GCSE

Combined Science: Trilogy

8464/C/2H Combined Science: Trilogy Chemistry Paper 2H

Report on the exam

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Contents

The below table is interactive. You can press the control button and click on the title of the question to go directly to that page.

Overview

This paper is one of the six examined components for Combined Science: Trilogy. All of these papers follow a similar structure and test the same assessment objectives.

This paper has 70 marks available to students and is made up of six questions.

- Approximately 40% of marks assess AO1; 40% of marks assess AO2; and 20% of marks assess AO3.
- Approximately 40% of marks target Standard demand, 40% of marks target Standard/high demand and 20% of marks target High demand.

Questions 1 and 2 on this paper and questions 6 and 7 on the Foundation Tier paper are common. These questions are identical and are targeted at standard demand.

Questions are set at three levels of demand for this paper:

- **Standard demand** questions are designed to broadly target grades 4–5.
- **Standard/high demand** questions are designed to broadly target grades 6–7.
- **High demand** questions are designed to broadly target grades 8–9.

A student's final grade is based on their attainment across all six papers.

Summary of overall performance

Students generally found the questions that were common with the Foundation tier accessible at this tier. Students found the recall of simple chemical tests (question 01.5), identifying a polymer (question 01.6) and applying knowledge of a Required Practical Activity to a different independent variable (question 02.1) the most challenging of the common questions.

A description of how sulfur dioxide is formed (question 03.2) was not well known.

Students found applying knowledge of the formulas of common gases to an unfamiliar reaction in a catalytic converter (question 03.5) the most challenging question on the paper.

Calculations (questions 04.2, 05.7, 06.4 and 06.7) were well attempted by many students.

Question 1 (standard demand)

01.1 About two thirds of students knew the definition of a hydrocarbon. Those who did not achieve the mark often used words such as ‘atom’ or ‘mixture’ instead of compound so were not credited. Similarly, students who gave answers in terms of carbon or hydrogen molecules (instead of atoms) were not given any marks.

01.2 Three-quarters of students achieved the mark for correctly determining the formula of decane. The most common incorrect response was $C_{10}H_{20+2}$.

01.3 This question has typically been targeted at high demand in previous years. However, this year it was set at standard demand, with the diagram containing more detail and the mark scheme for loosened a little to separate the first two marking points. Nearly all students on this tier were able to start the explanation of fractional distillation.

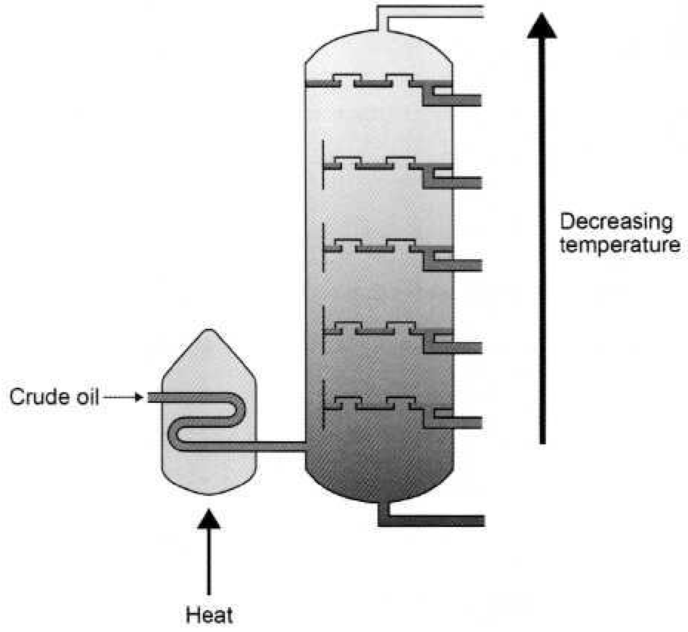
Four marks were available for this question. Most students who gained 1 mark did so for correctly identifying that the crude oil is heated. Some students indicated that the crude oil was heated once it was in the fractional distillation column itself, which was not creditworthy. Fewer students were able to explain that some of the hydrocarbons were vaporised/evaporated/boiled or turned into a gas for marking point 2. A third of students explained that there was a temperature gradient in the column. This could have been explained as a comparative statement, for example, the column is cooler at the top or by using sensible temperature values. Some students were able to explain that the hydrocarbons/fractions condensed or were able to give a clear description of condensation at different heights in the column or at different temperatures.

The most common responses that gained no marks referred to the different sizes and boiling points of the hydrocarbons/fractions.

0 1 . 3 Crude oil is a mixture of hydrocarbons.

Figure 1 represents industrial equipment used to separate crude oil into fractions.

Figure 1



Explain how crude oil is separated into fractions.

Use **Figure 1**.

[4 marks]

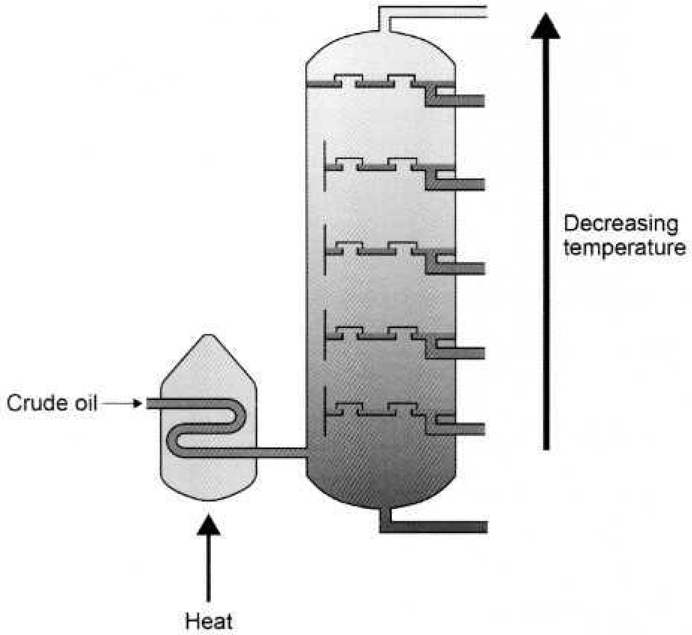
Firstly, crude oil is heated until evaporated. Each fractions has different boiling points. The longer hydrocarbons reaches to the bottom fractions as they have very high boiling points, so the small hydrocarbons reaches the top fractions as they have low boiling points, so then at each fraction these condense.

This response gains the first two marking points in the first line. The student then describes the lengths of the hydrocarbons but the language used is very muddled, and is suggesting that the different heights in the column are the fractions. Because of this the mention of 'condense' is insufficient as it is linked to an incorrect interpretation of fraction. No further marks are gained.

0 1 . 3 Crude oil is a mixture of hydrocarbons.

Figure 1 represents industrial equipment used to separate crude oil into fractions.

Figure 1



Explain how crude oil is separated into fractions.

Use **Figure 1**.

[4 marks]

Crude oil is a mixture of different hydrocarbons with different boiling points. First the crude oil is heated to a very high temperature to ~~ensure~~ completely vaporise it, then its passed into a factionating column which is hottest at the bottom and coolest at the top. This means ~~hydrocarbons will continue~~ the gaseous hydrocarbons will rise until the temperature reaches the boiling point, causing them to ~~d~~ condense and collect in the trays. This means ~~crud~~ boiling point is used to seperate crude oil into fractions.

There is nothing creditworthy in the first sentence. Marking points 1 and 2 are gained in the second sentence. The student then goes on to describe the temperature gradient on line 5: '… hottest at the bottom, and coolest at the top' for marking point 3. The description of the gaseous hydrocarbons condensing their boiling points is sufficient for marking point 4.

01.4 Most students correctly balanced the cracking equation.

01.5 Students find the recall of chemical tests challenging, with fewer than half of students gaining both marks on the test for an alkene.

01.6 Fewer than 20% of students applied their knowledge from paper 1 and the scaffolding provided to correctly identify the structure as a polymer, with the mark scheme also allowing hydrocarbon as an answer.

Question 2 (standard demand)

02.1 This question was well attempted overall with very few blank responses. Many students were able to list some of the key points necessary for a valid result.

To reach Level 2, three key steps, or two with control variables, were required. To achieve Level 3 marks, all key steps and control variables were needed.

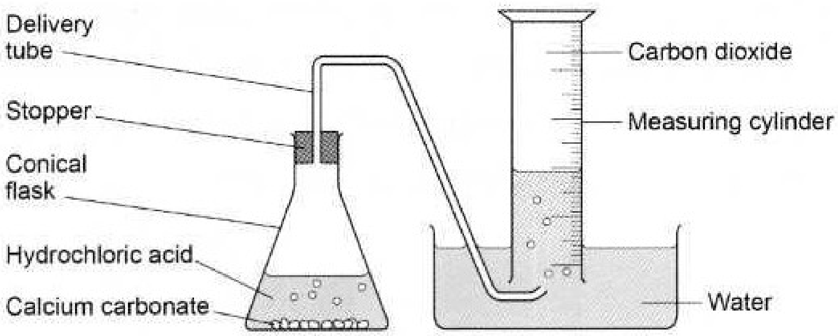
The two most common steps identified were adding the hydrochloric acid to the calcium carbonate in the conical flask and attaching the stopper and delivery tube. Many students could not then access Level 3 as they often referred to 'counting the bubbles of gas' or to 'reading the volume when the reaction had finished', both of which would not allow a valid result to be obtained. Another common response was to 'repeat the experiment changing the mass of calcium carbonate' instead of using different-sized pieces with the same mass. This once again limited the response to Level 2, even if control variables were identified.

A significant number of students did identify one or more control variables, but only listed one or two key steps, again limiting their responses to Level 2. Only a minority of students were able to obtain 6 marks.

0 7 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 6 shows the apparatus.

Figure 6



Describe a method the student could use to produce valid results.

[6 marks]

1.) Measure the mass of the calcium carbonate

2.) Add 50 cm^3 of hydrochloric acid into the conical flask and pall the ~~delivery~~ stopper over to trap the gasses in.

3.) connect the delivery tube to the water so that the gases can enter it.

4.) Measure the ~~amount of tar particle size~~ amount of carbon dioxide.

5.) ~~Also measure the amount of Repeat the experi~~ Record the results of carbon dioxide and how much calcium carbonate was used.

6.) Repeat steps 1-5 ~~but~~ with different masses of calcium

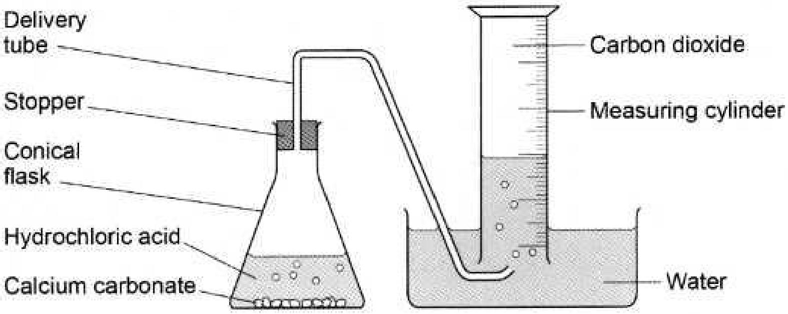
Turn over ▶

This student (from a Foundation tier paper) has achieved the first two key steps; however, they have not described what they are going to measure or change in the repeats to achieve the other key steps. The student has specified 50 cm^3 of hydrochloric acid and done repeats (of something) so that they have given a control variable. This would therefore just place this script into Level 2 and 3 marks are awarded.

0 2 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



Describe a method the student could use to produce valid results.

[6 marks]

- Use a balance to ~~find out the m~~ make sure your using the correct mass of calcium carbonate
- then place the calcium carbonate into the hydrochloric acid and place the stopper with the delivery tube on very quickly.
- record the amount of carbon dioxide in the measuring cylinder every 30 seconds ~~repeat this~~ until the calcium carbonate stops bubbling.
- repeat this method but with bigger particle size of calcium carbonate but they have to be the same mass as the smaller particles.

In this response from a Higher tier paper the student has suggested that the ‘correct mass’ of calcium carbonate should be used in the first bullet point. This is insufficient for a control variable, but in the final bullet point the ‘same mass’ has been identified, so there is one control variable here. The first two key steps are identified in the second bullet point. Key steps 3 and 4 are given in the third bullet point. ‘Amount’ would not be acceptable in a points-based mark scheme, but this response should be marked holistically as it is an extended response. There is no explicit mention of starting a stopwatch; however, it is implied in the statement ‘every 30 seconds.’ The final bullet point gives the repeats with a different particle size and one control variable.

Therefore, there are all five key steps, and one control variable so this is a Level 3 response and is awarded 5 marks. An additional control variable is needed for 6 marks.

02.2 The vast majority of students on this tier scored some marks for this question, with marking points 1 and 2 being more commonly awarded.

A significant number of students still confuse 'number of collisions' with 'frequency of collisions' and there were many responses that simply stated 'there would be more collisions between particles' which was not creditworthy for marking point 3.

0 2 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

Increasing the temprature will increase the rate of reaction because an increased temprature will give the particles more energy meaning they will be moving faster meaning more collisions occuring.

0 2 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

When the temperature increases the particles have more energy and move around. Because of this the particles collide more frequently with each other, resulting in the rate of reaction increasing

The first student clearly gains marking points 1 and 2 in the first two lines. However, they only write about more collisions rather than more frequent collisions, so the response is insufficient for marking point 3.

The second answer is not structured as in the mark scheme; however, it covers each of the marking points clearly and gains all 3 marks.

02.3 A large majority of students gained marking point 1; however, fewer than a third gained the second mark. Many students spent time explaining how a catalyst worked rather than answering the question that was asked. It is important that students understand command words so that they do not waste time in examinations with unnecessary working.

02.4 The majority of students answered this question correctly. The most common incorrect response was simply ‘biological catalyst’.

Question 3 (standard/high & high demand)

03.1 This question was answered well by most students. There was excellent recall about ‘plankton’ and the subsequent steps in the formation of crude oil. Some students missed out on full marks as they either omitted the correct time frame or offered a general response such as ‘many years’ or ‘a long time ago’.

A few students misread the question and described the extraction of and separation of crude oil (part of which had been required for question 01.3).

0 3 . 1 Describe how crude oil was formed.

[4 marks]

~~crude oil formed millions of years ago~~
crude oils has formed over millions of years as Plankton fell to the ocean floor after death and fossilised, trapping with them pollutant gases.

0 3 . 1 Describe how crude oil was formed.

[4 marks]

Crude oil was formed through ancient biomass, such as plankton, that was buried under mud for millions of years and due to extreme heat and pressure it turned into crude oil.

The first student gained 2 marks for the time scale and plankton dying.

The second student has given a very clear, concise response to the question scoring all 4 marks.

03.2 Very few students were able to achieve both marks on this question as the identification of sulfur as an impurity in (fossil) fuels was rarely seen. However, more students were able to successfully describe the oxidation of the sulfur to form sulfur dioxide.

03.3 Most students were able to give one problem. Acid rain was most often given as the initial creditworthy response. Those students that did not achieve the second marking point (for respiratory issues or asthma) often offered generalisations such as ‘breathing difficulties’, ‘lung cancer’, which was insufficient to gain credit.

03.4 More than 50% of students gained 1 mark. The link between carbon monoxide and incomplete combustion was regularly seen, although some students had difficulty in describing what exactly was being burnt, with many stating that it was the carbon monoxide in the fuel that was undergoing combustion. There were several excellent descriptions of carbon monoxide, its properties, its dangers and how it affects the human body, but this was not what was asked for in the question and these gained no marks.

03.5 This high-demand AO2 question proved to be the most challenging on the paper, with over 90% not receiving any credit. Many students could not give the formula for nitrogen gas and a significant proportion could not write the formulae of carbon monoxide or carbon dioxide. Students who knew the formulae could generally successfully balance the equation.

Question 4 (standard/high demand)

04.1 Although about 40% of students gained 1 or more marks it was rare to see the two marking points together; a tenth of students gained 2 marks. Many students simply repeated the question by stating the red ink did not move: the phrase ‘with the solvent’ was conspicuous by its absence. Insoluble was the most often seen correct answer. Incorrect explanations included ‘too heavy’, ‘too strong’, ‘a pure colour’, ‘unreactive’, ‘least soluble’ and ‘not soluble enough’.

04.2 This question was well answered, with just over half of students gaining full marks. The most challenging step was the correct rearrangement of the equation.

04.3 Fewer than 1 in 5 students correctly answered this question. Very few students referred to the colours having the same R_f value. Several students answered in terms of primary colours; or of one of the inks being insoluble, when of course it had to be two of the inks, not just one. Many answers related simply to the diagram rather than showing an understanding of the principles of chromatography.

04.4 Over 80% of students were not able to gain a mark for this question. There was a wide variety of suggestions for changes in the experiment: almost everything in the experiment other than the solvent. Often specificity of language stopped students gaining the mark, as ‘stronger solvent’ ‘weaker solvent’, ‘more solvent’ and ‘less solvent’ were common, none of which were creditworthy. The ink, the colour of paper, leave for longer and use longer paper were also common incorrect responses.

Question 5 (standard/high & high demand)

05.1 Three-quarters of students correctly responded that the energy change in the backwards reaction was equal to the energy change in the forward reaction.

05.2 Half of students identified the correct equilibrium shift.

05.3 The multiple-choice questions at the beginning of question 5 become progressively harder, testing the students' understanding of Le Châtelier's principle. Fewer than half of all students correctly answered this question on the effect of pressure on the equilibrium.

05.4 Making the link from the stem that energy is released to the reaction being exothermic, and consequently the effect that a temperature change would have made on the position of this equilibrium, made this the most difficult of these multiple-choice questions. Fewer than 40% of students selected the correct answer.

05.5 Fewer than a third of students correctly gave the effect of a catalyst on equilibrium position for 1 mark. This was a high demand question and the small number of students who gained the second mark reflected this.

Many students had the same misconception that a catalyst only speeds up the forwards reaction. There were two common answers following this misconception: either that this meant the equilibrium would shift right as the forwards reaction had been sped up or that the equilibrium would therefore shift to the left to oppose this.

05.6 Most students were able to gain 1 mark, for the correct time. Common incorrect responses were 200 and 82.5 (seconds). If students put 82.5 then they had the misconception that the equilibrium was reached when the lines crossed and so were prevented from getting any further marks. Students often referred to equilibrium being where the moles were equal at 82.5 seconds.

The mark scheme identified where equilibrium was reached, how the graph showed this and what the graph meant in terms of moles of the three gases.

For the second marking point, a clear description of the line flattening out, not just straightening, was required as 'straightening' could be vertical.

The third marking point is for the number of *moles* not changing. Some students stated that the reaction had stopped, meaning that they could not be awarded the third marking point. Equally, if a student stated that the number of moles was equal, the mark could not be given.

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation All the lines go straight to show that the ~~mole~~ number of moles is not changing, ~~and the reaction is ready~~ meaning the reaction has reached equilibrium.

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation This is where the line flattens out on the graph. The reaction has taken place and reached equilibrium because the number of moles of each gas is not changing, so therefore the reaction is no longer occuring.

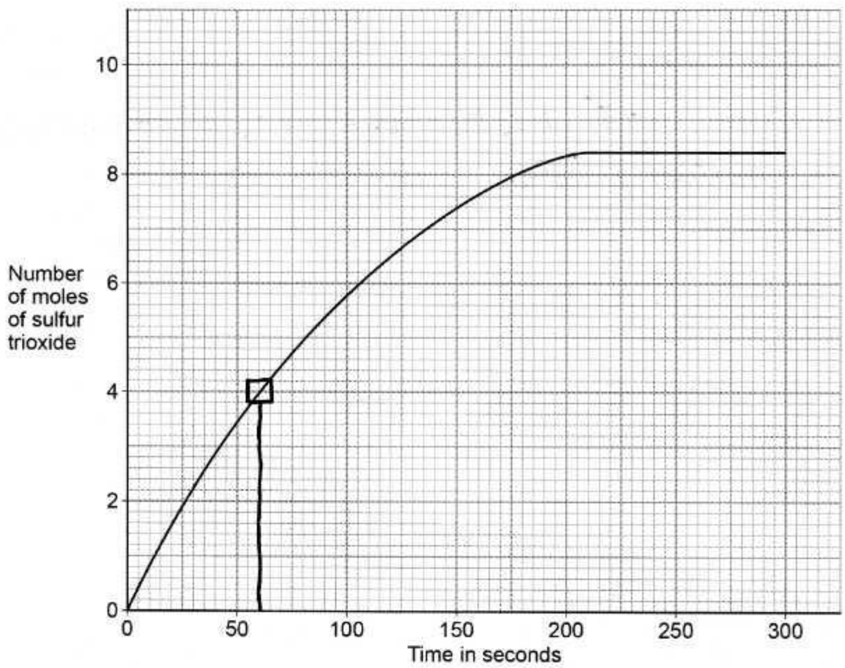
In the first response the student gains the mark for the time, but the 'lines go straight' is insufficient for marking point 2. Marking point 3 is given for the number of moles not changing.

The second response gains marking point 1 for a correct time. Marking point 2 is also given for the '… line flattens out …'. The student would have been given the third marking point for '… the number of moles of each gas is not changing …'; however, this mark cannot be awarded as the student goes on to state that the '… reaction is no longer occurring'.

05.7 It is evident that students are becoming more familiar with drawing gradients to calculate rates, with a third of students gaining full marks on this high-demand calculation. It should be noted that students who do not draw a tangent cannot gain any marks since the fundamental chemical idea is not known and understood.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

2÷50 = 0.04 mol/s

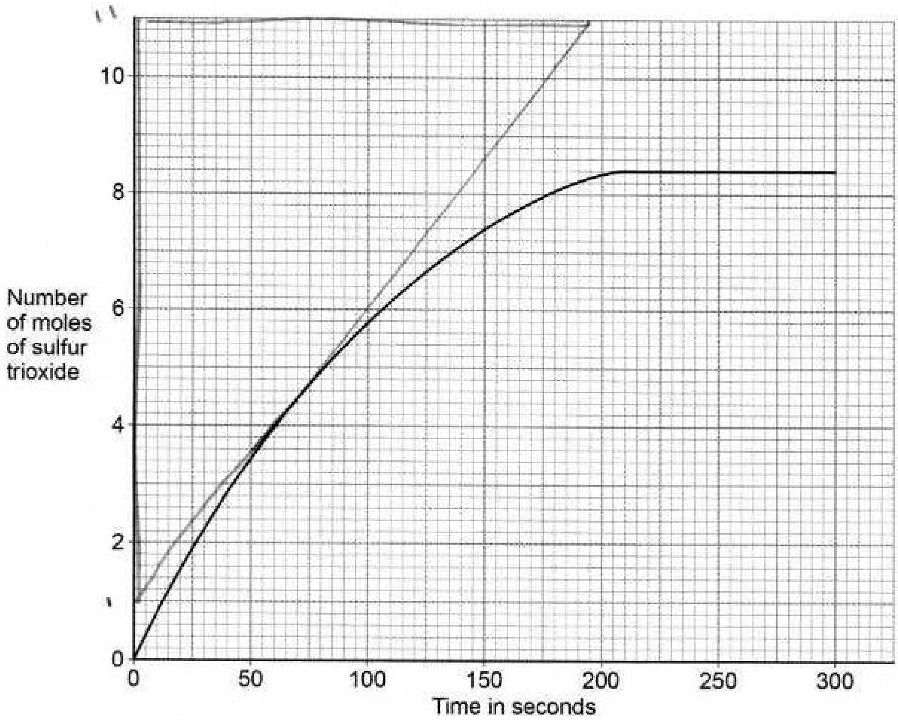
Rate = 0.04 mol/s

The student needs to first draw a tangent at 60 s in order to be able to calculate the rate. Here, no tangent has been drawn, so no marks are awarded.

The most common errors were misreading the *x*-step and/or the *y*-step. Progress could still be made in the calculation if it was clear that the values had come from a tangent and had been used correctly. Substitution into the equation upside down meant that neither marking point 3 nor marking point 4 could be given.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

11 − 1 = 10 $\frac{10}{195}$ = ~~[crossed out]~~ 0.051282

195 − 0 = 195

Rate = ~~[crossed out]~~ 0.051282 mol/s

This student has made a good attempt at drawing the tangent at 60 s, so marking point 1 can be awarded. They have drawn a triangle on the graph and substituted correct values for the *y*-step and the *x*-step into the expression (10 ÷ 195), which they have then correctly evaluated. The recurring dots can be ignored as there was no significant figures mark for this question. All 4 marks are awarded.

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.

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

[3 marks]

plants are groown on a soil which has a high consentration of low grade ores. As the plant grows the metal compounds are absorbed ~~tht~~ through the plants roots ~~by~~ diffusion and active transport and ~~travel~~ 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.

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 = 34800 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.

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

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