OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



MARK SCHEME

C6.3 INTERPRETING AND INTERACTING WITH EARTH SYSTEMS

SCORE	PERCENTAGE
/254	%

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Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2			B	1	
			Total	**1**	
3	a		$S + O_2 \rightarrow SO_2$ (1) $2SO_2 + O_2 \leftrightharpoons$ (1) $2SO_3$ (1) $SO_3 + H_2O \rightarrow H_2SO_4$ (1)	4	One mark for each correct balanced equation One mark for reversible reaction sign
	b		Neutralisation (1)	1	
			Total	**5**	
4	a		(150 000 ÷ 750 000) × 100 (1) 20 (1)	2	
	b		600 000:900 000 (1) 2:3 (1)	2	
	c		**Any two from:** Number of vehicles has not increased (1) More use of public transport / cycling / walking / car sharing (1) New cars more efficient with less carbon dioxide being produced (1) Tax lower on low emission vehicles therefore more smaller engine vehicles being used (1)	2	
			Total	**6**	
5			A	1	
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
6		i	Titrate ammonia against sulfuric acid to obtain volumes needed for complete neutralisation (1) Add these volumes without the use of indicator (1) Slow evaporation of reaction mixture / heat reaction mixture over a steam bath (1) Burette and other chemical apparatus not suitable for using large quantities / very difficult to use a steam bath in the large scale (1)	4	**ALLOW** heat neutral mixture with carbon or charcoal and then filter off carbon **ALLOW** Slow evaporation of filtrate / heat filtrate over a steam bath if method involving carbon is used
		ii	34 (g or tonnes) of ammonia makes 132.1 (g or tonnes) of ammonium sulfate / 17 (g or tonnes) of ammonia makes 66 (g or tonnes) of ammonium sulfate (1) So 51 tonnes makes 198.1 tonnes of ammonium sulfate (1)	2	**ALLOW** one mark for correct calculation of M_r for ammonia **AND** ammonium sulfate **IGNORE** units for the first marking point **ALLOW** one mark for 2 moles of ammonia makes 1 mole of ammonium sulfate
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
7	a		(900 000 ÷ 750 000) × 100 – 100 or ((900 000 – 750 000) ÷ 750 000) × 100 (1) 20 (1)	2	
	b		ANY TWO FROM Idea that insufficient data since none of the data refers to climate change or global temperature (1) Idea that the data itself is limited since it is for one city and not a global figure (1) % increase of carbon dioxide in the air is much less than increase in carbon dioxide emissions (1) Idea that the significant % increase of carbon dioxide emitted has had very little effect on the mean global temperature (1)	2	No mark for no on its own
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
8	a	i	1500 (1)	1	units **not** needed **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.
		ii	decreases / gets smaller / gets less (1)	1	**allow** goes up to start with and then goes down / AW (1) **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.
	b		**any three from:** (UK decreases but) world is increasing (1) world uses more fertilisers than UK / AW (1) both UK and world use less phosphorus than nitrogen / ora (1) idea that 'blip' on graph for UK in 1997 not shown in the world / AW (1)	3	**allow** graph (a) for UK and graph (b) for world **Examiner's Comments** Good responses described that world use of fertilisers is increasing and that both the UK and the world use less phosphorus containing fertilisers than nitrogen containing fertilisers.
	c	i i i	 **?E** ?because idea that uses smallest amount of pesticides (1) idea that uses smallest amount of fertilisers (1)	2	**No marks for E, marks are for explanation** **allow** cannot tell because the figures give are mean values and so other countries may use lots of fertilisers and pesticides on **allow** other countries with correct justification **Examiner's Comments** Most candidates scored for correctly identifying that country **E** uses the smallest amount of fertilisers and pesticides.

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Question			Answer/Indicative content	Marks	Guidance
		ii	1.4×10^9 / 1 400 000 000 (1)	1	unit **not** needed **Examiner's Comments** Examiners saw a wide range of incorrect values calculated.
	d		nitrous oxide (1) largest source from farming (1)	2	N_2O (1) it is 88% is **not** sufficient but **allow** 88% from farming (1) **allow** fertilisers contain nitrogen and this gas contains nitrogen (1) **ignore** just quoting numbers **Examiner's Comments** Most candidates correctly chose nitrous oxide and explained their choice because it is the largest source from farming.
			Total	**10**	
9			No there is no change with any results with washing-up liquid (1) volume of lather decreases with hard water using soap (1)	2	**No marks for no, marks are for explanation** If **yes** no marks for this question **allow** volume of lather stays at 60 cm^3 (1) **allow** idea that volume of lather changes with hard water (1) **BUT** do not allow volume of lather increases with hard water **allow** volume of lather with hard water is less than 30 cm^3 (1) **Examiner's Comments** Good responses appreciated that the prediction is not supported by the results because although the volume of lather decreases with hard water using soap there is no change with any results with washing-up liquid.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
10			[Level 3] Answer gives some properties of CFCs that makes them suitable for use as a propellant AND Explains why CFCs have now been banned in the UK Quality of communication does not impede communication of science at this level. (5–6 marks) [Level 2] Answer gives one property of CFCs that make it suitable for use as a propellant and explains why CFCs have now been banned in the UK OR Answer gives some properties of CFCs that makes them suitable for use as a propellant Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Answer gives one property of CFCs that make it suitable for use as a propellant OR States a reason why CFCs have now been banned in the UK Quality of communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C Indicative scientific points about properties may include: • non-flammable • inert / unreactive • non-toxic / not poisonous • low boiling point / gas / evaporates easily • insoluble in water Indicative scientific points about banning may include: • causes ozone depletion • increased risk of skin cancer • increased risk of cataracts • increased ageing of skin • increased risk of sunburn • society or government have accepted evidence from scientists Use the L1, L2, L3 annotations in RM Assessor, do not use ticks Examiner's Comments This 6 mark question was targeted up to grade C. To gain credit at Level 3 candidates needed to give some properties of CFCs that make them suitable for use as propellants and to explain why CFCs have now been banned in the UK. Many candidates simply stated that CFCs damage the ozone layer and only gained credit at Level 1. A common misconception was that CFCs cause global warming.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
11		i	34 - 36 (1)	1	units **not** needed **Examiner's Comments** This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Most candidates could interpret the graph and give a value between 36 and 35 millions of tonnes.
		ii	Controls effective because gradient is less (than it would have been) after 1977 / controls effective since the use of fertilisers has grown at a much greater rate than the pollution / controls effective because of the sudden decrease at 1977 (1)	1	**allow** controls effective since concentration of nitrate less after 1977 **allow** figures quoted from graph to show decrease of nitrate concentration **allow** not (very) effective since little change in the gradient of graph before and after 1977 **Examiner's Comments** This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Candidates usually referred to the decrease in the concentration of nitrate ions after 1977 although some did mention the difference in gradient of the line before and after 1977.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
12	a	i	1 260 000 000 (1)	1	unit **not** needed **allow** 1.26×10^9 or 1.3×10^9 Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. candidates had to interpret a table of data. Many could calculate the mass of pesticides used in county **E**. Only a small number of candidates gave the answer in standard form which avoided writing so many zeros. A small proportion of candidates divided the number by 1000 instead of multiplying it by 1000
		ii	(percentage of) land available (for agriculture) is (much) less (1) so need to get very high crop yield from the land (1)	2	assume answers apply to country **B** but **allow** ora for **A** if specified **ignore** country small / 4% used for agriculture / 4% available unlike (another quoted value) **allow B** has lots of pests (1) Examiner's Comments This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Candidates often appreciated that the land available for agriculture was much less than in country **A** but were less likely to link this to the need to improve crop yield. Some candidates referred to country **B** having a large number of pests and this was also given credit in the mark scheme.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	nitrous oxide (1) largest source from farming (1)	2	N_2O it is 88% is **not** sufficient but **allow** 88% from farming **allow** fertilisers contain nitrogen and this gas contains nitrogen **ignore** just quoting numbers **Examiner's Comments** This question assessed evaluation and analysis skills and was focused on the use of fertilisers. Candidates had to interpret three pie charts. Candidates often chose nitrous oxide citing the evidence that it had the greatest percentage in the farming sector of the pie-chart. Some candidates in used an alternative approach stating that nitrous oxide contains nitrogen and many fertilisers contain nitrogen.

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Question			Answer/Indicative content	Marks	Guidance
		ii	**more** carbon dioxide produced by farming (1) **more** nitrous oxide produced by farming (1) **more** methane produced by farming (1)	3	**allow all** (three greenhouse) **gases** are in greater percentage from farming than from residential use (3) must compare data and **not** just quote the data **allow** farming is 147 and residential is 17 for one mark if no other mark awarded **Examiner's Comments** This question assessed evaluation and analysis skills and was focused on the use of fertilisers. The best answers noted that all three gases (carbon dioxide, methane and nitrous oxide) had a larger percentage coming from farming than residential. Other candidates just quoted the data from the pie-charts without making any comparison; this was not given any credit. Some candidates added all the percentage of each gas from the three pie charts but again most candidates using this approach did not make a comparison of the numbers they had calculated.
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
13			(No or an implication of no) temporary hard water reduces volume (of lather) in soap (1) temporary hard water does not reduce volume (of lather) in washing-up liquid (1)	2	If **yes** no marks for this question magnesium sulfate or sodium chloride cause temporary hardness in water = 0 for the question just quoting results is **not** sufficient. answers must specify that the results used are for temporary hard water or for calcium hydrogencarbonate **allow** calcium hydrogencarbonate reduces volume (of lather) in soap solution **allow** calcium hydrogencarbonate does not reduce volume (of lather) in washing up liquid **allow** one mark for idea that calcium hydrogencarbonate causes temporary hard water if no other mark awarded in the question **Examiner's Comments** Candidates found this question demanding and often did not specify which sample was temporary hard water and gave general answers covering all of the results. The best answers compared the results with calcium hydrogencarbonate with distilled water both with soap and with washing-up liquid. Some candidate thought that magnesium sulfate caused temporary hard water and others that sodium chloride caused hard water.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
14	a		reaction **4** / O_3 ? O_2 + O (1)	1	**allow** makes oxygen atoms and oxygen molecules / makes O and O_2 **Examiner's Comments** This question was about CFC and ozone depletion. Candidates often chose reaction 4 but reactions 1 and 2 were effective distractors.
	b		**any two from:** idea that C—Cl bond breaks (1) homolytic fission (1) one electron (from bond) goes to one atom (1) and the other electron (from bond) to the chlorine (1)	2	allow C—C*?* ? C + C*?* breaking a chlorine atom from the molecule is **not** sufficient reference to formation of chlorine (free) radicals is **not** sufficient **allow** leaving chlorine (atom) with an unpaired electron **not** chlorine has a free electron covalent bond splits evenly is **not** sufficient **Examiner's Comments** This question was about CFC and ozone depletion. Many candidates could not explain the formation of a chlorine atom from a CFC. The idea that a C—Cl bond was broken was seldom mentioned and the idea of homolytic fission was poorly expressed.

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Question			Answer/Indicative content	Marks	Guidance
	c		reference to reactions **2 and 3** (1) chlorine atom is regenerated (at end) / chlorine atom is a catalyst / (the two reactions are a) chain reaction / chlorine atoms are not destroyed (1)	2	**allow** reference in terms of quoting the equations or reference in word form **allow** chlorine (free) radical for a chlorine atom **Examiner's Comments** This question was about CFC and ozone depletion. Candidates did not always clearly indicate reactions 2 and 3 although the idea that there was a chain reaction was often included within the answer.
	d		**any two from:** took a long time to collect evidence / needed to do lots of research / it was difficult to collect the evidence (1) difficult to convince government of the disadvantages of CFCs / lots of money had been put into developing CFCs (1) needed agreement of other scientists / lots of scientists had to work on the task (1) (time needed) to develop alternatives to CFCs (1)	2	**allow** took a long time to realise CFCs were 'reactive in the stratosphere' / took a long time for CFCs to have an effect on the ozone layer **allow** initially technology not available to test the effects in the stratosphere **allow** slow action / inertia by government **allow** political clout of the manufacturers prevented immediate action **allow** took a long time to get agreement between different countries / UK government only responded after other governments had banned CFCs **Examiner's Comments** This question was about CFC and ozone depletion. Candidates often appreciated that due to lack of technology it took a long time to link CFCs with ozone depletion. Other candidates focused on the problems that changing from CFC to alternatives or the problems of convincing a government to implement a ban. Some candidates merely focused on the properties of CFCs rather than addressing the question set.

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Question			Answer/Indicative content	Marks	Guidance
			Total	7	

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Question			Answer/Indicative content	Marks	Guidance
15			Level 3 States the correct percentage of both of the gases AND Describes the effect of two of these processes on the percentage of oxygen and carbon dioxide. Quality of communication does not impede communication of science at this level. (5-6 marks) Level 2 States the correct percentage of both of the gases OR Describes the effect of two of the processes on the percentage of oxygen and carbon dioxide OR States the correct percentage of one of the gases And describes the effect of one of the processes on the percentage of oxygen and carbon dioxide. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 States the correct percentage of one of the gases OR Describes the effect of one of the processes on the percentage of oxygen and carbon dioxide. Quality of communication impedes communication of the science at this level. (1 – 2 marks) Level 0 Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C Indicative scientific points may include: • Percentage of oxygen is any value between 20 and 22% • Percentage of carbon dioxide is any value between 0.03 and 0.04% • Respiration and combustion decrease percentage of oxygen and increase percentage of carbon dioxide • Photosynthesis increases percentage of oxygen and decreases percentage of carbon dioxide Use the L1, L2, L3 annotations in Scoris, do not use ticks <u>Examiner's Comments</u> This question on carbon dioxide and oxygen in the air was used to assess the quality of written communication in a six-mark question. Candidates could often not recall the percentage of oxygen and of carbon dioxide in air and typically gave values for carbon dioxide in excess of 20%. However many candidates could describe the three processes combustion, photosynthesis and respiration in terms of their effect on the levels of oxygen and carbon dioxide in the air. One common misconception was to refer to breathing rather than respiration and other referred to plants breathing instead of photosynthesis.

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Question			Answer/Indicative content	Marks	Guidance
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
16			[Level 3] Explains how photosynthesis and combustion and/or respiration keep the percentage of each gas almost constant AND explains two possible changes in the composition of the air due to increasing population. Quality of communication does not impede communication of science at this level. (5 – 6 marks) [Level 2] Identifies two of the three processes of photosynthesis, combustion, respiration AND explains a possible change in the composition of the air due to increasing population OR explains how photosynthesis and combustion and/or respiration keep the percentage of each gas almost constant. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Identifies two of the three processes of photosynthesis, combustion and respiration OR explains a possible change in the composition of the air due to increasing population. Quality of communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* Indicative scientific points for processes may include: • Photosynthesis increases percentage of oxygen and decreases percentage of carbon dioxide • Respiration and combustion decrease percentage of oxygen and increase percentage of carbon dioxide • Idea of a balance between respiration and/or combustion with photosynthesis allow burning for combustion ignore breathing (for respiration) ignore references to nitrogen Indicative scientific points for change in composition may include: • More carbon dioxide or less oxygen because more energy production using fossil fuels • More carbon dioxide or less oxygen because increase in population leads to more deforestation • More carbon dioxide or less oxygen because more transportation using fuels that burn • Increased population leads to more carbon dioxide or less oxygen due to more respiration Use the L1, L2, L3 annotations in RM Assessor; do not use ticks Examiner's Comments This question tested ideas about gases in the air and human influences on the atmosphere. This 6 mark question was targeted at all grades up to, and including, grade A* and discriminated well. At level 3 (5 ? 6 marks) all aspects of the question needed to be addressed and candidates were required to explain how photosynthesis and

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Question			Answer/Indicative content	Marks	Guidance
					combustion and/or respiration keep the percentage of each gas constant. They also had to explain two possible changes in the composition of the air due to increasing population. When candidates did not gain full credit it was usually because they focused on just carbon dioxide without describing how the oxygen varied, thereby limiting their marks. The use of 'carbon' instead of carbon dioxide appeared in many answers as did 'breathing' instead of respiration.
			Total	6	
17			any two from: all the readily extractable resources will be used up in the future (1) will have to find replacements / AW (1) idea of not enough fuel to power vehicles or homes / make electricity / make chemicals (1) conflict between making petrochemicals and fuels (1) UK dependent on oil and gas from politically unstable countries / AW (1)	2	**allow** (all) it / oil / coal / fossil fuels will run out / be used up (1) **allow** crude oil will have to be extracted from more inaccessible areas (1) **allow** crude oil will become very expensive / may lead to rationing / may lead to conflicts (1) Examiner's Comments This question focused on crude oil. Many candidates were able to explain the problems of not having sufficient crude oil in the future.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
18	a		C and E (1)	1	both required for 1 mark Examiner's Comments This question was well-answered, with most candidates correctly identifying both cars.
	b		Level 3 (5–6 marks) Candidates recall that carbon monoxide is made by incomplete combustion or when there is not enough oxygen supplied to the fuel AND recognises a problem of both carbon monoxide AND of oxides of nitrogen. Quality of written communication does not impede communication of science at this level. Level 2 (3–4 marks) Candidates recall that carbon monoxide is made by incomplete combustion / when there is not enough oxygen supplied to the fuel AND recognises a problem of carbon monoxide OR of oxides of nitrogen. Quality of written communication partly impedes communication of science at this level. Level 1 (1–2 marks) States that carbon monoxide is made from burning petrol / fuel in a car engine OR gives a problem caused by carbon monoxide OR gives a problem caused by oxides of nitrogen. Quality of written communication impedes communication of science at this level. Level 0 (0 marks) Insufficient or irrelevant science such as repeating the question. Answer not worthy of credit.	6	This question is targeted at grades up to grade E Relevant points at levels 2 and 3 may include: • carbon monoxide is made by incomplete combustion or when there is not enough oxygen supplied to the fuel AND • carbon monoxide is poisonous • carbon monoxide can kill humans AND • oxides of nitrogen cause photochemical smog • oxides of nitrogen cause acid rain • acid rain kills plants, kills aquatic life, erodes stonework and corrodes metals • oxides of nitrogen or smog causes respiratory problems e.g. asthma allow level 2 (3 marks) if answer includes correct problems of both carbon monoxide and oxides of nitrogen but no reference to incomplete combustion. Relevant points at level 1 may include: • carbon monoxide and /or oxides of nitrogen made when fuel / petrol / diesel burn • carbon monoxide is poisonous • carbon monoxide can kill humans • oxides of nitrogen cause photochemical smog • oxides of nitrogen cause acid rain

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Question			Answer/Indicative content	Marks	Guidance
					Use the L1, L2 and L3 annotations in scoris; do not use ticks Examiner's Comments This question was marked using a level of response approach. Most candidates stated that petrol burned in a car engine or that carbon monoxide was poisonous, thereby accessing Level 1. Level 2 required candidates to recall that incomplete combustion takes place and to give a problem associated with carbon monoxide or oxides of nitrogen. In addition, at Level 3 candidates needed to quote a problem associated with both carbon monoxide **and** oxides of nitrogen. Level 3 was only achieved by the best candidates.
			Total	7	
19			takes a long time to form (1) are used up faster than they are formed or cannot be made again or finite (1)	2	**allow** takes (many) years to form or thousands or millions of years to form (1) **ignore** takes hundreds of years to form **allow** once it's gone, its gone / can't be replaced (1) **ignore** cannot be used again **allow** runs out eventually / will run out of fossil fuels or named fossil fuel e.g.coal (1) Examiner's Comments Most candidates scored 1 mark, usually for the idea that non-renewable fuels are finite. Fewer gained the second mark for taking a long time to form. The main error was candidates who stated ‘it can't be used again’.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
20	a	i	2000 (1)	1	Examiner's Comments?? This was the best answered question on the paper with very many candidates correctly interpreting the graph to state 2000.
		ii	decreases / gets smaller / gets less (1) better pollution controls / introduction of limits to amount of pollution (1)	2	**allow** use of catalytic converters on cars / less cars (on the road) (1) **allow** new machinery producing less pollution (1) **allow** less industrial output / reduction in population / change in fuels used (1) **allow** more renewable energy sources used (1) **allow** factories have moved elsewhere **allow** greater public awareness (1) **allow** government initiatives (1) Examiner's Comments Most candidates correctly identified the trend but fewer could suggest an acceptable reason. The most common suggestions revolved around increased public awareness.
	b	i	Germany (1) 2320 tonnes (is the greatest) (1)	2	**allow** when all added together Germany is the most (1) **allow** Germany has the largest population / Germany is the most industrialised (1) Examiner's Comments Most candidates correctly identified Germany with many calculating the mass as 2320 tonnes or suggesting that Germany had the largest population.

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Question			Answer/Indicative content	Marks	Guidance
		ii	No **any two from:** In Germany NH_3 bigger than SO_2 (1) In Sweden NH_3 bigger than SO_2 (1) In Estonia SO_2 is the highest value / SO_2 is higher than NO_x (1) In Poland SO_2 bigger than NO_x (1)	2	**No** marks for no on its own. Marks are for the explanations **allow** only Slovakia and UK show this pattern (1) Examiner's Comments Part (ii) was less well answered. Better candidates usually scored both marks because they detailed those countries that did not match the trend and explained why, often quoting amounts from the table. Weaker candidates lacked the precision required in their answers.
		iii	$\frac{52}{3600} \times 100$ (1) 1.44 (%) (1)	2	FIRST LOOK AT ANSWER IF ANSWER = 1.44 or 1.4 AWARD 2 MARKS **do not allow** 1 / 1.45 Examiner's Comments In part (iii) only about a third of candidates performed the calculation correctly. Often incorrect values were selected from the table. Part (iii) was common with the higher tier. The comparison between the two percentages was often vague or candidates stated that the percentage of the population and the percentage of ammonia were similar which was insufficient to score.

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Question			Answer/Indicative content	Marks	Guidance
		iv	Other countries make more than their share (of ammonia) / Sweden makes less (ammonia) than expected / Sweden makes less (ammonia) per million of population (1)	1	**allow** Sweden has better anti-pollution laws **ignore** values are roughly the same **allow** Sweden makes less than average **allow** ecf from percentage above 1.9% in (i) Examiner's Comments Most candidates found part (iv) difficult. Part (iv) was common with the higher tier.
			Total	10	

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Question			Answer/Indicative content	Marks	Guidance
21	a		**Y** (1) Idea that uses most soap (before boiling to get a lather) (1)	2	If not **Y** then scores 0 Examiner's Comments Just under half of all candidates scored 2 marks on this question, correctly selecting sample **Y** and stating that it used most soap. **'X'** was the commonest incorrect response.
	b		soapless detergents form a lather with hard water / ora (1)	1	**allow** soapless detergents do not form a scum (1) **allow** soapless detergents form more lather (with hard water) (1) **but ignore** more lather is made Examiner's Comments The action of soapless detergents on hard water was not well understood. Many were reacting soapless detergents with soap or thought that there was no lather with soapless detergents.
	c		**Y** (1) idea that boiling does not remove any of the hardness / volume of soap does not change after boiling (1)	2	If not **Y** then scores 0 **allow** it doesn't take less soap after boiling (1) **allow** (volume of) soap doesn't change (1) Examiner's Comments Over two thirds of candidates correctly identified sample **Y** and recognised that the volume of soap used was the same before and after boiling.
	d		add washing soda / add sodium carbonate / use an ion exchange resin (1)	1	**allow** add calgon (1) **allow** distillation (1) Examiner's Comments Methods for softening hard water were not well known. It was rare to see the use of washing soda or an ion exchange resin. Distillation was an acceptable answer. Most candidates thought that heating permanently hard water would soften it.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
22	a		NO_x (1) greatest (negative) gradient (1)	2	The second marking point is **dependent** on the correct pollutant **allow** greatest (negative) slope / steepest graph **allow** correct comparison of mass change shown by quoting values e.g. 190, 80 and 20 (within ±1 square) has greatest change in mass is not sufficient unless supported by data – one piece of data is sufficient ?Examiner's Comments?? Many candidates recognised that the oxides of nitrogen showed the greatest change in mass between 1990 and 2000. To get full marks candidates had to support this answer with data taken from the graph. Many candidates stated that the graph was steeper here or gave the actual value of the decrease (190 tonnes). Some candidates used data from the whole of the graph from 1990 to 2015 rather than from the period asked for in the question.
	b	i	$\frac{52}{3600} \times 100$ (1) 1.44 (%) (1)	2	FIRST LOOK AT ANSWER IF ANSWER = 1.44 or 1.4 AWARD 2 MARKS **do not allow** 1 / 1.45 Examiner's Comments Many candidates could calculate the percentage as 1.44% but were not always able to explain its significance.

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Question			Answer/Indicative content	Marks	Guidance
		ii	Other countries make more than their share (of ammonia) / Sweden makes less (ammonia) than expected / Sweden makes less (ammonia) per million of population (1)	1	**allow** Sweden has better anti-pollution laws **ignore** values are roughly the same **allow** Sweden makes less than average **allow** ecf from percentage above 1.9% in (b)(i) Examiner's Comments Many candidates could calculate the percentage as 1.44% but were not always able to explain its significance. Candidates were expected to state that Sweden makes less ammonia that would have been expected from the EU average.
		iii	FIRST LOOK AT ANSWER IF ANSWER = 25 AWARD 2 MARKS $\frac{974}{39}$ (1) 25 (1)	2	**allow** 24.974 correctly rounded up for the first mark Examiner's Comments Many candidates could calculate the mass of sulfur dioxide per million of population made in Poland as 25 tonnes. Some candidates ignored the comment in the stem about quoting the answer to 2 significant figures. Candidates in.

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Question			Answer/Indicative content	Marks	Guidance
		iv	Poland makes more (sulfur dioxide) than expected / Poland makes more (sulfur dioxide) than the average / Poland makes more (sulfur dioxide) per million of population (1)	1	**allow** Poland uses a fuel that makes lots of sulfur dioxide **allow** fewer pollution control laws in Poland / Poland cannot afford (modern) pollution controls **allow** some countries produce less than the average **allow** pollution instead of sulfur dioxide **allow** ecf from (b)(iii) if below 9.1 Examiner's Comments Many candidates were not always able to explain the significance of this answer in terms of Poland making more sulfur dioxide than expected from the EU average. Candidates often just mentioned that Poland made lots of pollution.
		v	Quotes some evidence that indicates a higher population gives more pollutants / ora e.g. Germany has a higher population than Estonia **and** makes more pollutants (1) Quotes some evidence that indicates a higher population gives less pollutants / ora e.g. UK has a higher population than Poland **and** makes less pollutants (1)	2	**The data quoted must be able to be checked to see if it is correct and not ambiguous** **allow** the higher populated countries like Germany Poland and the UK produces a lot more pollution Examiner's Comments Many candidates made general comments in (v) without quoting any data from the table to support each of the two statements. The best answers chose countries and compared population and amount of pollutants for example Estonia has a smaller population than Sweden but makes more sulfur dioxide.
			Total	10	

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Question			Answer/Indicative content	Marks	Guidance
23	a		X? temporary Y? permanent Z? temporary and permanent / both (types of hardness) all **three** correct (2) **but** any **two** correct (1) **then any two from:** X is temporary as hardness removed (by boiling) (1) Y is permanent as no hardness removed (by boiling) (1) Z contains both temporary and permanent as some hardness is removed (by boiling) (1)	4	These marks are dependent on correct identification of X, Y or Z **allow** X is temporary since volume of soap goes down (to that of distilled water) **allow** Y is permanent since the volume of soap does not go down (after boiling) / permanent does not change from 20 cm^3 (1) **allow** Z contains both temporary and permanent as volume does go down but not to volume of distilled water / does not go down to minimum volume of soap ?Examiner's Comments?? Candidates were often able to identify the hardness in samples X and Y but found Z much more demanding since it contained both types of hardness. Many candidates understood that temporary hardness is removed when the water as boiled but permanent hardness is not removed. Some candidates referred to the different volumes of soap solution needed to form a lather in their explanations.

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Question			Answer/Indicative content	Marks	Guidance
	b		reacts with calcium or magnesium ions (to make calcium carbonate or magnesium carbonate) (1) calcium carbonate or magnesium carbonate are insoluble / are formed as a precipitate (1)	2	**allow** reacts with calcium or magnesium salts or compounds **allow** reacts with named soluble calcium or magnesium salt or compound **allow** removes calcium ions or magnesium ions **allow** calcium ions removed by forming insoluble carbonate ?Examiner's Comments?? Candidates were often unable to explain how washing soda removes hardness in water. A common misconception was to describe a type of ion-exchange resin rather than describe the formation of insoluble calcium carbonate. Some candidates were imprecise and referred to the removal of calcium rather than of calcium ions, calcium salts or soluble calcium compounds from the water.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
24	a		(purification processes) do not remove dissolved or soluble substances (1)	1	**allow** they are soluble / they are dissolved ?Examiner's Comments?? Many candidates appreciated that the fertilisers dissolved in water. Some candidates just mentioned that their particles were too small to be separated from the water without mentioning anything about their solubility in water. A common misconception was that fertilisers were not killed by chlorination.
	b		large energy requirement (1) expensive (1)	2	**allow** heat for energy **allow** high cost of equipment **allow** issues related to scaling up / needs lots of water (1) **ignore** takes a long time ?Examiner's Comments?? Candidates often mentioned the idea that distillation requires lots of energy and as a result that the purification of sea water would be expensive. Candidates often repeated the information in the stem of the question in terms of using a large amount of water.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
25	a	i	any one from less used for in electricity generation (1) less used for other uses (1) less used for farming (1)	1	 allow new ways to generate electricity that do not use water allow less demand for rather than less used for fewer farmers or less farming is not sufficient Examiner's Comments Most candidates appreciated from the bar chart that less water was being used for electricity generation. Some candidates mentioned the increase in use of methods to generate electricity that did not use water such as solar power or wind turbine.

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Question			Answer/Indicative content	Marks	Guidance
		ii	percentage = $\frac{\text{volume for public water supply}}{\text{total volume}} \times 100$ (1) **but** $\frac{13000}{42000} \times 100$ (2)	2	**allow** $\frac{13000}{42000} = 0.3095$ (1) 0.3095 x 100 (1) No mark for 30.95% **allow** ecf from wrong interpretation of bar charts for the first mark **allow** alternative approaches for example showing that 30.95% of 42000 is 13000 i.e. 30.95 divided by 100 (1) and then 0.3095 x 42000 (1) **Examiner's Comments** Candidates often showed clearly the working out of the required calculation. Almost all candidates could interpret the bar chart to appreciate that the total daily volume of water was 42000 megalitres. Most candidates showed that 13000 was 30.95% of 42000, however some candidates showed that 30.95% of 42000 was 12999 (13000) instead. Centres must advise candidates that in calculations such as these the marks are awarded for the working out, and so all the working out has to be fully shown.
		iii	increase (1)	1	**allow** went to 37.14 (%) **Examiner's Comments** Some candidates did a second calculation to work out the percentage of water used for public water supply and therefore show that it had increased. Other candidates used a more qualitative approach in terms of the volume of water used for public water supply being constant but the total decreasing.

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Question			Answer/Indicative content	Marks	Guidance
	b		prediction made water meters increases (so less water used) (1) population increases so more water used (1) water leakage has not changed so no effect (1)	3	**no marks** for the prediction but without a prediction maximum two marks **Examiner's Comments** Candidates were often able to use the data provided to make a comment about the volume of water needed for public water supply in terms of the population increase, number of water meters and the amount of water loss. Candidates found the data about water loss the most difficult to interpret because it did not really change. The question asked for a prediction and many candidates did not make an overall prediction and so were not awarded full marks.
	c	i	Albania (1)	1	**Examiner's Comments** Many candidates chose Albania.
		ii	Niger (1) Idea that the ratio of population to water used or availability is the highest of all the countries (1) This mark is dependent on the correct country	2	**Allow** high population but very little water A population of 15 million is **not** sufficient Has the most population to share the water is **not** sufficient **Examiner's Comments** Candidates chose a variety of different countries including the United States, China and Bangladesh even though the data only supported one country namely Niger. The best explanations compared the amount of water available with the population and found that Niger had the smallest amount of water available per person.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
26			Level 3 Applies knowledge to identify with reasons the type of hardness in all of the samples AND explains in detail how washing soda softens hard water Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) Level 2 Applies knowledge to identify, with reasons, the type of hardness in two of the samples OR Applies knowledge to identify, with a reason, the type of hardness in one of the samples and attempts to explain how washing soda softens hard water Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 Applies knowledge to identify, with a reason, the type of hardness in one of the samples OR attempts to explain how washing soda softens hard water Quality of written communication impedes communication of the science at this level. (1 – 2 marks) Level 0 Insufficient or irrelevant science. Answer not worthy of credit. (0marks)	6	This question is targeted at grades up to A/A*. Indicative scientific points may include: Types of hardness and explanation • sample A contains permanent hardness • as not softened by boiling • sample B contains both temporary and permanent hardness • as some (but not all) of the hardness is removed by boiling • sample C contains only temporary hardness • as it completely softened by boiling How washing soda softens hard water • hard water contains dissolved calcium ions and /or magnesium ions • calcium ions and magnesium ions removed from water • calcium and magnesium ions removed by precipitation as insoluble carbonates Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments Many candidates made good attempts at answering the question and often found it easier to compare the three water types rather than describe how sodium carbonate softened water. Candidates made good use of the data to conclude that water sample A contained permanent hardness and sample C contained temporary hardness. Candidates found it much more difficult to explain that sample B contained both types of hardness. The idea that temporary hard water is softened

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Question			Answer/Indicative content	Marks	Guidance
					by boiling was well known. Candidates found describing how sodium carbonate softens hard water very challenging and rarely mentioned the formation of insoluble calcium or magnesium carbonate. The most common misconception was that hard water contained calcium carbonate. Only the very best answers included an equation to show how the water was softened. Answers were often well organised with the identification of water samples followed by the water softening by sodium carbonate.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
27	a	i	LOOK FOR ANSWER FIRST OF ALL IF year = 2078 AWARD 2 MARKS in 2003 it is 8.0 so at 50% it will be 4.0 (1) 2078 (1)	2	look for working out on the graph ALLOW ecf from incorrect 50% value Examiner's Comments A significant proportion of the candidates just gave the answer of 2078 and did not show any working out. The best answers stated the value at 2003 and then halved this value — this allowed for a possible award of an error carried forward.
		ii	(yes or no) 45 years after the ban still expect lots of CFCs (1)	1	allow the graph is not steep enough allow takes about 75 years to halve amount Examiner's Comments The best answers did use the data to justify their answer while other candidates just gave an answer based upon CFCs being inert. Comments that did not use the data were not given credit in the mark scheme.

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Question			Answer/Indicative content	Marks	Guidance
		iii	any two from: not all countries may have banned CFC / more countries may ban the use / some countries may lift the ban (1) idea that not sufficient data to make firm prediction (1) new research to remove CFCs may be done (1) idea that concentration measurements may not be accurate until new technology introduced (1)	2	 **allow** CFCs are still being released into the atmosphere **allow** there is not enough evidence **allow** takes a long time to do research on CFCs **allow** the drop in concentration may not be constant **Examiner's Comments** The most common answers were linked to either future use of CFCs, CFCs still being emitted into the air or the idea that you cannot predict if new ways of removing CFCs from the atmosphere may be discovered.
	b		LOOK FOR ANSWER FIRST OF ALL IF age = 43 years AWARD 2 MARKS 1970 is the year having 2.0 (1) so age is 43 years (1)	2	 **allow** ecf from wrong year from graph ie 2013 — year **Examiner's Comments** Some candidates gave the correct answer of 43 years often with no supporting working out. Candidates should ensure they show their working out since in this question one mark could be obtained from an error carried forward even if the final answer was incorrect. A small proportion of the candidates did not attempt this question.

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Question			Answer/Indicative content	Marks	Guidance
	c	i	2.2% (1)	1	**allow** 2% **allow** 2.22 / 2.23% **allow** 2.3 % **Examiner's Comments** Some candidates calculated the correct value of 2.2%. Some did not understand the question and gave an answer of 97.8 or 97%.
		ii	**any two from:** (no because) CFC12 decrease is much later / no apparent decrease (1) initial concentration of CFC12 much lower so more difficult to tell if any effect (1) CFC12 may have a much longer lifetime in the air (1) idea that the ban may not have been a universal one (1) rate of decrease of CFC11 is greater (than CFC12) (1)	2	**allow** CFC11 peaked in 1993 and CFC12 in 2000 **allow** ora **allow** ora **Examiner's Comments** Candidates had to compare tabulated data with graphical data but some candidates compared the same graph twice and as a result stated there was no difference. Candidates who were awarded marks appreciated that that the percentage of CFC11 went down before that of CFC12 and that there was a difference in the rate of decrease. Candidates had to refer to the correct CFC in order to be awarded a mark.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
28	a		**Any two from:** Contains both temporary **and** permanent hardness (1) temporary because volume of soap goes down on boiling (1) permanent because boiled water needs more soap than distilled water (1)	2	**Examiner's Comments** Only the best candidates were able to deduce that the water had both temporary and permanent hardness. Many candidates misinterpreted the question and thought there were several different water samples rather than just tap water. Candidates also did not relate explanations to the volume of soap solutions needed and instead made comments about the temporary hardness being removed by boiling.
	b		Mg^{2+} removed / Ca^{2+} removed (1) are replaced by Na^{+} ions (1)	2	**not** magnesium removed / calcium removed **allow** Ca^{+} ions **not** are replaced by sodium **allow** magnesium or calcium ions swapped for sodium ions (2) **allow** calcium ions displace sodium ions / ora **Examiner's Comments** Good answers were very concise and just mentioned that calcium ions are swapped for sodium ions. Other candidates used incorrect terminology and referred to sodium and calcium as elements or atoms rather than ions. Some candidates referred to the removal of chloride ions rather than magnesium or calcium ions. A small proportion of the candidates did not attempt this question.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
29	a	i	electricity generation (1)	1	**Examiner's Comments** Most candidates could correctly identify electricity generation in part (i).
		ii	**any three from**: decrease in total water usage (1) decrease in use for electricity generation (1) decrease in amount used for farming (1) other uses decreases (1)	3	**allow** (virtually) no change in use for farming (1) **Examiner's Comments** They also correctly interpreted the data to recognise three other patterns.
		iii	$\frac{13000}{42000} \times 100$ (2) **but if incorrect then** $\text{percentage} = \frac{\text{volume for public water supply}}{\text{total volume}} \times 100$	2	**allow** $\frac{13000}{42000} = 0.3095$ (1) **allow** $\frac{13}{42} \times 100$ (1) 0.3095 x 100 (1) No mark for 30.95% **Examiner's Comments** This part was more challenging, but was well answered by better candidates. Occasionally the number of zeroes involved proved a stumbling block for some candidates who often then attempted to manipulate the answer to 30.95%.
		iv	increase (1)	1	**allow** went to 37.14 (%) **Examiner's Comments** About a third of candidates correctly identified an increase. Many stated that the percentage did not change, presumably because the question states that the volume does not change, failing to recognise that the total volume used had fallen.

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Question			Answer/Indicative content	Marks	Guidance
	b		water meters increases (so less water used) (1) population increases (so more water used) (1) idea of a balance between more and less water being used (1)	3	Examiner's Comments This question required candidates to process information from two graphs and use it to support a prediction. Most candidates identified that the number of homes with water meters was increasing and that the population was rising. Only a few candidates could make the final step to say that these two changes would balance each other out for the third mark.
			Total	10	

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Question			Answer/Indicative content	Marks	Guidance
30			Level 3 Applies knowledge to correctly rank all of the samples in order of hardness AND identifies the type of hardness in two of the samples with a correct explanation for at least one of them. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) Level 2 Applies knowledge to correctly rank all of the samples in order of hardness AND identifies the type of hardness in one of the samples (no explanation needed). OR identifies the type of hardness in two of the samples (no explanation needed). OR Identifies the type of hardness in one of the samples with a correct explanation. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) Level 1 Applies knowledge to either correctly rank two of the samples in order of hardness OR identifies the type of hardness in one of the samples (no explanation needed). Quality of written communication impedes communication of the science at this level. (1 – 2 marks) Level 0 Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C. Indicative scientific points may include: Order of hardness • B>A>C Types of hardness and explanation • sample A contains permanent hardness • as not softened by boiling • sample B contains both temporary and permanent hardness • as some (but not all) of the hardness is removed by boiling • sample C contains only temporary hardness • as it completely softened by boiling Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments Many candidates found this to be a difficult question. Few candidates could place the water samples in order of hardness. This was usually because they thought that if some or all of the hardness could be removed by boiling then the water sample must be softer than one where hardness was not removed by boiling. This gave an order of B, C, A which limited the response to level 1 (1 or 2 marks). Better candidates identified sample A as permanently hard water and sample C as temporary hard water. Very few noted that sample B contained both temporary and permanent hardness. Correct identification of the type of hardness in one of the samples with a correct reason scored level 2 (3 or 4 marks). Correct identification of the type of hardness in two of the samples with no explanation also scored level 2. To gain level 3 candidates needed to rank the samples correctly in order of hardness and identify the types of hardness in two of the

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Question			Answer/Indicative content	Marks	Guidance
					samples with correct reasons.
			Total	6	
31			any two from nitrates (1) lead (compounds) (1) pesticides (1) herbicides (1)	2	allow fertilisers / named fertiliser (1) allow chlorinated hydrocarbons / aluminium (compounds) (1) ignore chlorine / fluoride / dust / allow other more obscure pollutants e.g. hormones (1) Examiner's Comments This question was poorly answered. Few candidates could recall fertilisers or lead compounds. Common answers included 'dust', 'chlorine' and 'dirt'.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
32			(sea water because) **any two from:** removes more of the pollutant / removes 9% more of nitrogen dioxide / 99% of nitrogen dioxide removed (1) does not form a waste product (1) cheap(er) (1) readily available (near the coast) (1) OR (limestone because) idea of does not have to be pumped (a long way) from the sea (1) need less mass of material (1)	2	**No marks** for sea water or for limestone - the marks are for the explanation **allow** does not produce waste (1) **allow** only a small amount needed (1) **Examiner's Comments** Good responses to this question displayed an ability to interpret the data about limestone and sea water and decide, with reasons, which method would be more suitable for removing nitrogen dioxide from the waste gases of the power station. The mark scheme allowed candidates to choose either limestone or sea water, provided their choice was clearly justified.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
33			(aluminium because) low(est) density (1) and does not corrode (1) **or** (copper because) best conductor (1) and only corrodes slowly (1)	2	no mark for metal; marks are for explanation **ignore** (aluminium because) it is light **ignore** other factors from the table **allow** (copper because it is) a good conductor (1) **ignore** other factors from the table **allow** one mark for iron because it is strongest **Examiner's Comments** This question focused on reactions of copper compounds and the purification of copper. This question, which required candidates to evaluate evidence and draw conclusions, was well answered with most candidates choosing aluminium because it has the lowest density and does not corrode. Credit was not given for references to aluminium being light.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
34	a		gas percentage **nitrogen** (78%) **oxygen** (21%) (carbon dioxide) **0.035%** **all three correct** (2) **but** **one or two correct** (1)	2	**allow** carbon dioxide between 0.03 and 0.04% **Examiner's Comments** Most candidates correctly identified nitrogen and oxygen as the missing gases in the table. When candidates did not gain full marks it was usually because they failed to correctly recall the percentage of carbon dioxide in the air. 1%, being the difference between the percentages quoted and 100%, was a common error.
	b	i	**any two from:** idea that air quality is maintained (1) reduce or prevent harm to living organisms (1) control or reduce smog (1) protect buildings and / or metals (1)	2	**allow** so that air is safe to breathe (1) **allow** reference to reducing asthma (1) **allow** (carbon monoxide) is poisonous or toxic (1) **ignore** just kills people **ignore** damage the environment **allow** reduce damage to ozone layer (1) **allow** greenhouse effect or global warming or acid rain (1) **allow** an effect of damage to ozone layer, global warming or acid rain (1) **Examiner's Comments** Most candidates were able to explain two reasons why it is important that atmospheric pollution is controlled.

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Question			Answer/Indicative content	Marks	Guidance
		ii	(catalytic converter) changes carbon monoxide into carbon dioxide (1) balanced symbol equation: $2CO + 2NO$? $N_2 + 2CO_2$ formulae (1) balancing (1)	3	**allow** changes nitrogen oxide / NO into nitrogen / N_2 (1) **first marking point can be credited from a symbol equation (even if incorrect)** **allow** any correct multiple, including fractions **allow** = / ? instead of ? **not** and / & balancing mark is dependent on the correct formula **but allow** 1 mark for a balanced equation with minor errors of case, subscripts, superscripts, etc eg 2CO + 2NO ? N2 + 2CO2 **Examiner's Comments** Many candidates understood that carbon monoxide is changed into carbon dioxide. When candidates did not gain full credit it was usually because they could not construct the correct balanced symbol equation.
	c		as (the concentration of) smoke increased, the number of deaths increased / ora (1) as (the concentration of) sulfur dioxide increased, the number of deaths increased / ora (1)	2	**allow** as concentration increases deaths increase (1) **allow** idea that graphs have the same shape (1) **allow** the higher the (concentrations of) smoke and sulfur dioxide, the more deaths (per day) (2) **Examiner's Comments** This question was well answered with candidates able to correctly interpret the graph and describe the relationship between the number of deaths and the concentrations of smoke and sulfur dioxide.
			Total	9	

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Question			Answer/Indicative content	Marks	Guidance
35		i	granite	1	**allow** correct answer ticked, circled or underlined in list if answer line is blank Examiner's Comments many candidates were able to recognise granite as a rock used in buildings.
		ii	**any two from:** landscape destroyed / landscape has to be reconstructed when mining or quarrying has finished (1) habitats destroyed (1) (increased) noise (1) (increased) traffic (1) (increased) dust (1) idea of eyesore / visual pollution (1)	2	**allow** a problem (1) and an explanation of why it is a problem (1) e.g. (increased) noise (1) means people not able to relax / sleep (1) **allow** idea of killing animals living in the area (1) **ignore** just killing animals or plants **allow** (increased) air pollution (1) **ignore** just pollution Examiner's Comments Candidates often gave vague answers referring to big holes or pollution and did not focus on the actual environmental consequences. The best answers mentioned noise pollution, pollution by dust or the destruction of plant and animal habitats.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
36	a	i	oxygen carbon dioxide (1)	1	**both** required for the mark **Examiner's Comments** Was well answered.
		ii	increases decreases (1)	1	**both** required for the mark **Examiner's Comments** Was well answered.
	b		(carbon monoxide is formed by) incomplete combustion (of petrol or diesel in car engines) (1) (carbon monoxide is a problem because) it is poisonous (1)	2	**allow** it is toxic **ignore** it is harmful **ignore** it will kill you **Examiner's Comments** Candidates knew that carbon monoxide was poisonous but few knew that it is made during incomplete combustion. The most prevalent answer referred to cars as being the source of carbon monoxide.
	c		as (the concentration of) smoke increased, the number of deaths increased / ora (1) as (the concentration of) sulfur dioxide increased, the number of deaths increased / ora (1)	2	**allow** as concentration increases deaths increase (1) **allow** idea that graphs have the same shape (1) **allow** the higher the (concentrations of) smoke and sulfur dioxide, the more deaths (per day) (2) **Examiner's Comments** Very well answered although some candidates only scored one mark as they forgot to mention both smoke and sulfur dioxide.

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Question			Answer/Indicative content	Marks	Guidance
	d		carbon monoxide / nitrogen monoxide (1)	1	**allow** CO / NO **Examiner's Comments** Many candidates correctly named carbon monoxide as a pollutant removed by catalytic converters. A common incorrect answer was carbon dioxide.
			Total	**7**	
37			(concentration) increases (1) reaches a maximum / later on it decreases (1)	2	**Examiner's Comments** Almost all correct.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
38	a		any year in the range 1990–1994 (1) because this is the maximum / this is where the concentration stops increasing / this is where the concentration starts decreasing (1)	2	**allow** a year before 1990 if the explanation refers to the idea of a time-lag between the ban and when it has an effect give credit for correct response to second marking point if year range extends just beyond 1994, eg 1995 / 1996 **Examiner's Comments** Mostly correct, but a few lost a mark by going outside the year range, or just stating “1990s”.
	b		LOOK FOR ANSWER FIRST OF ALL IF age = 43 years AWARD 2 MARKS 1970 is the year having 2.0 (1) so age is 43 years (1)	2	**allow** ecf from wrong year from graph ie 2013 – year **Examiner's Comments** About half the candidates answered this question correctly. A common wrong answer was “20 years” (1950 to 1970).
	c		LOOK FOR ANSWER FIRST OF ALL IF year = 2078 AWARD 2 MARKS in 2003 it is 8.0 so at 50% it will be 4.0 (1) 2078 (1)	2	look for working out on the graph **allow** ecf from incorrect 50% value **Examiner's Comments** Many candidates lost marks because they were not able to draw a straight line along the “4” line on the graph and therefore selected the wrong year.
	d		Concentration of CFC12 is (always) smaller than CFC11 (1)	1	assume unqualified answers refer to CFC12 **allow** ora if specified **Examiner's Comments** Generally well answered, the only common mistake was not to compare the two CFCs and only describe the shape of the graph.

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Question			Answer/Indicative content	Marks	Guidance
	e		as ozone decreases CFC increases / ora (1)	1	**allow** when CFC concentration is high ozone is low / ora **allow** when one goes up the other goes down **Examiner's Comments** A common error was to talk about how one of the gases changes as the distance from the South Pole increases. A second error was to forget that ozone is a gas.
			Total	8	
39	a		**any two from** (increased) risk of (sun)burn (1) accelerated ageing of skin (1) skin cancer (1) (increased) risk of cataracts (1)	2	**Ignore** just cancer **allow** damage to eye, **ignore** blindness **Examiner's Comments** Almost all candidates scored at least 1 mark, usually for “skin cancer”, and many scored both marks. The only common mistake was to mention global warming.
	b		CCl_3F has 5 atoms and C_2HF_5 has 8 atoms (1)	1	**allow** C_2HF_5 has three more atoms / ora **Examiner's Comments** Few candidates scored a mark. A common mistake was to add up the atomic masses, or to give C2HF5 because it has 5 fluorine atoms or to give no explanation at all.
			Total	3	

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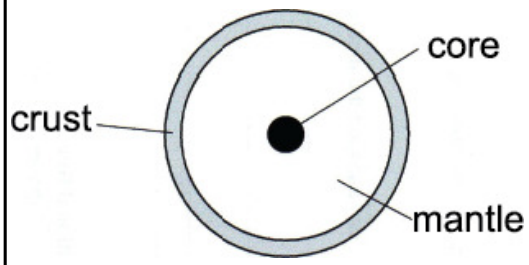
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Question			Answer/Indicative content	Marks	Guidance
40	a	i	B (1)	1	**allow** other ways of indicating correct response eg ringing or ticking the correct answer Examiner's Comments Only about half the candidates were able to identify the hardest water.
		ii	water sample **A** has lots of lather / no scum (1)	1	Examiner's Comments Poorly answered, a majority talked about chlorine sterilising water.
	b		**any two from** distilling water (1) use of ion exchange (column) (1) adding washing soda / Calgon (1) boiling (1)	2	**ignore** heat the water but **allow** heat water to decompose calcium / magnesium hydrogen carbonate **allow** removing the (soluble) calcium / magnesium ions **ignore** use of water softener / brita or other named filter Examiner's Comments Few candidates were able to write about methods used to soften water. The most common answer which scored a mark was 'boiling'.
			Total	4	
41			sand and water ☐ limestone and sand ☐ limestone and clay ☑ limestone and granite ☐ sand and clay ☐	1	**more than one tick scores 0** Examiner's Comments Most candidates knew that cement is made when limestone and clay are heated, although 'limestone and sand' and 'sand and clay' were common misconceptions.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
42	a		 **all three** labels correct (2) **but** **one** or **two** labels correct (1)	2	**allow** inner or outer core for core **Examiner's Comments** Most candidates could identify at least one layer but often struggled to name all three layers. Some candidates referred to an inner and outer core and others referred to the magma rather than the mantle. Some candidates labelled the crust as the lithosphere and this was given credit.
	b		rock **B** because (rock **B**) contains large crystals (1)	1	candidates must identify rock **B and** give explanation for the mark **allow** larger grains / bigger pieces / bigger blocks **ignore** rock is bigger / larger structure **Examiner's Comments** Candidates needed to identify rock **B** and explain why it would have bigger crystals. Good answers appreciated that the crystals in rock **B** were big so that the molten rock must have cooled slowly.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
43	a		used up faster than they are made (1)	1	**allow** takes a long time to be made / takes millions of years to make **allow** it is a finite resource / will eventually run out cannot be produced again is **not** sufficient **not** cannot be reused / can be reused **Examiner's Comments** Many candidates gave imprecise definitions for the term non-renewable fuels. In particular they referred to fuels that were used up rather than mentioning the rate of production of the fuel being much less than the rate of use. Candidates that referred to the finite nature of a non-renewable fuel were awarded a mark.

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Question			Answer/Indicative content	Marks	Guidance
	b		**any two from:** corrodes metals / rusts iron / rusts (ferrous) metals (1) reacts with marble or limestone (statues) (1) damages statues / damages buildings / erodes stonework / AW (1) kills plants / damages trees / can damage crops (1) kills (aquatic) animals / destroys animal habitats (1) increases amount of heavy metal ions in water / increases concentration of aluminium in water (1)	2	**not rusts** aluminium or other non-ferrous metals **allow** erodes or dissolves rocks such as limestone and chalk **allow** dissolves buildings **allow** corrodes buildings **allow** deforestation **allow** harms plants **allow** harms animals pollutes the environment or habitats is **not** sufficient **allow** causes or triggers asthma **not** damages the ozone layer **not** greenhouse gas / global warming **Examiner's Comments** The environmental effects of acid rain were well known by the candidates. The most common correct answers involved the killing of plants or aquatic animals or the erosion of rocks, buildings and statues.
			Total	3	
44			C ✓	1(AO 1.1)	<u>Examiner's Comments</u> Many candidates knew that 'potable water' means safe to drink and chose tap water as the best of the alternatives given.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
45			D ✓	1(AO 1.1)	Examiner's Comments While most of the higher ability candidates knew that the early atmosphere was formed by volcanic activity, many lower ability candidates were also quite familiar with this.
			Total	1	
46			D ✓	1(AO 2.2)	Examiner's Comments Many candidates realised that option D best described the advantages of instrumental methods, with the remaining choices being fairly evenly split between the others.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
47	a		CO_2 emissions (in the UK) have decreased (from 1993 to 2013 / from 2006) ✓ Global sea levels have risen (from 1993 to 2013) ✓ (Therefore) data suggests that CO_2 emissions are not the (only) cause of rising sea levels / Idea that factors other than CO_2 emissions contribute to rising sea levels / data does not support a link (between human activity and climate change) ✓	3(AO 3.1b)	**ALLOW** idea that there is a negative correlation between CO_2 emissions and global sea levels / CO_2 emissions and global sea levels are inversely proportional **for 2 marks** **ALLOW** idea that sea levels were still rising when CO_2 emissions were decreasing **for 2 marks** **ALLOW** idea that the data does not completely support a link **ALLOW** idea that there is a mismatch between the data, ie one is UK but one is global Examiner's Comments The whole of this question was common with the Higher Tier paper. Many candidates successfully described the trends of the two lines. However, some assumed that the graph illustrated what they were expecting and made statements such as 'this shows that humans have a massive impact on global warming'. Some lower ability candidates clearly did not understand that the two lines on the chart referred to different Y axes, so discussed sea level and CO_2 emissions being equal in 2008 or 2010.

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Question			Answer/Indicative content	Marks	Guidance
	b		Any two from: Idea that CO_2 emissions (from burning fossil fuels) are only from the UK and not a global figure ✓ Global CO_2 emissions could be increasing ✓ Idea that CO_2 emissions from other sources (not just burning fossil fuels) should be considered ✓ Idea that there is a lag between CO_2 emissions impacting on global sea levels ✓	2(AO 3.2a)	ALLOW idea that different countries produce different CO_2 emissions ALLOW idea that emissions from one country will not have a large impact on global CO_2 levels IGNORE idea that other factors may affect global sea levels IGNORE idea that there are other greenhouse gases <u>Examiner's Comments</u> Some candidates gained credit for realising that there were other sources of CO_2 but the majority discussed factors other than CO_2 such as methane emissions. These answers could not be given credit because the question was specifically about the link between CO_2 emissions and global sea levels. A significant minority of candidates mentioned difficulty of acquiring data on CO_2.

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Question			Answer/Indicative content	Marks	Guidance
	c	i	**Any one from:** Idea of melting ice caps / melting glaciers / melting sea ice ✓ Altered weather patterns ✓	1(AO 1.1)	 **IGNORE** 'melting ice' **ALLOW** specific examples or effects of altered weather patterns eg drought in some places or flooding in others **ALLOW** specific effects of rising sea levels eg coastal erosion / flooding of low lying land **IGNORE** rising temperatures <u>Examiner's Comments</u> Many candidates went no further than the stem, stating that temperatures would rise. Examiners were looking for a little more detail than this. There were many references to the ozone layer, the greenhouse effect, acid rain and global warming, which were not creditworthy.
		ii	**Any one from:** Reduce consumption of fossil fuels ✓ Use biofuels ✓ Use renewable energy sources ✓ Stop carbon dioxide escaping when fuels are used ✓ Plant more trees / reduce deforestation / AW ✓	1(AO 1.1)	 **ALLOW** specific examples eg car share / cycle to work / use public transport / use electric cars / don't leave appliances on standby **ALLOW** specific renewable energy sources eg wind / solar energy / tidal **IGNORE** use carbon neutral energy sources **ALLOW** use carbon capture (and storage) <u>Examiner's Comments</u> This question was very well answered, with suggestions ranging from tree planting to increased use of public transport. This was clearly an issue that candidates have discussed.
			Total	**7**	

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Question			Answer/Indicative content	Marks	Guidance
48			D ✓	1(AO 2.1)	
			Total	1	
49			C ✓	1(AO 1.1)	Examiner's Comments  Misconception Some candidates do not recognise water vapour as a greenhouse gas. Candidates also confuse nitrogen with nitrous oxides so think nitrogen itself is a greenhouse gas.
			Total	1	
50			B ✓	1(AO 1.1)	
			Total	1	

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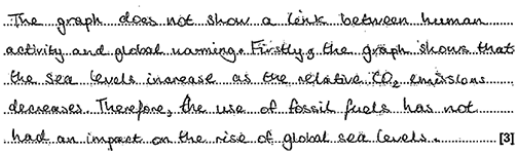
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Question			Answer/Indicative content	Marks	Guidance
51	a		CO_2 emissions (in the UK) have decreased (from 1993 to 2013 / from 2006) ✓ Global sea levels have risen (from 1993 to 2013) ✓ (Therefore) data suggests that CO_2 emissions are not the (only) cause of rising sea levels / Idea that factors other than CO_2 emissions contribute to rising sea levels / data does not support a link (between human activity and climate change) ✓	3(AO 3.1b)	**ALLOW** idea that there is a negative correlation between CO_2 emissions and global sea levels / CO_2 emissions and global sea levels are inversely proportional **for 2 marks** **ALLOW** idea that sea levels were still rising when CO_2 emissions were decreasing **for 2 marks** **ALLOW** idea that the data does not completely support a link **ALLOW** idea that there is a mismatch between the data, ie one is UK but one is global Examiner's Comments Good responses to this question evaluated the information in the graph to describe that despite carbon dioxide emissions declining from (approximately) 2006, global sea levels have continued to rise; therefore, the data does not support a link between human activity and climate change. Many candidates also appreciated the mismatch between the data, ie one is UK but one is global. Lower ability candidates thought that they should be finding a link and contrived one from the period 1995 – 2005. AfL Candidates should be encouraged to write their answers clearly and concisely. Many candidates wrote more than was necessary in their answer to this question and often contradicted themselves as a result.

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Question			Answer/Indicative content	Marks	Guidance
					Exemplar 1  The graph does not show a link between human activity and global warming. Firstly, the graph shows that the sea levels increase as the relative CO_2 emissions decreases. Therefore, the use of fossil fuels has not had an impact on the rise of global sea levels. [3] This response illustrates a clear, concise answer to this question, which was given all 3 marks.
	b		**Any two from:** Idea that CO_2 emissions (from burning fossil fuels) are only from the UK and not a global figure ✓ Global CO_2 emissions could be increasing ✓ Idea that CO_2 emissions from other sources (not just burning fossil fuels) should be considered ✓ Idea that there is a lag between CO_2 emissions impacting on global sea levels ✓	2(AO 3.2a)	**ALLOW** idea that different countries produce different CO_2 emissions **ALLOW** idea that emissions from one country will not have a large impact on global CO_2 levels **IGNORE** idea that other factors may affect global sea levels **IGNORE** idea that there are other greenhouse gases **Examiner's Comments** Many candidates correctly stated that CO_2 emissions can come from sources other than the burning of fossil fuels or that the CO_2 emissions (in the data) are only from the UK and are not a global figure. **AfL** Examiners use **bold type** to draw the candidates' attention to key aspects of a question. Despite the emboldening of '**CO_2 emissions by fossil fuels**' in this question, many candidates described other factors, or other greenhouse gases, which may affect global sea levels and did not gain marks.

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Question			Answer/Indicative content	Marks	Guidance
	c	i	Any one from: Idea of melting ice caps / melting glaciers / melting sea ice ✓ Altered weather patterns ✓	1(AO 1.1)	 IGNORE 'melting ice' ALLOW specific examples or effects of altered weather patterns eg drought in some places or flooding in others ALLOW specific effects of rising sea levels eg coastal erosion / flooding of low lying land IGNORE rising temperatures <u>Examiner's Comments</u> Good responses to this question described melting ice caps or altered weather patterns. A significant number of candidates did not relate their answer to climate, but to the effect on animals or ecosystems, and therefore did not gain the mark. The most common response was 'increased temperatures; this also did not gain the mark as 'rise in global temperatures' and 'global warming' were both mentioned in the stem of the question.
		ii	Any one from: Reduce consumption of fossil fuels ✓ Use biofuels ✓ Use renewable energy sources ✓ Stop carbon dioxide escaping when fuels are used ✓ Plant more trees / reduce deforestation / AW ✓ Recycle plastics etc (rather than burning) ✓	1(AO 1.1)	 ALLOW specific examples eg car share / cycle to work / use public transport / use electric cars / don't leave appliances on standby ALLOW specific renewable energy sources eg wind / solar energy / tidal IGNORE use carbon neutral energy sources ALLOW use carbon capture (and storage) <u>Examiner's Comments</u> Most candidates were able to suggest a method to lower carbon dioxide levels.

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Question			Answer/Indicative content	Marks	Guidance
			Total	7	
52	a		(Amount of carbon dioxide was reduced by) photosynthesis (by plants) ✓ Carbon dioxide dissolved into the oceans ✓ Shell formation by sea creatures ✓	1 (AO1.1)	
	b		(Amount of carbon dioxide) increases / AW ✓	1 (AO3.1a)	Must have the trend, not just the start and end amounts
	c	i	Burning fossil fuels ✓	1 (AO1.1)	**ALLOW** respiration / volcanic activity / production of cement or concrete **DO NOT ALLOW** deforestation
		ii	**Any one from:** Idea of reducing consumption of fossil fuels ✓ Use of biofuels ✓ Use renewable energy sources ✓ Idea of stopping carbon dioxide escaping when fuels are used ✓	1 (AO1.1)	**ALLOW** specific renewable energy sources eg wind / solar energy / tidal **ALLOW** use carbon capture (and storage)
	d	i	Any value <7 ✓	1 (AO2.1)	
		ii	**Any one from:** Acid rain ✓ erosion of stonework ✓ corrosion of metals ✓ kills trees or kills living things in rivers / lakes ✓ breathing difficulties ✓	1 (AO1.1)	
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
53			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Describes how incomplete combustion of hydrocarbons such as propane happens. **AND** Describe the problems of incomplete combustion for campers, including a correct balanced symbol equation. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes how incomplete combustion of hydrocarbons such as propane happens. **AND** Attempts to describe the problems of incomplete combustion for campers. **OR** Includes a correct balanced symbol equation. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Describes how incomplete combustion of hydrocarbons such as propane happens. **OR** Attempts to describe the problems of incomplete combustion for campers. **OR** Attempts a correct balanced symbol equation. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO2 × 1.1) (AO4 × 2.1)	**AO1.1 Knowledge and understanding of why incomplete combustion happens** • Insufficient oxygen / air • This can happen if there is not enough ventilation, such as in a caravan • Not enough oxygen / air for complete combustion **AO2.1 Application of knowledge and understanding of sources of CO and the associated problems** • Carbon monoxide gas is produced, which is toxic • Carbon monoxide combines with haemoglobin / red blood cells • So less oxygen can be carried / there is a lack of oxygen to cells • Can cause unconsciousness / death • Carbon particles / soot produced • Cause blackening of the inside of the caravan • Less energy produced so wastes camping gas / fuel • • Takes longer to heat the caravan / to cook food **AO2.1 Application of knowledge and understanding to produce a balanced symbol equation** Eg $C_3H_8 + 3½O_2 \rightarrow 3CO + 4H_2O$ OR $C_3H_8 + 3O_2 \rightarrow 2CO + C + 4H_2O$ Other balanced equations are possible
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
54	a		Idea that both carbon dioxide levels and variation in air temperature shows an increasing trend ✓ (Therefore) data suggests that carbon dioxide emissions are linked to global warming ✓ OR Idea that carbon dioxide levels have increased steadily but variation in air temperature has fluctuated ✓ (Therefore) data does not support a link between carbon dioxide emissions and global warming ✓	2 (AO2×3.1 b)	Evidence and conclusion must be linked ALLOW there is a positive correlation (between carbon dioxide levels and variation in air temperature)
	b		Any three from: Idea that energy transferred by radiation from the Sun warms up the Earth's surface ✓ Idea that infrared radiation is emitted by the Earth's surface ✓ Idea that some infrared radiation goes directly into space ✓ Idea that greenhouse gases absorb (some) infrared radiation (radiated by the Earth's surface) ✓ Idea that greenhouse gas molecules emit infrared radiation (in all directions), warming the Earth's surface / atmosphere ✓	3 (AO1.1)	DO NOT ALLOW references to the ozone layer ALLOW energy instead of infrared radiation throughout IGNORE idea of trapping infrared radiation ALLOW named greenhouse gases eg carbon dioxide / methane

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Question			Answer/Indicative content	Marks	Guidance
	c	i	**Any one from:** Burning fossil fuels ✓ Deforestation ✓ Intensive use of fertilisers (by farmers) ✓ Cement manufacture ✓	1 (AO1.1)	**ALLOW** example of burning fossil fuels
		ii	**Any two from:** Global warming / increased temperature of Earth's atmosphere ✓ Melting ice caps ✓ Rising sea levels ✓ Altered weather patterns / extreme weather events ✓ Flooding ✓ Increasing ocean acidity ✓	2 (AO1.1)	**ALLOW** climate change
			Total	**8**	

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