

1.1	methane		1	AO1 5.9.2.2
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1.2	any two examples from: • rising sea levels • melting ice • agricultural problems • extremes of weather • loss of habitats	allow effects from the same bullet point ignore global warming ignore acid rain ignore global dimming do not accept reference to ozone	2	AO1 5.9.2.3
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1.3	$\frac{6.0}{4.1} \times 0.0235$ $= 0.0344(\text{kg})$	an answer of 0.0344(kg) scores 2 marks allow correct rounding allow calculator reading if no mark awarded: allow 1 mark for 34.4 or 0.344 allow 2 marks for 34.4 g	1 1	AO2 5.9.2.4
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1.4	use less plastic or use recycled plastic	allow carbon capture ignore any reference to energy / fuels	1	AO1 5.9.2.4 5.10.2.2
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1.5	Level 3: Relevant points (reasons / causes) are identified, given in detail and logically linked to give a clear account.	5–6	AO1 5.9.1.2 5.9.1.3 5.9.1.4
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content nitrogen increased • because volcanoes produced nitrogen • because (denitrifying) bacteria produced nitrogen • because ammonia was converted to nitrogen oxygen increased • because algae and plants produced oxygen • by photosynthesis carbon dioxide decreased • because algae and plants used carbon dioxide • by photosynthesis • because oceans formed and carbon dioxide dissolved in the water • because carbon dioxide formed carbonates, which precipitate as sediments or formed sedimentary limestone rocks • because algae / plants and animals formed fossil fuels / coal / crude oil / natural gas		

2.1	<u>damp / moist</u> litmus paper bleaches / goes white	ignore colour of litmus paper	1 1	AO1 5.8.2.4
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3.1	Level 3: Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO2
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO1
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1
	No relevant content	0	
	Indicative content changes • carbon dioxide has decreased • oxygen has increased processes • volcanic activity released water vapour • the water vapour condensed to form oceans • carbon dioxide dissolved in oceans • carbonates produce sediments • carbon locked up in sedimentary rocks • algae and plants evolved / appeared • algae / plants absorbed carbon dioxide • by photosynthesis • which also released oxygen • carbon locked up in fossil fuels		4.9.1.2 4.9.1.3 4.9.1.4

4.1	incomplete combustion (because) insufficient / limited oxygen supply		1 1	AO1 4.9.3.1
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4.2	nitrogen (from atmosphere) reacts with oxygen (from atmosphere)		1	AO1 4.9.3.1
	at high temperature (in engine) or with a spark (from spark plug)	ignore heat / hot	1	

4.3	any two from: • acid rain • respiratory problems • carbon monoxide • global dimming or smog	max 1 mark if global warming mentioned allow specific effects of acid rain allow specific respiratory problems eg breathing difficulties, asthma	2	AO1 4.9.3.2
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5.1	high temperatures (in the engine)		1	AO1 5.9.3.1	E
	enable oxygen and nitrogen (from air) to react	allow combine / bond for react	1		

5.2	Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6		E
	Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3–4		
	Level 1: Relevant points are made. They are not logically linked.	1–2		
	No relevant content	0		
	Indicative content Examples of relevant points might include: • car C produces the most CO₂ during manufacture • car A produces the most CO₂ per km when driving • car C produces the most CO₂ from manufacture and 40,000km when driving • car B produces the most CO₂ from manufacture and 100,000km when driving Examples of linked statements might include: • car A produces least CO₂ during manufacture, but most CO₂ per km • car C produces most CO₂ during manufacture, but least CO₂ per km • car A produces least CO₂ during manufacture, but car C produces the least CO₂ per km Examples of judgements might include: • overall car A has the smallest carbon footprint as it has the smallest CO₂ production during manufacture, the smallest mass of CO₂ after 40,000km of driving and the smallest mass of CO₂ produced after 100,000km of driving. • car A eventually (after 157,895km) will have the largest carbon footprint because the mass of carbon dioxide produced per km is highest.		AO3 5.9.2.2 5.9.2.45.10.2.1	

6.1	glowing splint relights		1 1	AO1 5.8.2.2
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7.1	different amounts of oxygen available	allow complete combustion and incomplete / partial combustion	1	AO2 5.9.3.1
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7.2	$2 \text{C}_4\text{H}_{10} + 9 \text{O}_2 \rightarrow 8 \text{CO} + 10 \text{H}_2\text{O}$	allow correct multiples / halves	1	AO2 5.7.1.3 5.9.3.1 5.1.1.1
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7.3	short wavelength radiation which enters the atmosphere	because uv / ultra violet radiation which enters the atmosphere	1	AO1.1 5.9.2.1
	is absorbed by materials and re-emitted		1	
	as a longer wavelength radiation	as ir / infrared radiation	1	
	(the longer wavelength radiation is trapped by) a greenhouse gas / carbon dioxide / methane which stops radiation escaping (from the atmosphere)	allow so temperature increases	1	

8.1	not enough oxygen	allow not enough air do not accept no oxygen / air	1	AO1 4.9.3.1
	(so) incomplete combustion		1	

8.2	$2\text{CH}_4(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g}) + 4\text{H}_2\text{O}(\text{g})$	allow correct multiples / fractions	1	AO2 4.9.3.1
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9.1	(Titan has) little / no oxygen	ignore references to respiration	1	AO3 4.9.1.3
	(so) photosynthesis has not occurred (on Titan)	allow (so) no plants / algae to produce oxygen (on Titan)	1	
	(therefore) little / no carbon dioxide present (on Titan) or (therefore) oxygen-using animals cannot have evolved (on Titan)		1	

9.2	(methane) allows short(er) wavelength radiation to pass through (from the sun)	allow (methane) allows uv / ultraviolet radiation to pass through (from the sun)	1	AO1 4.9.2.1
	(which is) re-emitted from the surface as long(er) wavelength radiation	allow (which is) re-emitted from the surface as ir / infra-red radiation	1	
	(which is) absorbed (by methane in the atmosphere)	allow (which is) trapped (by methane in the atmosphere) if no other mark is awarded, allow 1 mark for methane absorbs long(er) wavelength radiation or methane absorbs ir / infra-red radiation	1	

10.1	glowing splint	do not accept burning splint	1	AO1 4.8.2.2
	(which) relights	dependent on correct test in MP1 ignore with a pop	1	

11.1	(bubble gas through) lime water turns milky / cloudy / white or white precipitate forms	MP2 is dependent upon correct response in MP1 allow (bubble gas through) calcium hydroxide (solution)	1 1	AO1.2 5.8.2.3
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11.2		MP2 is dependent upon correct response in MP1		AO1 5.8.2.1
	burning / lit splint	allow flame do not accept glowing splint	1	
	burns with a (squeaky) pop sound	allow pops	1	

12.1	D B C A		1	AO1 5.9.2.1
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12.2	(maximum % =) 96 (%)	allow a value in the range 95 to 97 (%)	1	AO2 5.9.1.1 5.9.1.2 5.9.1.4 5.9.2.2
	(maximum mass =) $\frac{96}{100} \times 5.15 \times 10^{18}$	allow correct use of incorrectly determined percentage	1	
	= 4.94×10^{18} (kg)	allow 4.944×10^{18} (kg)	1	

12.3	Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	4–6	AO1 5.9.1.1 5.9.1.2 5.9.1.3 5.9.1.4 5.9.2.2
	Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1–3	
	No relevant content	0	
	Indicative content: during the first billion years of the Earth's existence carbon dioxide levels increased due to • intense volcanic activity from 4.4 to 2.7 billion years ago carbon dioxide levels decreased as • water vapour condensed to form oceans • carbon dioxide dissolved in the oceans • carbonates precipitated • sedimentary rocks formed from 2.7 to 1.7 billion years ago carbon dioxide levels decreased as • algae appeared • plants evolved • algae and plants photosynthesised • sedimentary rocks formed • fossil fuels formed over the past 100-200 years carbon dioxide levels increased due to • the industrial revolution • human activity • the burning of fossil fuels		

13.1	incomplete combustion (because of) insufficient oxygen	max 1 mark if soot wrongly identified	1 1	AO1 4.9.3.1
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13.2	sulfur reacts with oxygen to form sulfur dioxide	allow SO ₂ for sulfur dioxide	1	AO1
	(so) less sulfur dioxide emitted	allow sulfur burns to form sulfur dioxide	1	AO1
	(so) less acid rain		1	AO2
	(so less) limestone reacts with acid rain		1	AO2
				4.9.3.1 4.9.3.2

13.3	(car engines work at) high temperatures		1	AO1
	(so in the engine) nitrogen (from air) reacts with oxygen (from air)		1	4.9.3.1

14.1	test: (use a) glowing splint result: relights	do not accept burning splint	1	AO1 4.8.2.2 4.9.1.3
		dependent on correct test in MP1 ignore with a pop	1	

14.2	ammonia nitrogen	 if no other mark awarded, allow 1 mark for NO / NO ₂ / N ₂ O / NO _x or equivalent named compounds	1 1	AO3 4.7.3.3 4.9.1.2
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15.1	at high temperatures (in the engine)		1	AO1
	nitrogen		1	5.9.3.1
	reacts with oxygen (to produce nitrogen dioxide)		1	

15.2	(X =) $(33 \times 7) - [(37 \times 3) + 35 + 34 + 29]$ $= 22$ (micrograms per m^3)	allow $33 \times 7 = (37 \times 3) + 35 + 34 + 29 + \mathbf{X}$	1 1	AO2 5.9.3.1
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15.3	countryside data has smallest values		1	AO3 5.9.3.1
	(so) 2 is a higher proportion / percentage of the value	allow (so) countryside is ± 2 out of a value between 6 to 8	1	

16.1	use limewater or use calcium hydroxide solution		1	AO2 5.8.2.3
	(which) does not turn milky / cloudy	allow (which) stays colourless	1	

17.1	Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO2
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO1
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1
	No relevant content	0	
	Indicative content • carbon dioxide produced • (which is) a greenhouse gas • (therefore) surface temperature increases • (therefore) global warming • (so) climate change • (so) polar ice caps melt • (so) increasing sea levels • (so) flooding • (so) extreme weather events • (so) reduction in biodiversity • (so) famine / drought • sulfur dioxide produced • (which causes) acid rain • (so) damage to buildings / statues • (so) damage to trees • (so) damage to aquatic animals • (so) respiratory problems in humans • carbon / soot produced • (which are) particulates • (which cause) global dimming • (so) respiratory problems in humans • carbon monoxide produced • (which is) toxic		4.9.2.2 4.9.2.3 4.9.3.1 4.9.3.2

17.2	any two from: • sunshine is unreliable • increased demand for energy • lack of space	ignore references to cost	2	AO3 4.9.2.4 4.10.1.1
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18.1	nitrogen increased	allow (because of) denitrifying bacteria	1	AO1 5.9.1.2 5.9.1.3
	(because of) emission from volcanoes		1	
	oxygen increased		1	
	(because of) photosynthesis		1	

18.2	carbon dioxide is used during photosynthesis		1	AO1 5.9.1.4
	in trees		1	
	(which) die and are compressed		1	
	over millions of years		1	

18.3	coal has a higher proportion / percentage of carbon		1	AO2 5.9.3.1
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19.1	(use) damp litmus paper	MP2 is dependent upon MP1	1	AO1 4.8.2.4
	(the paper) is bleached or (the paper) turns white	ignore paper turns red	1	

20.1	(the percentage of) nitrogen increased		1	AO3
	(because of intense) volcanic activity		1	AO1
				4.9.1.2

20.2	(the percentage of) carbon dioxide decreased (because) carbon dioxide dissolved in oceans or (because of) formation of carbonate (precipitates / sediments)	do not accept references to photosynthesis	1 1	AO3 AO1 4.9.1.2
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20.3	(the percentage of) carbon dioxide decreased and (the percentage of) oxygen increased		1	AO3 4.9.1.3 4.9.1.4
	the increase and decrease (in percentage) occur at the same / similar rate	allow the changes (in percentage) are the same / similar in the same period of time	1	

20.4	photosynthesis	allow a description of photosynthesis	1	AO1 4.9.1.4
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20.5	plankton (died)	allow tiny marine organisms (died)	1	AO1 4.9.1.4
	and (the organisms) were covered by sediments	allow and (the organisms) were buried allow and (the organisms) were in anaerobic conditions	1	
	and subjected to high temperature and high pressure (over millions of years)		1	

21.1	oxygen		1	AO1 5.8.1.2
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21.2	air	allow the atmosphere allow from volcanoes	1	AO1 5.9.1.1 5.9.3.1
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21.3	global dimming		1	AO2 5.9.3.1
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21.4	(diesel) burns at a high temperature or (diesel) burns at a temperature greater than 100 °C		1	AO2
	(which is) above the boiling point of water		1	AO3 5.2.2.1 5.9.3.1

21.5	sulfur dioxide (is produced when diesel is burnt) (which causes) acid rain (which results in) any one from: • damage to buildings / statues / bridges • damage to trees / plants • damage to aquatic life • acidification of lakes / rivers / soil • respiratory problems	allow (which affects) asthma	1 1 1	AO1 5.9.3.1 5.9.3.2
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22.1	(test) damp litmus paper		1	AO2
	(result) litmus paper bleached	allow litmus paper turns white ignore litmus paper turns red	1	AO1 5.8.2.4

23.1	any one from: • melting ice • rising sea levels • flooding • extremes of weather • loss of habitats	ignore global warming do not accept acid rain do not accept global dimming do not accept references to ozone	1	AO1 5.9.2.3
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23.2		allow uv / ultra-violet for short wavelength radiation allow ir / infra-red for long wavelength radiation ignore references to the ozone layer		AO1 5.9.2.1 5.9.2.3
	(greenhouse gases) allow short wavelength radiation to enter the atmosphere		1	
	(which are) absorbed by the earth and re-emitted as longer wavelength radiation		1	
	(which is) absorbed by (greenhouse gases in) the atmosphere		1	
	(this) increases the temperature leading to global warming		1	

23.3	trees use carbon dioxide		1	AO2 5.9.1.3 5.9.1.4
	(for) photosynthesis		1	
	(and) carbon dioxide causes global warming	allow (and) carbon dioxide is a greenhouse gas	1	

24.1	(test) glowing splint	MP2 is dependent upon MP1 being awarded do not accept burning / lit splint	1	AO2
	(result) relights	allow glows more brightly	1	AO1 5.8.2.2

25.1	(test) burning / lit splint	MP2 is dependent upon MP1 being awarded allow flame do not accept glowing splint	1	AO1 4.8.2.1
	(result) burns with a (squeaky) pop sound	allow pops	1	

26.1	(limewater turns) milky / cloudy	allow white precipitate (formed) allow calcium carbonate is produced	1	AO1 4.8.2.3
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27.1	water vapour		1	AO1 4.9.2.1
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27.2	(increased population so) more energy required	allow (increased population so) more transport required	1	AO3 4.9.2.2
	(so) more (fossil) fuels burned OR (increased population so) more farmland required (1) (so) more deforestation (1)	allow a named fossil fuel	1	

27.3	(increased population so) more food required		1	AO3 4.9.2.2
	(so) more methane-producing food production OR (increased population so) more waste produced (1) (which) produces more methane on decomposition (1)	allow more use of beef cattle (in food production) allow more rice grown	1	

27.4	any two from: • melting ice • rising sea levels • flooding • extremes of weather • loss of habitats	ignore global warming do not accept acid rain do not accept global dimming do not accept references to ozone	2	AO1 4.9.2.3
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