Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		**Test tube** 1 - a mass value > 4.42(g) ✓ **Test tube 2** - 4.46(g) ✓	2 (2 x AO 3.2a)	**Examiner's Comments** More candidates scored a mark for Test tube 2 than did for Test tube 1. Lower attaining candidates thought that the nail in Test tube 1 would lose mass, rather than recalling that during rusting iron reacts with oxygen and water to form hydrated iron oxide.
	b		**Test tube 4** Idea that the scratch in the paint exposed the iron to air/oxygen and/or water (so it rusted) ✓ **Test tube 5** Idea that (even when the zinc coating is scratched) the zinc will corrode first ✓ because zinc is more reactive (than iron) / zinc loses electrons more easily (than iron) ✓	3 (2 x AO 3.2b) (1 x AO 1.2)	**ALLOW** the iron reacted with the air/oxygen and/or water **ALLOW** idea of sacrificial protection **DO NOT ALLOW** zinc will rust (first) **Examiner's Comments** Good responses to this question identified that in Test tube 4 the scratch in the paint exposed the iron to oxygen/air and/or water. They then went on to describe that in Test tube 5 the zinc will corrode first because zinc is more reactive than iron. Lower attaining candidates usually knew the conditions needed for rusting but thought the role of the zinc coating was limited to that of being a barrier. The idea that paint was permeable to oxygen/air and water was also common. **Misconception** A significant number of candidates appreciated that zinc is more reactive than iron but then incorrectly stated that the zinc would rust in preference to iron.

	c	i	Copper oxide / CuO loses oxygen or copper oxide / CuO is reduced ✓ Carbon (atoms) / C gains oxygen or carbon (atoms) / C is oxidised ✓	2 (2 x AO 2.2)	**DO NOT ALLOW** copper loses oxygen **BUT ALLOW** copper gains electrons / copper (cat)ions are reduced (to form copper atoms) **ALLOW** carbon loses electrons **Examiner's Comments** Good responses to this question explained the redox reaction in terms of copper oxide losing oxygen and carbon gaining oxygen. Examiners also saw responses in terms of loss and gain of electrons. A frequent error was stating that copper loses oxygen.
		ii	**First check the answer on the answer line** **If answer = 12 (tonnes) award 3 marks** **If answer = 12,000,000 g award 3 marks** Mass of CuO = $15 \times \frac{63.5}{79.5}$ or $15 \times \frac{127}{159}$ ✓ = 11.98 ✓ To 2 **significant figures** = 12 (tonnes) ✓	3 (2 x AO 2.2) (1 x AO 1.2)	**ALLOW ECF** marks for e.g., $15 \times \frac{79.5}{63.5} = 18.78$ and (to 2 sig figs) 19 (tonnes) **ALLOW ECF** if significant figures are correct from an incorrect calculation of mass **Examiner's Comments** Candidates had been well prepared for reacting mass calculations, with most candidates gaining 3 marks. Some candidates did not express their answers to 2 significant figures. Errors that were made often arose from doubling only one of the A_r of Cu (from 63.5 to 127) or the M_r of CuO (from 79.5 to 159).
		iii	**Quantitative answer:** Pure copper is twice as conductive ✓ compared to 99% pure copper ✓ **BUT** **Qualitative answer:** Pure copper is a better conductor than 99% pure / impure copper / ORA ✓	2 (2 x AO 3.2b)	**ALLOW** answers quoting 2 correct values from the graph for 2 marks e.g., 99% pure copper has relative electrical conductivity of about 49, but 100% pure copper has relative electrical conductivity of 100 **OR** e.g., copper extracted from copper oxide has a relative electrical conductivity of about 49, but when purified by electrolysis has relative electrical conductivity of 100 **ALLOW** idea that copper with less impurities is a better conductor / ORA **Examiner's Comments**

					Lower attaining candidates misinterpreted the question and gave answers relating to the electrolysis reaction. Many candidates identified that the graph showed that impurities in copper brought about a decrease in its electrical conductivity. Higher attaining candidates were able to give a quantitative answer in terms of pure copper being twice as conductive as 99% pure copper or quoting two values from the graph to illustrate this relationship.
			Total	**12**	
2			A ✓	1 (AO 1.1)	
			Total	**1**	
3			**D ✓**	1 (AO 1.1)	
			Total	**1**	
4			**Level 3 (5–6 marks)** Analyses the information to give a clear and detailed comparison of the environmental impacts of each car over its lifetime. **AND** Applies knowledge and understanding of scientific ideas to give a detailed evaluation of the difference in emissions with an explanation of why a steel car has the smallest environmental impact. *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)** Analyses the information to give a clear comparison of some of the environmental impacts of each car over its lifetime and suggests which car has the smallest environmental impact with some reasoning. **OR** Applies knowledge and understanding of scientific ideas to give a clear	6 (2 × AO 2.1) (4 × AO 3.2a)	**AO3.2a Analyse ideas and information to make judgements and** **AO2.1 Apply knowledge and understanding of scientific ideas** **Production** • extraction of aluminium from aluminium ore uses electrolysis which uses lots of energy • due to energy required for electrolysis production of aluminium, it produces the most CO_2 emissions • iron (for steel) is extracted by heating iron ore with carbon • this requires less energy (than electrolysis) so produces less CO_2 emissions **Driving** • aluminium has a lower density (than iron) so has better fuel

			evaluation of the difference in emissions with an explanation of which car has the smallest environmental impact. *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)** Analyses the information to compare an environmental impact of each car. **OR** Applies some knowledge and understanding of scientific ideas to attempt an explanation of the difference in emissions in one of the three life-cycle stages. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 mark** *No response or no response worthy of credit.*		economy and reduces CO_2 emissions **End of life** • aluminium's higher CO_2 emissions when producing the metal mean that there is a greater saving (than with iron) on CO_2 emissions by recycling the metal **Overall** • lifetime CO_2 emission for aluminium is 42 408kg, compared to 41 952kg for steel/iron • steel/iron therefore has the least environmental impact **Examiner's Comments** This 6-mark Level of Response question assessed AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to analyse the information to give a clear and detailed comparison of the environmental impacts of each car and then to use their knowledge and understanding of scientific ideas to explain why a steel car has the smallest environmental impact. Some of the responses were excellent, showing a clear numerical analysis of the data at each stage of the life-cycle assessment and explaining the extraction of aluminium by electrolysis compared to the extraction of iron by reduction of iron ore with carbon. The responses of lower scoring candidates often: • simply quoted data from the table rather than analysing and evaluating the data • did not apply any knowledge of how metals are extracted.

					Exemplar 1  This is a Level 3 (6 mark) response in which the candidate has quantitatively analysed the information to give a clear and detailed comparison of the environmental impacts of each car over its lifetime. The candidate has also applied their knowledge and understanding of scientific ideas to give a detailed evaluation of the difference in emissions and has correctly explained why the steel car has the smallest environmental impact.
			Total	**6**	
5			**B**	1 (AO 1.1)	**<u>Examiner's Comments</u>** A common error was A, with candidates thinking that alloys combine the properties of the metals they are made from.
			Total	**1**	

6			**C**	1 (AO 1.1)	
			Total	**1**	
7			**C**	1 (AO 1.1)	
			Total	**1**	