



GCSE

Combined Science: Synergy

8465/3H Paper 3 Physical Sciences Higher Tier

Report on the examination

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General comments

There were 10 questions on this paper. Questions 1, 4, 6 and 9 covered physics content and questions 2, 3, 5, 7, 8 and 10 covered chemistry content. The questions are designed to increase from standard demand to high demand through the paper.

This paper also contained items targeting mathematical and practical skills. Most students showed the method of their working when completing calculations. It can be difficult for examiners to credit responses if they cannot clearly follow the method the student has used. Even simple calculations that are easily done on a calculator should be included. Access to the Physics Equations Sheet seemed to benefit many students. Many students seemed unfamiliar with laboratory techniques and equipment. Two Required Practical Activities were targeted in this paper, RPA16 and RPA21.

In general students should be reminded to use correct technical language in responses and to take care to write formulae accurately. Ideally students should use full sentences when writing a description or an explanation. Whilst diagrams can sometimes support a written response, they are unlikely to be creditworthy without being clearly labelled.

Levels of 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, however, is based on their attainment across the qualification as a whole, not just on questions that may have been targeted at the level at which they are working.

Questions 1, 2 and 3 are common with questions 8, 9 and 10 on the Foundation tier. These questions are identical with each other and are targeted at standard demand.

Question 1 (standard demand)

- 01.1** Students found this multiple-choice question very easy. Most students successfully used the Physics Equations Sheet to identify the correct equation linking distance, speed and time.
- 01.2** Students found this calculation easy, and more than 90% of students correctly calculated the mean speed of the rugby player.

- 01.3** Students found this multiple-choice question very easy. Almost every student successfully used the Physics Equations Sheet to identify the correct equation linking acceleration, change in velocity and time.
- 01.4** About a quarter of students scored full marks for this calculation of the deceleration of the rugby player. Almost two thirds of students scored just two marks, because their conversion of time was incorrect or not attempted. Some students incorrectly substituted into the equation and about one in ten students did not score a mark.
- 01.5** Students found this multiple-choice question very easy. Almost every student successfully used the Physics Equations Sheet to identify the correct equation linking acceleration, mass and resultant force.
- 01.6** Over 40% of students scored full marks for this calculation of resultant force. Many students did not convert mass from g to kg but scored two marks by substituting into the equation the unconverted value for mass and correctly evaluating this. However, some students incorrectly substituted into the equation, gaining no marks.
- 01.7** Only about one in three students gave a creditworthy response which included the idea of immediate action being taken to mitigate a player's possible head injury. Students were told that the team doctor was automatically alerted to a deceleration of 540 m/s^2 or more. Some students simply repeated this but did not suggest what action the doctor might take. Some referred to resultant force but again did not suggest the action that should be taken. Others suggested that a player might seek medical attention but did not indicate when. This did not address the need for a timely response in mitigating head injuries to rugby players. Some students suggested that data could be collected to help rugby players improve their performance or for research purposes. These responses were not creditworthy as they missed the essential safety feature of the new mouthguard. Some students ignored the data transfer feature altogether and instead focussed on other protective advantages of a mouthguard. These included the advantages of a mouthguard being new or the protection that wearing a mouthguard would give to teeth.

Question 2 (standard demand)

- 02.1** Many students did not understand this question, and just under a quarter of students gave a creditworthy response. Many students focussed on describing gold or restating the stem information. Common responses included: gold is pure, an element, not a compound, a metal, a solid, or is an ore in the Earth's crust. Stating that gold does not form compounds does not explain why. Stating that gold is not very reactive or has low reactivity is not equivalent to gold is unreactive. Some students stated that gold did not react with a specific element such as oxygen. However, this was insufficient for the mark as it does not convey the idea that gold is unreactive in general.
- 02.2** Whilst about a half of students identified that carbon is the substance oxidised, only about one fifth of students went on to state the reason that this because oxygen is **gained** by carbon in the reaction. Responses such as oxygen reacts with carbon or is

added to carbon were insufficient. Other chemically correct comments in responses were disregarded.

- 02.3** Less than half of students gave a creditworthy response comparing the reactivity of aluminium and carbon.
- 02.4** This question was not understood well, with only a about 30% of students scoring any marks. This was mostly for stating that energy was required to melt the mixture or the aluminium oxide. Very few scored the second mark, and it was rare for a student to recognise that the production of an electrical current for electrolysis required energy. Many students gave responses referring to the strength of bonding or the need to separate the ions, without considering what this might mean practically.
- 02.5** Less than half of students scored full marks for this calculation of a percentage decrease. About a fifth of students did not produce any creditworthy working. However, most students picked up some marks for correct working, most commonly the first step. A majority of students took the main approach. Some students took the alternative approach, but many only calculated the percentage energy for recycled aluminium. Most students were able to correctly round their calculated answer and so gained the final mark. A few students attempted to unnecessarily convert MJ to J, and these attempts usually resulted in a power of ten error.

Question 3 (standard demand)

- 03.1** Just over half of students successfully completed this ratio calculation, including correctly converting either the diameter or the length of the nanotube. However, many students' attempts at conversion were incorrect. Some students tried converting both diameter and length, most commonly by multiplying both by 10^6 . In this case, the correct conversion of length was contradicted by an incorrect conversion of diameter. Incorrect or no conversion still allowed access to the ratio calculation. Some students calculated the ratio of diameter to length which was not creditworthy.
- 03.2** This question separated out students well. Directly comparing features of graphite and diamond was required to access Level 2 and about a third of students did so. Some very good responses could not be awarded full marks due to the presence of a serious chemical error. Serious errors included referring to weak covalent bonds, incorrect forms of bonding or an incorrect number of bonds per atom. Some students wrote excellent responses which demonstrated detailed knowledge and understanding with about one in ten students scoring full marks. However, many responses to this item demonstrated a substantial lack of knowledge and understanding of the structure and bonding of diamond and graphite. Roughly a fifth of students did not produce any creditworthy content, simply writing descriptions of the diagrams of diamond and graphite provided. Many students referred to properties of diamond and graphite which was not creditworthy as the question was about structure and bonding. In addition, when attempting to explain these properties, some students demonstrated misunderstandings. A common suggestion was that diamond is harder than graphite

because the (covalent) bonds in diamond are stronger than the (covalent) bonds in graphite.

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

- 04.1** Just over a half of students successfully calculated the potential difference across each cell in the battery in this standard demand item.
- 04.2** Less than a fifth of students realised that the resistance of the LDR must be the same as that of the fixed resistor, and only a very few went on to explain correctly that this is because the potential difference is shared equally between the LDR and the resistor. Most students incorrectly tried to apply $V = IR$ to the problem.
- 04.3** Most students struggled with this high demand item and none scored full marks. Very few students recalled that the resistance of an LDR decreases as light intensity increases. Despite this, this standard/high demand mark was still the most common mark awarded. Even fewer students realised that as a result, current in the circuit would increase. Almost no students appreciated that the potential difference across the 2000 Ω resistor would increase as a result. A common suggestion was that the resistance of the LDR would increase when light was shone on it. Students then argued that the current would stay the same so the potential difference (shown on the voltmeter) would decrease. Only about 15% students gained any credit on this item, and very few scored two marks.
- 04.4** Just over a half of students stated that the reading on the voltmeter would be 6.0 V. Approximately a fifth of students explained that the voltmeter displayed the potential difference across the battery (or the potential difference was unaffected). A few students did not score the second mark due to ambiguous or unclear phrasing in their response. A common incorrect response was to repeat the information from the stem that the circuit had been set up incorrectly.

Question 5 (standard and standard/high demand)

- 05.1** Just under three in ten students correctly stated that when silver ions are reduced, they gain electrons. Occasionally reference to just silver, rather than silver ions, prevented the award of the mark, as did references to oxygen.
- 05.2** About a quarter of students added the correct symbols for copper and silver to the ionic equation. However, very few went on to successfully balance the equation. Many students erroneously added extra ions or electrons to the equation. Occasionally, marks could not be awarded because symbols were written incorrectly. The symbol for copper, Cu, must include an upper-case C which is discernibly taller than the lower-case u.
- 05.3** Students found this standard demand multiple choice question difficult. Less than a third of students identified $\text{Cu}(\text{NO}_3)_2$ as the correct formula for copper. The most popular

distractor was Cu_2NO_3 and CuNO_3 was also frequently chosen. The relatively even distribution of responses to this item suggested that writing ionic formulae including complex ions is not understood well by most students.

- 05.4** Just under two fifths of students completed the table showing the colours of the resultant solutions formed correctly. Many students did not appreciate that when a more reactive metal is added in excess, the displacement reaction goes to completion. As a result, students did not realise that the solution colour will change to that of the resultant metal nitrate solution. A wide range of colours were suggested by students, but only the colours given in the question were accepted. Some students were able to score one mark by using a symmetrical pattern of colours in the table. A few students did not write colours in boxes for the result of adding metals to corresponding metal nitrate solutions. In these cases, if students indicated no reaction and correctly completed the rest of the table, a compensation mark was given.
- 05.5** Less than one in ten students were able to explain how copper conducts electricity completely correctly. Over a half of students were able to score at least one mark, usually for stating that copper has delocalised electrons, and about a quarter of students scored at least two marks. Rather than electrons already being charged, a few students suggested that electrons become charged, which was not accepted. Some students did not describe electrons as moving through the metal, in other words, flowing in one direction. Terms such moving throughout or around do not suggest directional movement and so are not sufficient for the mark.
- 05.6** Most students struggled with this item and less than one in twenty students got it completely correct. Just under a quarter of students scored a mark. This was mainly either for stating that alloys contain different sized atoms or for stating that layers slide less easily. Many students struggled to express the concept of the distortion of layers in a creditworthy way. Terms such as irregular structures or uneven lines were insufficient for the mark. Referring erroneously to molecules or to differently shaped atoms or to intermolecular forces prevented the award of marks to some responses. Atoms or layers moving was considered insufficient for the idea of sliding in the last mark point.

Question 6 (standard, standard/high, and high demand)

- 06.1** Most students selected the correct equation to use from the Physics Equations Sheet. However, over a half of students struggled to substitute values into the equation correctly. Some students included the whole race distance of 400 m rather than just the distance the car accelerated in. Some students misinterpreted the value of acceleration, 25 m/s^2 , as v^2 . About a third of students did successfully complete the whole calculation and scored full marks.
- 06.2** Most students struggled to write an explanation of how opening the parachute affects the deceleration of the car. Almost half of students scored one mark, mostly by stating that when the parachute opens, air resistance increases. Some students went on to explain that this caused deceleration to decrease and so scored a second mark.

However, many students did not express this point, commonly referring to the car slowing down or deceleration being faster. Many students mentioned changes in various forces acting on the car. However few students explained that the increase in deceleration was due to the increase in resultant force acting on the car. As a result, very few students scored full marks on this item.

- 06.3** To determine the deceleration of the car, students had to draw a tangent on the curve. Many students did not recognise that a tangent was required, and some did not draw a creditworthy tangent. As a result, only about one fifth of students scored any marks on this high demand question. Students could score marks for determining a deceleration consistent with a tangent drawn at the wrong time on the curve. If multiple tangents were drawn, the one consistent with their calculation was marked. Most students who drew a creditworthy tangent went on to successfully determine a deceleration consistent with their tangent. Full marks were scored by just over 10% of students overall in this high demand question.

Question 7 (standard and standard/high demand)

- 07.1** This standard demand item tested recall of correct technical terms used on reaction profiles. It was answered less successfully, with very few students scoring full marks. Over two thirds of students scored at least one mark, and approximately a third scored two marks. The most common mark awarded was for the product label. The activation energy label was also frequently correct. However, very few students successfully labelled the overall energy change. Referring simply to energy change or to terms such as energy loss or energy release was insufficient for the mark.
- 07.2** As a reaction profile shows energy changes within a reaction, exothermic was the only acceptable answer for the type of reaction represented by the reaction profile. Nearly two thirds of students answered this standard demand question correctly.
- 07.3** This standard/high demand question required correct use of precise technical language to score marks. Students were asked to describe what happens when a lithium atom reacts with a chlorine atom. To score the first two-mark points, loss or gain of electrons from **atoms** was required. However, many students referred to lithium and chlorine in bulk, rather than to individual atoms of lithium and chlorine. In this case, a compensation mark was available, which benefited many students. The third mark was awarded for referring to the transfer of one electron. The direction of transfer was irrelevant as this was tested in the first two-mark points. However, any reference to the sharing of electrons prevented the award of the first three marks as this is covalent bonding. The last mark point was for the formation of the ions. These had to be referred to by the correct names (chloride ions, not chlorine ions) or by correctly written symbols. Stating that lithium forms positive ions and chlorine forms negative ions was acceptable but just stating that lithium becomes positive and chlorine becomes negative was insufficient for the mark. References to incorrect forms of bonding also prevented the award of the final mark. The majority of students scored at least two marks, mostly for

stating that lithium loses one electron to chlorine. Slightly more than a fifth of students scored three marks, but only about 5% of students scored full marks.

- 07.4** Just over four in five students correctly identified that reactivity increases going down Group 1. However, only about a third of students were able to score any marks for explaining why. Less than 10% of students scored full marks for their explanation. Many students correctly stated that the distance between the outer electron or shell and the nucleus increased going down the group. However, some students did not refer to the **outer** electron. Referring to an increasing number of shells was only creditworthy if it was clear that it is atoms that have more shells. Some students referred to the number of outer shells increasing, which is incorrect as there is only one outer shell. Very few students managed to express the concept of less attraction between the nucleus and the outer electron clearly enough. Simply referring to electrostatic forces was insufficient to secure the mark as these forces could be repulsive. Many students who refer to shells went on to refer to shielding. However, it needed to be clear that the shielding is between the nucleus and the outer electron. The final mark point for the electron being more easily lost was more commonly awarded.

Question 8 (standard and high demand)

- 08.1** Only about one in five students recalled that the reason graphite electrodes are used in this required practical is because they are inert.
- 08.2** Students found this standard demand multiple choice question difficult. Only about a third of students correctly deduced the other substance produced in the electrolysis of sodium chloride solution.
- 08.3** Students found this item difficult, with a very low proportion scoring any marks for writing a correctly balanced half equation. Many students attempted the equation but were clearly confused. Some students did not realise that chlorine gas consists of diatomic molecules, not just chlorine atoms. A few students did not add a negative charge to the electrons, so their symbol was incorrect. Nearly one in ten students did not attempt the item.
- 08.4** Most students struggled with this high demand item. Fewer than one in six students gained any credit, usually for stating that hydrogen is less reactive than sodium. Some students realised that hydrogen ions were present in the aqueous solution. However, very few explained that the hydrogen ions were produced from the breakdown of water molecules. Many students wrote that positive hydrogen ions are attracted to the negative electrode. This is correct but did not go far enough to gain credit. Some students correctly stated that the hydrogen ions gain electrons, but almost none stated that hydrogen molecules were formed. Nearly 20% of students did not attempt the item.

Question 9 (standard, standard/high, and high demand)

- 09.1** Some students showed understanding that there was some kind of force acting on the balance when the circuit was switched on. However, only about one in ten students was able to describe this in a creditworthy way. Many students simply referred to increasing weight or pressure on the balance. Some students suggested that the force of gravity was increased. Some students got confused and stated that the downwards force acted on the wire, not the magnet or the balance. Some students did state that a force acted on the balance due to the upwards force on the wire. However, they did not state the direction of the force on the balance. Only a handful of students went on to state that the downward force was due to Newton's 3rd Law and so scored the second mark.
- 09.2** Two thirds of students gained this standard demand mark, mostly for suggesting that the current in the wire should be increased. Increasing the potential difference was accepted as a way of increasing the current. Positioning the magnets closer together was accepted as equivalent to using stronger magnets. However, using bigger or more magnets was not sufficient for the mark. Some students suggested changes to the wire such as increasing its length or using a coil of wire. However, the wire was a fixed part of the apparatus and so changes to it were disregarded.
- 09.3** Approximately a fifth of students successfully used Fleming's left-hand rule to determine the magnetic poles in the apparatus. Most students simply got the north and south poles the wrong way around. However, some students suggested incorrect terms such as positive and negative instead.
- 09.4** Most students performed very well on this high demand physics calculation. Nearly two in three students scored five of the six marks. For the first step, most students successfully used the Physics Equations Sheet to identify $V = IR$. However, some students struggled with using values in standard form to calculate the current correctly. The calculated value of current was then substituted into $F = BIl$ and the force exerted on the wire was calculated. If $V = IR$ was not used to calculate current, marks could not be awarded for this subsequent calculation. Most students did not realise they should convert the length of the wire for use in $F = BIl$. Credit could still be scored by using the unconverted length. Those students that did convert length were generally one of the approximately one in ten students who scored full marks.

Question 10 (standard/high and high demand)

- 10.1** A very low proportion of students scored full marks on this standard/high demand question. Over half of all students scored zero marks, and about one in ten students did not attempt the question. The most commonly scored mark was for the idea of a spherical or ball shaped structure. Very few stated that the structure was hollow. Some students described hexagonal rings by stating that each carbon is bonded to five other carbons, but this is incorrect. Many students gave a number of bonds per atom, but this was frequently incorrect. Many students also referred to covalent bonding, which was not creditworthy as the question was about structure rather than bonding. Likewise, references to properties were ignored. However, the presence of delocalised electrons was accepted as a structural feature. A few students attempted to draw parts of the structure, but diagrams were usually unlabelled and rarely creditworthy. Some students suggested incorrect structural features such as cylindrical forms or layers. A few suggested that a buckminsterfullerene was a hydrocarbon. Major errors such as incorrect forms of bonding prevented the award of full marks.
- 10.2** Most students were able to gain at least one mark on this high demand extended response chemistry calculation. This was usually for determining the M_r of C_{60} . About three in ten students gained at least three marks. This suggested that they had completed at least one further step in the calculation correctly. Often, this was to determine the number of moles of C_{60} . Occasionally, an incorrectly determined number of moles was used to correctly determine the number of C_{60} molecules in the last step. About a sixth of students got the calculation completely correct and scored full marks. However, some students produced a mathematically correct answer which was chemically incorrect and so not creditworthy. This occurred if the Avogadro constant was multiplied by the M_r of C_{60} and then divided by the mass. In this case, only one mark was scored, for the M_r of C_{60} . Likewise, multiplying the Avogadro constant by the mass and then dividing by the A_r of carbon was also not creditworthy. The alternative approach was much less commonly used and very few students scored full marks using the alternative approach. Slightly more than 10% of students did not attempt the question.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the [Results Statistics](#) page of the AQA Website.