AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.10.1.4

Alternative methods of extracting metals (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**5**
Available paper years	**2019–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 01 · Mark scheme June 2019 | 8464/C/2H | Original Q4

04.1	growing plants (on low-grade ore) plants are burnt (to produce ash) (ash dissolved in acid to produce) solution of a copper compound electrolysis (of solution of a copper compound) **or** displacement (by adding scrap iron to a solution of a copper compound)	allow named plant allow named copper compound allow addition of scrap iron (to a solution of a copper compound)	1 1 1 1	AO1 5.10.1.4

04.2	 M_r $CuSO_4$ = 159.5 $\frac{0.319}{159.5}$ = 0.002 (mol)	an answer of 0.002 **or** 2×10^{-3} (mol) scores **3** marks allow correct use of incorrectly calculated value for M_r allow 2×10^{-3} (mol)	 1 1 1	AO2 5.3.2.1 5.3.2.5

04.3	both reaction profiles start at the same energy level and end at the same energy level.		1	AO3 5.6.1.4

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 01 · Mark scheme

04.4	the amount of carbon dioxide used to produce the ethanol is the same as the amount of carbon dioxide given off when the ethanol is burned	**alternative approach** there is sufficient carbon dioxide (in the atmosphere) (1) because carbon dioxide is constantly produced from burning fossil fuels (1) if no other mark awarded allow for **1** mark burning ethanol produces carbon dioxide	1 1	AO3 5.9.2.2 5.9.3.1

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 01 · Mark scheme

04.5	meets needs of current generation without compromising needs of future generations	 allow so there are enough resources for future generations ignore references to harming / damaging planet / environment	1 1	AO1 5.10.1.1

Total			**12**

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 01 · Mark scheme

June 2019 | 8464/C/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 02 · Mark scheme

November 2021 | 8464/C/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	production of copper is increasing at an increasing rate		1 1	AO2 5.10.1.1
04.2	increase in population / demand	allow more uses for copper	1	AO3 5.10.1.1
04.3	any **one** from: • more use of recycling • copper is a finite resource and may run out • alternative metals may be used in future	ignore only an estimate	1	AO3 5.10.1.1
04.4	**B**, **D**, **C**, **A**, **E**		1	AO1 5.10.1.4
04.5	any **two** from: • (phytomining is) slower to produce copper • large area of land required • insufficient yield to meet demand	ignore reference to cost ignore references to carbon dioxide ignore references to global warming allow plants grow slowly	2	AO3 5.10.1.4

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 02 · Mark scheme

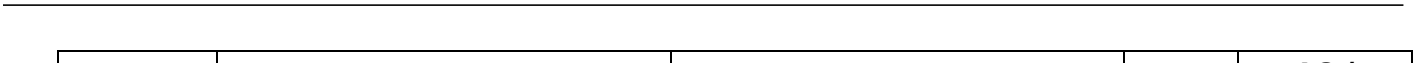
November 2021 | 8464/C/2H | Original Q4

04.6	(energy use through recycling = $27.2 \times 8.89 \times 10^9 \times \frac{41}{100}$) $= 9.914 \times 10^{10}$ (energy use through extraction = $70.4 \times 8.89 \times 10^9 \times \frac{59}{100}$) $= 3.693 \times 10^{11}$ (total consumption today = $9.914 \times 10^{10} + 3.693 \times 10^{11}$) $= 4.6844 \times 10^{11}$ (energy use if only recycling used = $27.2 \times 8.89 \times 10^9$) $= 2.418 \times 10^{11}$ (energy saving = $4.6844 \times 10^{11} - 2.418 \times 10^{11}$) $= 2.27 \times 10^{11}$ (MJ)	allow correct use of an incorrect energy use determined in MP1 and/or MP2 allow an answer correctly calculated to 3 significant figures which uses the values in the question	1 1 1 1 1 1	AO2 5.10.2.2
Total			**12**	

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 02 · Mark scheme

November 2021 | 8464/C/2H | Original Q4



5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 03 · Mark scheme

June 2022 | 8464/C/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	nitrogen increased		1	AO1 5.9.1.2
	(because of) emission from volcanoes	allow (because of) denitrifying bacteria	1	5.9.1.3
	oxygen increased		1	
	(because of) photosynthesis		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	carbon dioxide is used during photosynthesis		1	AO1 5.9.1.4
	in trees		1	
	(which) die and are compressed		1	
	over millions of years		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	coal has a higher proportion / percentage of carbon		1	AO2 5.9.3.1

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 03 · Mark scheme

June 2022 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	uses bacteria to produce solutions containing copper compounds from which copper is obtained by displacement / electrolysis	 allow to produce leachate solutions	1 1 1	AO1 5.10.1.4

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 03 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	1000 (kg of plants) gives 7.92 (kg of nickel)		1	AO2 5.10.1.4
	(mass = $\frac{7.92}{4.8}$ × 100 =) 165 (kg)		1	
	(conversion 165 kg =) 165 000 (g)	allow correct conversion of an incorrectly determined mass in kg	1	
	= 1.65 × 10^5 (g)	allow a correctly calculated and rounded conversion to standard form of an incorrect calculation of mass in grams	1	
	OR			
	(mass =) $\frac{0.792}{4.8}$ × 1000 (1)			
	= 165 (kg) (1)			
	(conversion 165 kg =) 165 000 (g) (1)	allow correct conversion of an incorrectly determined mass in kg		
	= 1.65 × 10^5 (g) (1)	allow a correctly calculated and rounded conversion to standard form of an incorrect calculation of mass in grams		

Total Question 5		**16**

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 04 · Mark scheme

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	large amounts of energy required	ignore references to time and/or cost	1	AO1 5.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	reverse osmosis using membranes	ignore desalination	1 1	AO1 5.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	(heat) until the mass is constant to ensure that all the water has evaporated		1 1	AO3 5.10.1.2 RPA13

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(mass =) $\frac{77.8}{100} \times 3.50$ = 2.72 (g)	 allow 2.723 (g)	1 1	AO2 5.10.1.2 RPA13

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	displacement using (scrap) iron electrolysis		1 1	AO1 5.10.1.4

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 04 · Mark scheme

June 2024 | 8464/C/2H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	plants are harvested and burned to produce ash (that contains metal compounds)		1 1 1	AO1 5.10.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.7	(area =) $\frac{750}{215}$ = 3.49 (hectares) (conversion = 3.49 × 10 000 =) 34 900 (m^2) **alternative approach** (conversion = $\frac{215}{10000}$ =) 0.0215 (kg/m^2) (1) (area =) $\frac{750}{0.0215}$ (1) = 34 900 (m^2) (1)	 allow 3.488372093 correctly rounded to at least 2 significant figures allow 3.49 × 10^4 (m^2) allow a correct conversion of an incorrectly determined area allow correct use of an incorrect conversion	1 1 1	AO2 5.10.1.4

Total Question 6	15

5.10.1.4 Alternative methods of extracting metals (HT only)

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(mass in one phone =) $1.73 \times 10^{-4} \times 197$		1	AO2 5.3.2.1 5.10.1.1
	= 0.034081 (g)		1	
	(total mass =) $0.034081 \times 2.48 \times 10^{6}$	allow (total mass =) $0.034081 \times 2\,480\,000$ allow correct use of an incorrectly determined mass in one phone	1	
	= 84520.88 (g)		1	
	(conversion 84520.88 g =) 84.5 (kg)	allow 84.52088 (kg) correctly rounded to at least 2 significant figures allow conversion at MP2, MP3 allow correct conversion of an incorrectly determined mass using all numbers from the question	1	
	alternative approach			
	(total moles =) $1.73 \times 10^{-4} \times 2.48 \times 10^{6}$ (1)	allow (total moles =) $1.73 \times 10^{-4} \times 2\,480\,000$		
	= 429.04 (1)			
	(total mass =) 429.04 × 197 (1)	allow correct use of an incorrectly determined total moles		
	= 84520.88 (g) (1)			
	(conversion 84520.88 g =) 84.5 (kg) (1)	allow 84.52088 (kg) correctly rounded to at least 2 significant figures allow correct conversion of an incorrectly determined mass using all numbers from the question		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	1.04×10^{20}		1	AO2 5.3.2.1 5.10.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	uses bacteria		1	AO1 5.10.1.4 5.10.2.2
	to produce leachate / solutions containing gold compounds		1	
	from which gold is obtained by displacement / electrolysis		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **two** from: • high-grade ores still available • land not available • phytomining takes a long time • very small yields produced • new technology		2	AO3 5.10.1.4

Total Question 6	11

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 01 · Examiner comments June 2019 | 8464/C/2H | Original Q4

Question 4 (standard/high demand)

04.1 The majority of students who obtained marks on this question did so from the first 2 marking points, although then many continued to describe the next process incorrectly as 'electrolysing the copper metal from the ash'. Converting the copper compounds found in the ash into a suitable copper solution or electrolyte, was rarely seen in the student responses. A significant minority of students who gained no marks on this question did not seem familiar with the process of phytomining, and gave answers based around normal mining, or heating the rock until the copper melted.

04.2 Around 73% of students gained some credit on this question, predominantly for correctly calculating the M_r of copper sulfate (159.5), although 111.5 (addition of all the A_r given in the question) was given regularly. The most common mistake was to multiply the figures (0.319 x 159.5) rather than divide ($\frac{0.319}{159.5}$). 15% of students scored all three marks, many giving their answers in standard form (2×10^{-3}), which, although not asked for, was accepted.

04.3 About 84% of students gained this mark with no pattern seen in the incorrect responses.

04.4 Only a few students achieved both marks by correctly linking the idea that the amount of CO_2 used to produce ethanol would be the same as would be released when the ethanol was burned. The vast majority of correct answers for both marks were based on the large amount of CO_2 in the air, and its regular replacement by burning fossil fuels. About 23% of students achieved 1 mark for highlighting that there was sufficient carbon dioxide in the atmosphere or that it is produced from the combustion of ethanol.

04.5 Around 17% of students gained credit on this question by recalling the definition of sustainability from the specification or were able to give an equivalent statement. Most students answered in terms of environmental issues or renewable routes, including 'long lasting' and 'won't run out'.

Answer 02 · Examiner comments November 2021 | 8464/C/2H | Original Q4

Question 4 (standard, standard / high and high demand)

Most students were successfully able to describe the general trend in the graph and account for the changes. In question 04.1, however, many failed to gain the second mark point as they did not recognise that the increase was not the same throughout the graph.

The disadvantages of phytomining compared to traditional mining tended to focus on pollution, carbon dioxide emissions and global warming as a result of the combustion of the plants. This did not gain credit as traditional mining methods also lead to a similar increase in the gas.

Students approached the calculation in question 04.6 using a variety of methods, which is to be encouraged. A significant number merely calculated the difference in mass rather than energy. Marking point 5 was awarded for an answer to a calculation using the data provided, given to 3 significant figures.

5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 03 · Examiner comments — June 2022 | 8464/C/2H | Original Q5

Question 5

Students were able to demonstrate knowledge of the changes to the Earth's atmosphere, but knowledge of some of the other areas of the specification assessed in this question were a lot less familiar to students.

05.1 Over 90% of students achieved at least 1 mark on this question. This was predominantly for identifying that the concentration of oxygen increased. This was linked to photosynthesis as the next most common mark, followed by an increase

Answer 03 · Examiner comments — June 2022 | 8464/C/2H | Original Q5

in nitrogen. The source of nitrogen from volcanoes was known by about 10% of students.

05.2 The formation of coal was not well known by students. About a quarter of students gained at least one mark, usually for knowing the timescale was over millions of years. 2 or more marks were achieved by fewer than 10% of students. The question asked how carbon dioxide was turned into coal. The most common misconceptions were around the idea that carbon dioxide is compressed.

05.3 Fewer than 2% of students gained the mark here. A comparison of the **proportion** of carbon in each fuel source was required for the mark. The most common responses were around the idea that coal was made from carbon dioxide, so released more back into the atmosphere.

05.4 Just over one third of students achieved at least one mark, usually for identifying bacteria. The least likely mark to be awarded was for the production of a solution containing copper compounds.

05.5 This was a high demand question where just over half of students scored at least one mark, often for a conversion from kg to g. Beyond that, students did not appear to be confident in interpreting the data given and only around 5% scored full marks.

Answer 04 · Examiner comments

Question 6 (standard/high & high demand)

06.1 About a quarter of students answered this question correctly. The most common incorrect responses included 'expensive' and 'time consuming'.

06.2 Methods for producing potable water from seawater were not well known.

Few students gave a creditworthy response in this question. By far the most common incorrect responses were a description of filtration or evaporation of the water followed by condensation, a repetition of the method given in question 06.1.

The few students who gave creditworthy responses clearly understood the process of reverse osmosis well and gained both marking points.

06.3 Very few students gained full credit in this question. A common misconception was that the question was asking why any chemical experiment should be repeated. The most common incorrect responses focused on reliability and repeating to find a mean.

Of the responses that did gain credit marking point 1 was achieved most often. Very few students appreciated the idea of heating to constant mass.

06.4 Students approached this question very well, using a variety of methods. Incorrect rounding was uncommon but was the main reason why marking point 2 was not gained following a correct calculation.

06.5 Many students recognised that electrolysis was a suitable method for extracting copper. However, further methods were not well known. Very few gained marking point 1. Those that did state displacement often gave an insufficient answer, not including that this process uses iron or giving an incorrect element such as carbon.

The most common incorrect responses were phytomining and bioleaching.

06.6 A large number of students had good knowledge of the process of phytomining, often gaining 2 of the 3 marks available in this question. Many students spent some time talking about the planting and absorption of the metal ions before getting to the creditworthy aspects of their response or in fact not getting to it at all and therefore not gaining the marks available.

'Burning' was the most common mark point gained. Many students forgot to include that the plants must first be harvested (marking point 1) and some missed marking point 3 by stating that the ashes contained the metal rather than the metal compound.

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 04 · Examiner comments June 2024 | 8464/C/2H | Original Q6

0 6 . 6 Describe how the metal compounds are obtained from the plants.

[3 marks]

plants are grown on a soil which has a high concentration of low grade ores. As the plant grows the metal compounds are absorbed ~~int~~ through the plants roots by diffusion and active transport and travel up the plant to its leaves. The plant is then burnt, the ashes contains a high concentration of the metal compounds.

0 6 . 6 Describe how the metal compounds are obtained from the plants.

[3 marks]

the plant is planted on top of the ore and the roots then absorb in the ore and the plant is cut down, burnt to ashes and then the ashes are

The first example shows the two most common problems that students had with this question. First, a significant amount of the answer is given over to describing how the metal compounds get into the plants. The first four and a half lines of this response are unnecessary. Once the student gets to how to get the metal compounds out of the plants, they miss out harvesting (the most common omission) from the answer. They are awarded 2 marks for burning and using the ashes.

The second student gives a concise account of extracting the metal compounds from the plants. The final marking point is for producing ash. The student begins to continue their answer, but nothing contradictory is written so all 3 marks are awarded.

06.7 Students approached this question very well, with over three-quarters gaining full credit. Of those who incorrectly calculated the area, many were still able to gain marking point 3 by carrying out a correct conversion.

Many students did not achieve full marks due to rounding too soon in their calculation. Although rounding errors are not taken into account until the final answer, if a solution is rounded too soon the answer is incorrect, so full marks cannot be awarded. Students should be encouraged to keep values in calculators for multi-step calculations so unnecessarily missing out on marks can be avoided.

A number of different methods were seen during marking that were not on the mark scheme. However, a correct answer was given full credit.

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 04 · Examiner comments June 2024 | 8464/C/2H | Original Q6

0 6 . 7 Nickel is produced by phytomining.

One hectare of plants produces 215 kg of nickel.

Determine the area required to produce 750 kg of nickel.

Give your answer in m^2.

One hectare = 10 000 m^2

[3 marks]

750 ÷ 215 = 3.48

× 10,000 = 34,800 m^2

Area required = 34,800 m^2

0 6 . 7 Nickel is produced by phytomining.

One hectare of plants produces 215 kg of nickel.

Determine the area required to produce 750 kg of nickel.

Give your answer in m^2.

One hectare = 10 000 m^2

[3 marks]

10,000 m^2 = 215kg

10 000 / 215 = 46.51

46.51 × 750 = 34,882.5

Area required = 34,882.5 m^2

In the first example, the student has rounded incorrectly, so even though the method is correct, full marks cannot be awarded because the answer is incorrect.

The second example shows an alternative to the methods on the mark scheme. The student has calculated the area required to obtain 1 kg of nickel and used the answer to calculate the total area required for 750 kg of nickel. However, the student has rounded too early in the calculation, meaning that the final answer is incorrect: 2 marks were awarded in this case.

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 04 · Examiner comments June 2024 | 8464/C/2H | Original Q6

Contact us

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 05 · Examiner comments

June 2025 | 8464/C/2H | Original Q6

Question 6 (Standard/High and High demand)

06.1 Students found the format the numbers were presented in difficult, and often incorrectly used figures such as 1.73 and 2.48, rather than 1.73×10^{-4} and 2 480 000
Many students were unable to carry out the full calculation, but most gained some credit for successfully multiplying by 2.48 million.
Of the students who successfully carried out the calculation many did not complete the correct conversion from grams to kilograms correctly, often using a factor of 100, rather than 1000.

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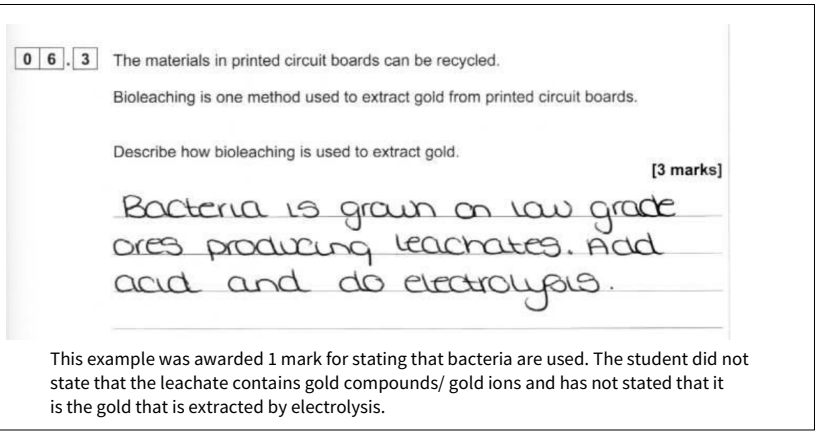
5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 05 · Examiner comments

June 2025 | 8464/C/2H | Original Q6

06.2 By selecting 1.04 x 10^{20}, the majority of students answered correctly.

06.3 The process of bioleaching was not well known.
Of the students that gained credit in this question many did so as they were able to identify that bacteria were involved.
Although some students were able to make a link to the idea of a leachate or solution, very few were able to explain that the leachate or solution contained gold compounds or gold ions.
When methods of extraction were included in a response they were often correctly identified.



0 6 . 3 The materials in printed circuit boards can be recycled.

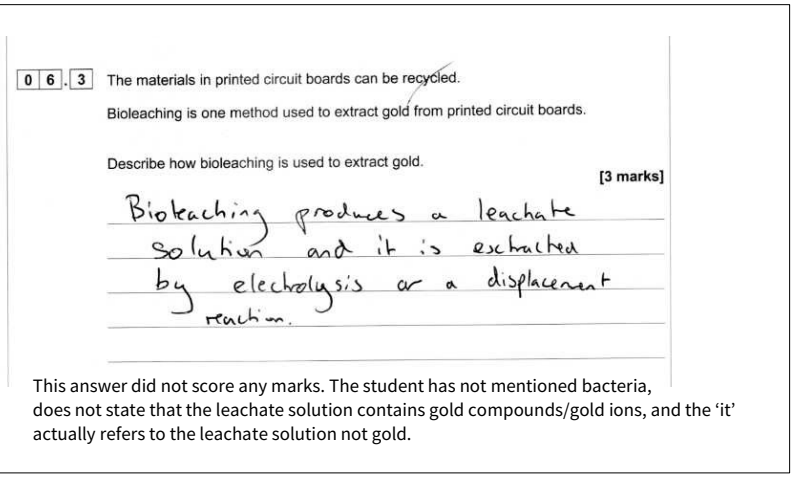
Bioleaching is one method used to extract gold from printed circuit boards.

Describe how bioleaching is used to extract gold.

[3 marks]

Bacteria is grown on low grade ores producing leachates. Add acid and do electrolysis.

This example was awarded 1 mark for stating that bacteria are used. The student did not state that the leachate contains gold compounds/ gold ions and has not stated that it is the gold that is extracted by electrolysis.



0 6 . 3 The materials in printed circuit boards can be recycled.

Bioleaching is one method used to extract gold from printed circuit boards.

Describe how bioleaching is used to extract gold.

[3 marks]

Bioleaching produces a leachate solution and it is exctracted by electrolysis or a displacement reaction.

This answer did not score any marks. The student has not mentioned bacteria, does not state that the leachate solution contains gold compounds/gold ions, and the 'it' actually refers to the leachate solution not gold.

06.4 Many students understood that phytomining is a time-consuming process and when marks were credited this was by far the most common correct response.

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 05 · Examiner comments

June 2025 | 8464/C/2H | Original Q6

Some students were aware that only small yields were produced and that a lot of land is needed but these ideas were not always clearly expressed using the correct terminology. Amount is not equivalent to yield, and lots of space is not equivalent to lots of land, for example.
Many students gave the answer of being expensive or damaging to the environment which are not specific to the process of phytomining.

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5.10.1.4 Alternative methods of extracting metals (HT only)

Answer 05 · Examiner comments

Contact us

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