' There were a number of vague pre-prepared answers about global warming (including the inevitable references to the ozone layer) which did not address the question but gave generalised answers vaguely related to global warming issues, such as how to reduce carbon emissions
change		explanation																			
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