1(a). Metal extraction produces a lot of waste. The zinc ions from this waste could leak into watercourses and contaminate soil. This plant, Alpine Penny-cress, grows on waste heaps that contain toxic zinc ions.

The cress plants take up the zinc ions and store them in their leaves.

Alpine cress takes up zinc ions from contaminated soil very well.

Oilseed rape cannot take up zinc. The table shows data on Alpine Penny-cress and oilseed rape.

Plant	Height (cm)	Dry mass per plant (g)	Plants per m^2	Time to fully grown (days)
Alpine Penny-cress	25	1	20	100
Oilseed rape	125	2	50	85

Scientists have put genes from Alpine Penny-cress into the oilseed rape plant.

Explain what effect this modified plant could have on the uptake of zinc ions in contaminated soil.

---

[2]

(b). The Alpine Penny-cress contains toxic zinc ions.

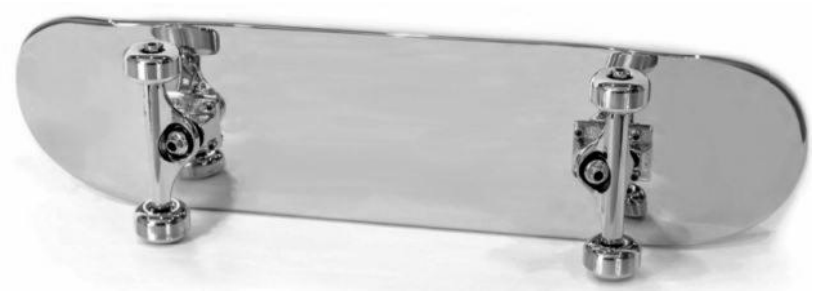
Abi decides to do some experimental research to find out whether the Alpine Penny-cress can be used as grazing for sheep.

What research would she need to do to find out if the Alpine Penny-cress is safe for sheep to eat?

---

[2]

2. Sam works for a company that makes skateboards.



Customers complain that their skateboards lose performance once they have got wet.

Skateboards have bearings in **each** wheel to help the wheels rotate smoothly and freely.

Skateboard wheel bearing

The bearings in the wheels contain smaller steel ball bearings. These rust if they get wet.

The word equation for rusting is:

iron + water + oxygen ⟶ rust (hydrated iron(III) oxide)

Balance the symbol equation for the formation of rust.

…….. Fe(s) + ……. $H_2O(l)$ +……. $O_2(g)$ ⟶ …….. $Fe_2O_3.3H_2O(s)$

[2]

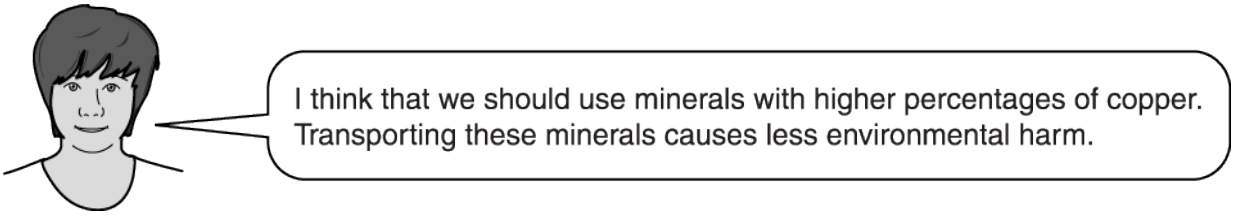
3. Zoe works for a mining company. The company extracts copper from two different minerals.

They use the minerals cuprite, Cu_2O, and chalcocite Cu_2S.

Zoe works out the percentage mass of copper in cuprite. It is 88.8%.

The minerals are transported from the mine to be processed to make copper.

Zoe thinks about the environmental harm caused by transporting each mineral.



Do you agree with Zoe?

Explain your answer.

---

[2]

4(a). Some metals can be extracted from metal oxides by heating with carbon.

The equation shows what happens when copper oxide is heated with carbon.

$$2CuO + C \rightarrow 2Cu + CO_2$$

(i) Which substance is oxidised and which substance is reduced in this reaction?

oxidised _____

reduced _____ [1]

(ii) Name the waste gas that is made in this reaction.

_____ [1]

(b). Large-scale metal extraction processes involve both costs and benefits.

(i) Companies choose metal extraction processes that use as little energy as possible.

Suggest why using less energy reduces both the **cost to the company** and the **cost to the environment**.

_____

_____

_____

_____ [3]

(ii) Give **two** examples of the ways that people **benefit** from large-scale metal extraction processes.

_____

_____

_____ [2]

(c). The table shows some data about the most cost-effective methods for extracting metals from metal oxides.

Metal oxide	Minimum temperature to make metal by heating with carbon in °C	Most cost-effective method of extraction
calcium oxide	2100	electrolysis
magnesium oxide	1600	electrolysis
aluminium oxide	2100	electrolysis
zinc oxide	900	heating with carbon
iron oxide	700	heating with carbon
lead oxide	400	heating with carbon
copper oxide	100	heating with carbon

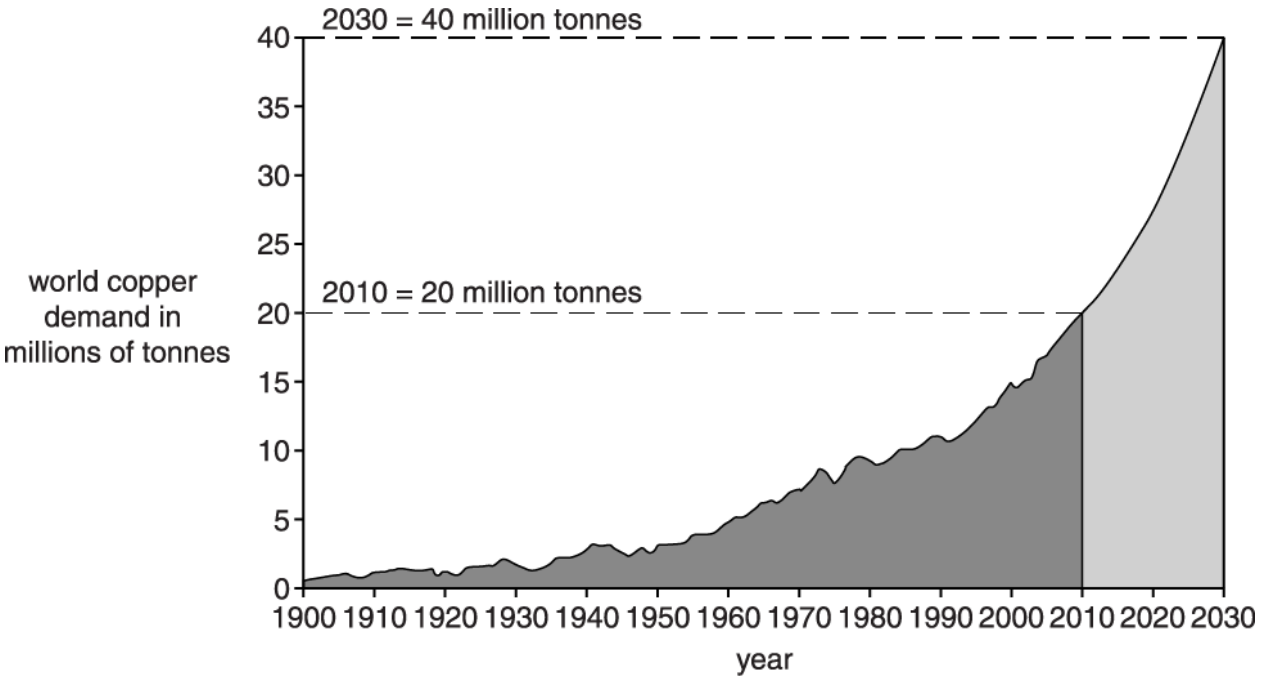
Use the data to explain how the method chosen to extract a metal is related to its reactivity and the energy involved.

The quality of written communication will be assessed in your answer.

[6]

5. Scientists are concerned about how the demand for copper is changing and how this will affect the supply of copper for the future.

The graph shows how the total world **demand** for copper has changed since 1900. The graph also shows the predicted demand for copper between 2010 and 2030.



The **supplies** of copper in the world come from four main countries. The copper deposits left in these countries are shown in the table.

Country	Estimated copper deposits in millions of tonnes
Chile	140
United States	90
Canada	23
Poland	36

Even if all scrap copper is recycled, this meets less than 50% of the world demand for copper.

Scientists are very concerned about the balance between the supply and demand for copper from 2010 onwards.

Use the information about copper to discuss why they are so concerned.

The quality of written communication will be assessed in your answer.

[6]

6. Manganese is a metallic element.

Manganese is made by heating manganese oxide, MnO_2, with carbon.

Carbon monoxide is also formed.

(i) Write a **balanced chemical** equation for this reaction.

Include state symbols in your equation.

[2]

(ii) Explain why carbon can be used to extract manganese from its compounds.

Use ideas about reactivity and reduction in your answer.

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		any two from: larger plants therefore take up more zinc ions ✓ more plants grow per m^2 therefore absorb more zinc ions per m^2 ✓ plants grow more quickly therefore more zinc ions can be removed in a shorter time ✓	2	
	b		find out amount / concentration of zinc ions in cress ✓ find out tolerance of sheep for zinc ions / whether zinc ions get into wool / meat ✓	2	
			Total	4	
2			$4Fe(S) + 6\ H_2O(l) + 3O_2(g) \rightrightarrows 2Fe_2O_3.3H_2O(s)$✓✓	2	One mark for 2 or 3 right Two marks for all 4 right Allow $2Fe(s) + 3H_2O + 1\ 1/2\ O_2(g) \longrightarrow$ $(1)Fe_2O_3.3H_2O(s)$✓
			Total	2	
3			*any two from:* (per tonne of copper produced) less ore needs to be transported / fewer journeys / less traffic; leading to lower amount of fuel needed / lower amount of energy needed; less CO_2 produced / less named pollutant e.g. carbon monoxide / particulates / NOx / SOx / less air pollution / less dust / less noise;	2	ignore pollution / damages environment / damages habitats etc. Must be linked to transport not metal extraction for marking points 2 and 3
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
4	a	i	carbon is oxidised **AND** copper (oxide) is reduced;	1	both answers for 1 mark Examiner's Comments Both parts were well answered; candidates identified the oxidised and reduced element and identified the gas, carbon dioxide, as a waste product.
		ii	carbon dioxide (must be name)	1	**Do not allow** CO_2
	b	i	**Any 3** Cost to company: saves or uses less fuel / electricity / example of fuel; Environmental: energy comes from fossil fuels / non-renewable or finite fuels; reducing pollutant gases / reduces emissions / reduces named pollutant gas e.g. SOx, NOx, COx; named environmental effect of gases (e.g. acid rain, greenhouse effect / climate change);	3	**Ignore** 'less cost' or 'less pollution' alone. **Ignore** 'uses less power' Ignore 'reduces cost of fuel' (not enough) **Allow**: 'Saving fossil fuels' (2) marks for cost to company and environment **Ignore** 'gives out less gases' or 'less waste' but **allow** 'less *waste* gases' Examiner's Comments ??Some candidates gave strong answers about the links between energy and finite fuel usage linked to air quality. The question stem included the phrases: 'costs and benefits', 'less energy', 'reduces costs to the company' and 'reduces costs to the environment'. In this type of question candidates need to take care that they add to these phrases when they reply in their answer. A common reason for a lower score in this question was that the candidate re-wrote these phrases without significantly adding anything of their own to the points. Candidates also need to take care to answer both sides of the question, in this case costs to both the company and the environment. Answers dealing with only one part of the question can only gain part of the available marks.

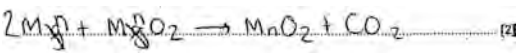
Question			Answer/Indicative content	Marks	Guidance
		ii	any 2 from: jobs / income; use of metals for products / example of metal use (e.g. cars / fridges etc); idea of local economy; idea of national economy; advantage of large scale: transport links to one area / control of waste is in one area / economy of scale idea / more economic to extract on a large scale / lower energy costs on a large scale / large scale can use continuous not batch processes;	2	**Ignore** 'to meet demand' or 'need metals' or 'use a lot of metals' alone (not enough) **Allow** 1 mark for 'economy' alone MP5 must be linked to idea of large scale extraction Examiner's Comments ??Most candidates gained a single mark, often for recognising that there would be more employment in the area near a large scale extraction. Candidates need to take care not to give 'cheaper' as an answer unless it is qualified by the reason for the reduction in cost. 'It is cheaper' alone is insufficient. 'Large scale metal extraction has cheaper fuel costs than many small scale extraction sites' is a better answer.
	c		**[Level 3]** Links **reactivity** with the **method used** and to **energy**. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** Makes a link between trends. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** Makes a correct statement about the data. Quality of written communication impedes communication of the science at this level.	6	**This question is targeted at grades up to C** **Indicative scientific points may include:** **Level 3: (Links reactivity and method and energy)** • More reactive metals use electrolysis which uses high energy / the more reactive a metal the more energy is needed and electrolysis is used • Less reactive metals use extraction with carbon which uses less energy / the less reactive a metal the less energy is needed and heating with carbon is used **Level 2: (Link between trends)** • Links reactivity to method of extraction • Links reactivity to temperature needed • Links reactivity to energy needed • Links temperature needed to method of extraction • Links temperature to energy • Links method used to energy

Question			Answer/Indicative content	Marks	Guidance
			(1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)		Level 1: (data) • Ca / Mg / Al are most reactive metals • Zn / Fe / Pb / Cu are less reactive metals • Ca / Mg / Al need a high temperature (for extraction) • Zn / Fe / Pb / Cu need a lower temperature (for extraction) • Ca / Mg / Al use electrolysis • Zn / Fe / Pb / Cu use heating with carbon • Mg or Al does not fit the trend Ignore references to melting point Statements about one metal alone indicate level 1 Examiner's Comments ??This was another overlap question, shared with the foundation tier. As the question was designed to discriminate up to grade C, most candidates on the higher tier scored high scores. In this level of response question, the question asked candidates to discuss three key aspects: method chosen, reactivity and energy. Level 3 answers addressed all three aspects. Answers which addressed one or two aspects were limited to the lower mark levels. The information in the table did not give any information directly about energy, but this could be deduced from the temperature needed for extraction. The discussion of energy was the aspect most commonly omitted by candidates. Some very good answers were seen, some of which discussed the lowering in energy needed to extract reactive metals if electrolysis was used rather than carbon extraction.
			Total	13	

Question			Answer/Indicative content	Marks	Guidance
5			[Level 3] Processes data about supply or demand and links data about both to a problem. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Identifies a problem and uses data about both supply and demand OR identifies a problem linked to processed data about supply or demand. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Identifies a problem and uses data about supply or demand. 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: Problems • idea that copper supplies will run out in the future / are finite / limited • Supply cannot meet demand Data about supply and demand Demand: • demand for copper is rising • Quotes value(s) from demand graph Supply: • Recycling / scrap can only supply 50% of demand • Quotes value(s) from supply table • only four countries have (large) copper supplies Processed data • between 2010 and 2030 copper demand is expected to double. • Demand for copper is rising faster (over time) • Attempts to estimate number of years' supply. • uses values from the supply table to compare to the annual demand • Total supply from 4 countries is 289 million tonnes • discusses a shortfall between demand and supply using data from both the table and the graph Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This question was shared with the foundation tier. A full spread of marks were seen on the higher tier paper, where the question discriminated well. The main

Question			Answer/Indicative content	Marks	Guidance
					barrier to scoring higher marks was that some candidates did not access all parts of the task fully. The question asked candidates to 'discuss why scientists are so concerned' in the context of the balance between supply and demand for copper. Some described data but did not clearly express why the data gives cause for concern. Others only discussed one aspect of the data; either demand or supply. Level 3 answers were expected to show some processing of the data, for example by calculating the total reserves of copper in the four main countries, or making an estimate of the years' supply left. About a third of the candidates gave answers at level 3.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
6		i	$MnO_2(s) + 2C(s) \rightarrow 2CO(g) + Mn(s)$ correct formulae and balancing ✓ state symbols ✓	2 (AO 2 × 1.2)	ALLOW state symbol mark for any version of manganese oxide + carbon → carbon oxide + manganese Examiner's Comments  AfL When asked to write an equation, candidates need to check that they know what type of equation they are asked for (ionic, balanced, word, half equation) and also whether they need to include state symbols. A relatively common shortcoming for this question was to omit either the balancing or the state symbols. In addition, candidates need to check the information given, a further misconception was to give CO_2 as a product. This error also shows that candidates have not taken time to self-correct their responses. The question stem instructs candidates that carbon monoxide is a product. Exemplar 2  [2] Although this equation shows correct formulae and balancing [1] the candidate has missed the instruction to 'Include state symbols' leading to only one mark. A relatively common error was to miss this instruction and similarly to miss the significant figures and decimal places instructions in the mathematical questions.

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 3  In this case there are two errors, both of which could have been 'self corrected' by the candidate has (s)he re-read the information given. The information states that manganese oxide is heated with carbon. It further states that carbon monoxide is formed. Neither carbon nor carbon monoxide is given in this equation. The instruction to 'include state symbols' has also been ignored. Therefore no marks could be credited.
		ii	Manganese is less reactive than carbon ORA ✓ carbon reduces / removes oxygen from / donates electrons to manganese (oxide) ✓	2 (AO 2 × 2.1)	<u>Examiner's Comments</u> Almost all candidates knew that either carbon is more reactive than manganese or that manganese is reduced. This led to most candidates earning at least one mark.
			Total	4	