

PHYSICS

Paper 5054/11
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	B	11	B	21	A	31	C
2	A	12	D	22	C	32	C
3	C	13	A	23	C	33	C
4	B	14	C	24	B	34	B
5	C	15	B	25	D	35	C
6	D	16	C	26	A	36	B
7	B	17	B	27	D	37	A
8	B	18	B	28	A	38	C
9	A	19	C	29	C	39	C
10	A	20	C	30	B	40	C

General comments

Candidates need to read the stem of a question carefully and consider all of the options before making a choice. Sometimes an incorrect answer has the appearance of being correct, using recognisable expressions or values that seem familiar to the candidate; candidates need to read all of the options to determine which best fits the question asked.

The incorrect options for a question are selected to appear plausible or to correspond to common misunderstandings and errors and candidates should always be aware that obtaining one of the options listed in a calculation is not always a sign of accuracy.

Comments on specific questions

Question 4

This question concerns the average speed of the student and so the relative direction between the first part of the journey and the second part is not important. It is the distance covered that was significant. Most candidates realised this and the correct option, **B**, was the most commonly selected response. The simple mean of the two speeds, option **C**, was also quite popular and so was option **D**. Option **D** came from the vector addition of the two original velocities. However, these two velocities do not occur at the same time and so adding them in this way does not lead to any relevant velocity.

Question 5

All four options include the quantity 'time' as the variable that was plotted on one of the axes. The car has a constant acceleration and so a speed-time graph and a time-speed graph would both be straight lines, and so candidates could eliminate these options. The distance-time graph for the car is a curve of increasing gradient, whereas a time-distance curve has a decreasing gradient. The question then became a matter of making sure that time was on the x-axis.

Question 6

Stronger candidates gave the correct answer here. The diagram seemed to have caused little misunderstanding and very few candidates chose option **B** which corresponds to a fall of an initially decreasing speed and an increasing final speed. Option **C** was most frequently selected, even though the absence of air resistance is referred to in the question.

Question 13

Many candidates managed to work their way through the necessary calculations and got close to the final answer. Both option **A** and option **B** were very widely selected. Option **B** is the distance of the 2.0 N weight from the pivot but this was not what was asked for. Many candidates worked through the more difficult parts of the question but did not complete the final subtraction.

Question 14

The correct option, option **C**, was most commonly selected but all the options were chosen by a significant number of candidates. This question assessed not only what was meant by the term 'centre of gravity', but also what its location depends on. Options **A** and **D** could be eliminated as they were both too far from the middle part of the object. Distinguishing between position **B** and **C** was more challenging. The object is wider lower down than it is further up and so the centre of gravity is likely to be lower down rather than further up. This suggests that position **C** is correct as it is below the halfway point whereas **B** is above it.

Question 15

The force on the trolley is equal to the rate at which its momentum changes and so the final momentum of trolley X needs to be determined. This can be done by applying the principle of the conservation of momentum to the collision. The two trolleys stick together and have the same final speed but they will each have a different value for their individual final momentums as they have different masses. The change in momentum of trolley X can therefore be calculated and consequently the rate of change of momentum of trolley X can also be calculated, supplying the value of the average force on the trolley during the collision. A very commonly selected incorrect answer was option **D**. This number was reached by adding together the magnitudes of the two original momentums and dividing this value by the time.

Question 19

Although the pressure on the base due to the liquid is dependent on the height h , the mass m is also dependent on h . As the density is not supplied in this question, the pressure has to be determined using m and so h is not needed in the expression asked for. Option **B** was by far the most commonly chosen answer and only a small minority gave the correct response, option **C**.

Question 21

The correct option, **A**, was frequently given but both options **B** and **C** attracted some candidates. The reason for the second reduction in volume being less than the initial reduction is dependent on the inverse proportionality between the pressure and the volume of the gas.

Question 22

Some stronger candidates drew a horizontal line and marked on it the melting and boiling temperatures. When the two other temperatures were then marked on the line, it was easier to see that in this case the substance is in the liquid state at both of the temperatures supplied. The correct option was the most commonly selected but the incorrect option **A** was also chosen fairly frequently.

Question 33

Candidates needed to note that one of the cells that forms the battery is reversed and effectively has a negative electromotive force. The total electromotive force that is registered on the voltmeter is now 3.0 V as the negative electromotive force cancels the electromotive force due to one of the other cells. This leaves an electromotive force due to the two remaining cells. Candidates needed to be aware that in series, both potential differences and electromotive forces add together arithmetically.

Question 34

Many candidates gave the correct answer. More candidates selected the incorrect option **D** than the correct option, **B**. Candidates needed to realise that current I_1 and current I_2 are identical and are both equal to current I_0 .

Question 38

The precise meaning of the numbers R and Z needed to be properly understood. The correct option was the most commonly chosen option, but it was closely followed by option **D**. Option **D** was probably chosen by candidates who did not immediately realise that the number R includes the number Z , as R corresponds to the number of neutrons and protons whereas Z is the number of protons.

PHYSICS

Paper 5054/12
Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	C	11	A	21	A	31	D
2	A	12	C	22	C	32	B
3	A	13	C	23	D	33	A
4	B	14	C	24	A	34	D
5	A	15	D	25	C	35	D
6	D	16	C	26	B	36	A
7	D	17	C	27	D	37	D
8	A	18	B	28	A	38	C
9	C	19	C	29	D	39	C
10	A	20	B	30	C	40	C

General comments

Candidates need to read the stem of a question carefully and consider all of the options before making a choice. Sometimes an incorrect answer has the appearance of being correct, using recognisable expressions of values that seem familiar to the candidate; candidates need to read all of the options to eliminate these incorrect answers.

The incorrect options for a question are selected to appear plausible or to correspond to common misunderstandings and errors and candidates should always be aware that obtaining one of the options listed in a calculation is not always a sign of accuracy

Question 2 and **Question 32** were very well answered. They were both fairly direct questions that tested an understanding of vectors and energy transfers. Other questions ranged in difficulty with some being more challenging for candidates than others.

Comments on specific questions

Question 4

Only stronger candidates answered this correctly. Essentially, the question assesses the meaning of the term 'magnitude' when used to describe a vector quantity. The most frequently selected answer was **A**. However, **A** is incorrect because in section Q the magnitude is increasing. The magnitude of a vector quantity is the absolute value of the quantity. Option **C** and the correct option, **B**, were chosen by a similar proportion of candidates.

Question 7

To answer this question, the mass in g needed to be expressed in kg and, the volume in cm^3 needed to be expressed in m^3 . This is not completely straightforward as there are two different conversion factors and there are several stages in the conversion where candidates can make an error. The correct option, **D**, was the second most commonly chosen option and many candidates chose option **A**. This option simply ignored the conversion of cm^3 to m^3 and gave an answer that would have been correct in kg/cm^3 .

Question 10

Stronger candidates answered this correctly. There are three forces on the rocket. When the rocket is moving upwards, the weight and air resistance act downwards and oppose the upward force on the rocket due to the engine. The resultant force is calculated by subtracting the sum of weight and the air resistance from the force due to the engine. It is the resultant force that causes the acceleration and therefore, it is the resultant force that has to be multiplied by the distance moved to calculate the work that is done in increasing the speed of the rocket.

Question 19

The question involves a few stages and candidates needed to know that ultrasound waves have frequencies that are greater than 20 000 Hz. The frequency is calculated using $f = v/\lambda$ and the value of λ substituted needs to be expressed in m rather than cm. The correct option was therefore **C**. This was chosen by more candidates than any other option, but a significant number of candidates selected option **A**.

Question 20

Almost all candidates selected either option **A** or option **B** but slightly more selected the incorrect option **A** rather than the key, option **B**. This indicated that most candidates knew that the angle of reflection is equal to the angle of incidence but that there was more uncertainty about the location of the angle of incidence.

Question 22

There are several stages here and although more candidates selected the correct option than any other, each of the incorrect options was chosen by a significant number of candidates.

Question 24

The key here was option **A** and many candidates gave this as their answer. However, many other candidates selected either option **C** or **D**. These two options are similar to look at except for the position of the nail. In both of these two final options, the switch is open and so the coil cannot be acting as a magnet.

Question 26

The options made it clear that the magnet rotates through 90° and so it is a case of determining the direction of rotation and what happens after the magnet has rotated. Effectively, the question is asking for the definition of the direction of a magnetic field in terms of the force that it exerts on an N pole and an S pole. Candidates who knew that the direction of a magnetic field is the direction of the force it exerts on an N pole were able to eliminate the options that corresponded to a clockwise direction of rotation and those who knew that the force exerted on the S pole is, in this case, equal to the force on the N pole, were able to deduce that the magnet stops moving after the rotation. However, option **D** was the most popular choice.

Question 28

This question assessed an understanding of the distinction between current and potential difference (or electromotive force). Most candidates selected an option in which the currents in the four resistors were equal although option **B** was chosen by a noticeable number of candidates. The most frequently selected option was option **D**, indicating some misunderstandings about combining resistors in series or how potential difference is allocated between the resistances in series.

Question 30

There were several stages to this question: the resistance of wire Y and its connection to wire X must to be deduced and then the dimensions of wire Y that led to the given total resistance value needs to be determined.

Eliminating the options where a series connection for the resistors is indicated is straightforward as a series connection cannot reduce the resistance from R to $R/2$. Even so, there were some candidates who selected option **B**.

To differentiate between the remaining (parallel) options, candidates needed to find the necessary resistance for Y so the total resistance of X and Y in parallel is $R/2$. The incorrect option **A** was the most commonly chosen option. It is possible that candidates were trying to find the dimensions of wire Y that gave it a resistance of $R/2$ alone rather than the value of Y that results in the arrangement of the two wires X and Y having a resistance of $R/2$.

Question 33

This is a question of deduction. Initially, Lenz's law can be used to deduce that the pole at end P is an N pole. However, the next stage involves two reversals: the magnet is leaving the coil, and the other end of the coil is being considered. Two reversals produce a result that is the same as the initial state and so option **A**, which suggests that in both cases an N pole is formed, is correct. Few candidates opted for option **D** but both option **B** and option **C** were more popular than the key.

Question 40

This question tested stellar evolution. The correct answer, option **C**, was more commonly chosen than any of the others but all options were chosen by a significant number of candidates.

PHYSICS

Paper 5054/21 Theory

Key messages

- To gain full credit, candidates should always give units, if required, when giving the final answer to numerical questions. They should also be encouraged to give answers to an appropriate number of significant figures (usually at least two), and for this reason, fractions are not accepted.
- A carefully drawn diagram can often show what candidates intend to convey much more accurately than just words. Whenever a diagram is asked for or suggested, candidates should draw it carefully and neatly and then label it so that its intention is clear.
- The number of marks shown and the amount of space provided give a guide to the length of the answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided.

General comments

Calculations were generally performed well and the majority of questions were accessible to all candidates. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it. Occasionally candidates who had performed a correct calculation either omitted to give a unit or gave an incorrect unit if the unit was not provided on the answer line.

Comments on specific questions

Question 1

- (a) The combined mass of the trolley and the block was calculated correctly by the majority of candidates. Occasionally, candidates who had calculated a correct value for the mass of the block, forgot to add the mass of the trolley to it to produce the combined mass as requested.
- (b) (i) Most candidates used $F = kx$ and substituted into the equation correctly to calculate the force exerted by the spring on the trolley.
- (ii) The work done by the spring on the trolley was usually calculated correctly. When the answer was incorrect, it was usually because candidates had used the incorrect equation.
- (iii) Fully correct answers to this more demanding question were rare. Many candidates realised and stated that the distance moved by the trolley per second increased as the speed of the trolley increased. Far fewer candidates continued to state that therefore the work done on the trolley per second increased, and consequently the power transferred to the trolley increased.

Question 2

- (a) (i) The initial gravitational potential energy of the ball was almost always calculated correctly.
- (ii) The calculation of the speed of the ball immediately before hitting the ground proved to be more challenging. Candidates who attempted to use the conservation of energy and equate the loss of gravitational potential energy to the gain in kinetic energy often had problems with the mathematics and forgot to find the square root of their calculated value of v^2 .
- (b) (i) Many candidates used the given assumption and calculated the maximum possible temperature increase of the ball if all of its kinetic energy was converted to internal energy upon impact with the ground. Many candidates did not recall the specific heat capacity equation correctly.

- (ii) Few candidates suggested a satisfactory reason as to why the actual temperature increase of the ball on impact with the ground may be smaller than the value they had calculated in the previous question. Very few candidates stated that some thermal energy is transferred to the ground upon impact or to the surrounding air.

Question 3

- (a) The mechanism of the part played by free electrons in the conduction of thermal energy in a metal was not well known. Only stronger candidates mentioned collisions between electrons and the vibrating particles of the metal and that the free electrons moved through the metal. Partial credit was available for candidates if they just mentioned free or delocalised electrons in their answers.
- (b) (i) The majority of candidates stated that the average speed of the particles in a gas increased as the temperature of the gas increased.
 - (ii) Few candidates were able to fully explain in terms of the particles of a gas why the pressure the gas exerts on the walls of the metal cylinder increases as the temperature of the gas increases. Most candidates knew that the molecules collided with each other/with the walls of the container. Fewer stated that the particles collided with the walls with greater force as the temperature increased and even fewer stated that the collisions with the wall would therefore be more frequent.
- (c) (i) Only the strongest candidates were able to explain why the pressure of the gas decreased when the gas expanded at constant temperature. The idea that the gas particles got further apart and as a consequence there were fewer collisions with the walls per second, resulting in a decrease of pressure, was rarely seen.
 - (ii) Only the strongest candidates answered this correctly. A small minority of candidates stated that the piston, after being released, would eventually stop moving when there was no resultant force on it. Few candidates were able to make the final step and state that this would happen when the pressure in the cylinder became equal to the (external) atmospheric pressure.

Question 4

- (a) Few candidates were able to complete the diagram and correctly show the paths of red light and violet light between the point of incidence of the white light on the left hand side of the prism and the screen placed on the other side of the prism. Diagrams showing the passage of the light through the prism were carelessly drawn, frequently without the use of a ruler. Although most candidates knew that refraction would occur on entry and exit, fewer candidates knew in which direction the light would bend.
- (b) Few candidates were able to correctly state what happens to the change in speed of the red light and the violet light as it passed from air into the glass block. Of those candidates who stated correctly that both red and violet light slow down on entering the prism only some went on to state that red light slowed down the least and so travelled more quickly than violet light in the glass.
- (c) (i) The majority of candidates correctly named the other five colours that appear between red and violet light on the screen. The order in which the colours appeared was usually correct.
 - (ii) Some candidates were able to correctly state how the frequency and the wavelength of the coloured light changes going from red to violet light. A common misconception was that the frequency of the light remained constant as the colour changed from red to violet.
- (d) Many candidates correctly stated that the region of the electromagnetic spectrum just beyond the red end of the visible spectrum is infrared.

Question 5

- (a) Candidates found this question challenging. Few candidates stated that ultrasound is transmitted by vibrating particles and that there are no particles in a vacuum. Most candidates simply restated the information from the question and said that sound cannot travel through a vacuum without explaining why.

- (b) Only stronger candidates gave a correct description of the difference between a transverse wave and a longitudinal wave. Few candidates linked the vibration direction to the direction of propagation of the wave. Vague answers such as “in a transverse wave the particles move at right angles to the wave” were common.
- (c) (i) The majority of candidates made some progress in the calculation of the wavelength of ultrasound in soft human tissue. The wave equation was usually quoted correctly. The greatest source of error was not converting the frequency of the ultrasound wave, 8.4 MHz into Hz. Most candidates who realised that the frequency was needed in Hz used an incorrect conversion factor and consequently their answers were out by a factor of 10^n where n was usually 3 or 6.
- (ii) Stronger candidates correctly stated that as ultrasound passes from soft tissue into bone the frequency does not change and the wavelength increases.

Question 6

- (a) Some candidates were able to name a substance from which a permanent bar magnet could be made. A popular incorrect answer was iron.
- (b) The pattern and the direction of the magnetic field around a bar magnet was known by the majority of candidates. There were many good diagrams showing the field lines on both sides of the magnet and the field direction was usually indicated correctly.
- (c) (i) Only a very small number of candidates drew correct arrows to show the direction of the forces acting on the poles of the bar magnet when it was placed in the field of the electromagnet. Despite being told in the question that the direction of the forces were horizontal, very few attempts actually showed a pair of horizontal forces.
- (ii) Candidates found this question challenging. No candidate stated that the forces acting on the magnet would produce a moment or turning effect. A few stronger candidates realised that the magnet would rotate, but very few of these stated that the magnet would end up parallel to the field lines of the electromagnet.

Question 7

- (a) (i) Most candidates used a correct equation, substituted correctly and obtained the correct answer for the current in the lamp.
- (ii) The resistance of the lamp was usually calculated correctly.
- (b) (i) Few candidates were able to complete the given partial circuit diagram correctly to show how they could obtain a ranges of readings to plot a current-voltage graph for the lamp. Very few circuit diagrams contained the variable resistor needed to get a range of currents. The purpose and method of connecting an ammeter and a voltmeter into the circuit correctly was not well known. Ammeters frequently appeared in parallel and voltmeters in series in the circuit.
- (ii) The shape of the current-voltage characteristic for a filament lamp was not well known. The majority of sketches were incorrect and showed a linear relationship between the quantities. When a curve was drawn, it was often drawn with an increasing rather than a decreasing gradient
- (iii) Only a minority of candidates stated that the resistance of a filament lamp increases when the applied voltage increases. Only stronger candidates attributed the increase of resistance to an increase in temperature of the filament of the lamp

Question 8

- (a) Many candidates were able to explain why hydrogen-3 cannot decay by the emission of an alpha particle. Of all the possible correct explanations, the fact that a nucleus of hydrogen-3 only contains one proton was most popular.
- (b) (i) Many candidates completed the nuclide equation for the decay of hydrogen-3 correctly. The main source of error here was an incorrect representation of the beta particle in the equation.

- (ii) Element Q was usually identified correctly.
- (c) (i) The term half-life was defined correctly by a majority of candidates. The most common incorrect answer was that half-life was one-half of the lifetime of the radioactive substance.
- (ii) Only the very strongest candidates explained that the fluctuation in the count rate of the sample was due to the spontaneous or random nature of radioactive decay.

Question 9

- (a) (i) Some candidates identified nuclear fusion as being the name of the nuclear reaction that occurs at the centre of a star. A popular incorrect answer was nuclear fission. The descriptions of fusion were generally not strong. Most candidates stated that fusion was the joining of nuclei together, but omitted to state that they were hydrogen nuclei. The end product of the fusion, helium, was almost never mentioned.
- (ii) Very few candidates had any idea of how the fusion reaction at the centre of the star helps to keep the star stable. The idea of the outward forces/pressure created by the high fusion temperatures produced, balancing the inward gravitational forces was rarely stated.
- (b) (i) Many candidates correctly stated that as a massive star approaches the end of its life its supply of fuel (hydrogen) runs out and so nuclear fusion reactions can no longer keep the star stable.
- (ii) This question was well answered and there were some very good descriptions of what happens to a massive star at the end of its life, after it has become a red supergiant.

PHYSICS

Paper 5054/22 Theory

Key messages

There were some questions in this paper where a significant number of candidates misinterpreted the instruction given in the question. For example, when an answer asks for an explanation, a description is not sufficient. The command word used for a question indicates what is required and the depth of the explanation or the extent of the description is also indicated by the mark allocation given for each question.

General comments

Many calculations require the recall of an equation or expression and some may require an additional rearrangement so that the quantity asked for becomes the subject of the equation. For example, some candidates inaccurately rearranged the learned equation such as $V = IR$ to give an incorrect expression such as $R = I/V$. The skill of rearranging equations is one that candidates need to master.

When diagrams are drawn, either as a sketch or to scale, care is generally needed. For example, in **Question 5(b)(iii)**, rays drawn with a ruler and sharpened pencil or a thin pen were much more likely to lead to an accurate answer than free-hand sketches. In **Question 8(d)**, the use of a ruler was not so significant but could have helped to indicate much more clearly what candidates intended to show.

Comments on specific questions

Question 1

- (a) (i) Only stronger candidates answered this correctly. Some candidates set the resultant force equal to the change in momentum and others wrote an answer in terms of other quantities. Answers in terms of acceleration were common. Some answers seemed to be in terms of moment rather than momentum.
- (ii) The most obvious way to answer this question was to use the correct definition of resultant force from the previous part. If candidates could not recall this, it was possible to obtain the correct answer here by using the speed and time values in the question to calculate an acceleration. This was not necessarily the acceleration experienced by any part of the water being expelled but it did generate the correct force by then using the expression $F = ma$.
- (b) (i) Many candidates did not apply the third law to the forces acting on the water and the jet ski and simply quoted from memory a learned version of the law. Some credit could be awarded in these circumstances for quoting the law using the wording given in the syllabus, but a quoted version given in terms of an action and an equal and opposite reaction rarely gained any credit. Although this wording was often seen, it does not make clear that the terms 'action' and 'reaction' specifically refer to forces.

Candidates who attempted to explain the presence of a forward force on the jet ski rarely referred to both the force on the water due to the jet ski or pump and the consequent force on the jet ski due to the water.

- (ii) Candidates needed to use the equation $F = ma$ here and this question was answered correctly by a majority of the candidates. Many candidates supplied the correct answer; others used an incorrect final answer to (a)(ii) but obtained full credit as a result of the error carried forward (e.c.f.).

- (c) The calculation of the energy in the kinetic store of the jet ski used a fairly standard expression and this question was answered well. A few candidates either wrote down the term 20^2 but did not then square the value 20 in the calculation, or wrote v^2 in one line and then wrote 20 (without the square) in the next. These errors led to an answer that was twenty times too small.

Question 2

- (a) This question was answered well by many candidates. Candidates need to use the expression mg for the force and πr^2 for the area. Some incorrect answers used the term m/g . The area of contact was sometimes expressed as r^2 or πr or even as $\pi(r/2)^2$. None of these variants could be awarded credit.
- (b) Full credit was rarely awarded for this question. A large number of candidates started the graph from the origin. This ignored the pressure due to the weight of the beaker and the pressure of the atmosphere. Thereafter, a correct shape was much more commonly seen. Other errors included candidates drawing a curve either side of $t = T$ or, in a few cases, drawing a horizontal line that decreases to zero after $t = T$.

Question 3

- (a) Candidates were expected to give an answer that described the convection current that is set up inside the freezer. In this example, the cause of the current is the increase in the density of the cooled air at the top of the freezer. Some candidates described a more standard convection current with the cause being the decrease in the density of the air at the bottom of the freezer compartment. Other candidates referred to convection currents in the cold liquid in the pipe. Another common error was to state that the particles of the air contract when cooled.
- (b)(i) Candidates confused the thermal conduction of energy by lattice vibration, which takes place in both metals and non-metals, and the thermal conduction of energy by the movement of free electrons which only occurs in metal. In this question the conduction was through a non-metal (plastic) and so it was a description of the thermal transmission of energy by vibrating and colliding particles that was wanted. This question was poorly answered.
- (ii) Only the strongest candidates answered this correctly. That the air is trapped and is a poor conductor was rarely mentioned. Candidates often mentioned that the thermal energy was trapped, but the precise meaning of this is unclear and could not gain any credit. Other commonly seen incorrect answers referred to evaporation or to convection within the solid plastic.

Question 4

- (a)(i) This question was answered well. There were some candidates who substituted the original value of the volume and others who had incorrectly rearranged the definition of pressure and who used the expression p/A . Likewise, candidates who tried at this point to apply $p_1V_1 = p_2V_2$ rarely gained any credit.
- (ii) This question was primarily concerned with the topic of resultant force and candidates who realised this obtained part or full credit. Others gave more general answers such as “The force is not large enough” or “The wax stops air entering the syringe.”
- (b)(i) Here, the question required candidates to apply an understanding of the particulate cause of pressure to a slightly unusual situation. Many candidates referred to the collisions between the particles and the walls and to the increase in the average separation of the particles. That the collisions occurred less frequently was mentioned less often and some candidates simply referred to there being fewer collisions. This was not precise enough as some comment on the frequency (or rate) of the collisions was needed.
- (ii) This question required the rearrangement and the application of the equation $p_1V_1 = p_2V_2$. The numbers in the question were not easy to manipulate and a variety of incorrect answers were given. It was common for the answer 1.25×10^5 (Pa) to be suggested. This assumed that the pressure was directly proportional to the volume rather than inversely proportional. Some candidates calculated a value for pV and gave that as the answer.

Question 5

- (a) This was a fairly straightforward question, and many candidates drew a cross section that was recognisable as that of a diverging lens.
- (b)(i) This was also fairly straightforward but only a few candidates gave an acceptable answer. Errors made included misinterpreting the scale and giving an answer such as 1.4 cm or giving an answer which was equal to the distance between the two focal points (which was 3.6 cm).
- (ii) This question was often answered correctly and the arrows drawn were in the correct location and of the appropriate size. Arrows that were too large were more common than those that were too short and a few arrows were too far from the lens.
- (iii) This question was generally answered well but drawings that were insufficiently precise could not obtain credit. There were candidates who drew lines that did not help in locating the image. Some other candidates omitted to draw an arrow to represent the image.
- (iv) Many candidates did not know what was meant by the term 'magnification'.
- (v) An explanation was required. Many candidates who gave the correct description of the image did not explain why their choice was the correct one. As the choice was between 'real' or 'virtual' for the description of the image, the explanation differentiated between those who knew the meanings of the descriptions and those who guessed which description was correct.

Question 6

- (a) Many answers revealed a limited understanding of the operation of a relay. Some candidates correctly explained that a current in the wire between A and B would produce a magnetic field. A common misunderstanding was that the switch labelled in the diagram was used to switch on the current in the magnetising coil.
- (b) Many candidates described the shape of the graph in **Fig. 6.3** rather than explain why an increase the value of R beyond R_H would produce the graph shown.
- (c)(i) Many answers gained full credit here. An error commonly seen was to keep the time in minutes rather than convert it to seconds. Some candidates simply multiplied 40 W by 12 V.
- (ii) This question was more challenging but it was often answered well, with a significant number of candidates obtaining full credit for calculating the correct final answer. Some candidates did not rearrange equations such as $V = IR$ and $P = VI$ correctly.

Question 7

- (a) Most candidates knew what was expected here and produced a sinusoidal curve of some sort. Some candidates did not use the correct period; a period of 0.040 s was not unusual. Another inaccuracy was the use of an incorrect maximum voltage or a voltage that varied between 0 and 300 V and without any negative voltage values.
- (b)(i) There were many candidates who stated that iron is used for the core of a transformer because of its electrical conduction property. Here, the answer demanded reference both to iron being a magnetic material and to the temporary nature of the magnetism produced in the core.
- (ii) There was a wide range of credit awarded here. Many candidates knew exactly how a transformer operates and described, in standard terms, how the changing magnetic field led to electromagnetic induction. A word such as 'induction' or a related word, e.g. 'induced', was required and 'produced' or 'generated' were not sufficient. A common error was a lack of reference to the current in the primary coil. The voltage of the mains supply is not of itself enough to produce a magnetic field as the voltage needs to produce a current. Some candidates incorrectly referred to the current passing through the core from the primary coil to the secondary coil.

- (iii) Many candidates calculated the correct value of the maximum voltage across the secondary coil. Some candidates, who quoted the correct equation that related the input and output voltage to the ratio of the number of turns on the primary and on the secondary coil, rearranged it incorrectly.

Question 8

- (a) (i) This question was not well answered as many candidates did not describe the composition of an alpha particle with sufficient precision. An answer such as “It is made from helium” was not enough for any credit to be awarded. The term ‘composition’ indicates that an answer in terms of the correct number of neutrons and protons is required.
- (ii) The answer required here was ‘helium nucleus’ but other answers were acceptable. A reference to a helium atom was incorrect and gained no credit.
- (b) (i)(ii) Both parts of this question required candidates to use the composition of the thorium nuclide given in the stem of the question to deduce the composition of the radium nuclide that is produced by the emission of an alpha particle from the thorium nuclide. Many candidates omitted the last stage and gave answers that related to the thorium nuclide.
- (c) Many candidates approached this question correctly and there were a significant number of completely correct answers. Some of the candidates who did not receive full credit wrote down three successive halvings from 7.2×10^{16} to 9.0×10^{15} (which consists of four numbers, of course) and then gave an incorrect answer multiplying the half-life by four. Other candidates noted that the ratio of 7.2×10^{16} to 9.0×10^{15} is 8.0 and calculated an answer such as $75\,000 \times 8.0$ or $75\,000/8.0$.
- (d) (i) This question was often answered well but some candidates drew lines which were not clearly straight and horizontal and what was intended was equally unclear.
- (ii) This question was answered well.

Question 9

- (a) (i) This question was answered quite well but on occasion either the factor of 2π was ignored or the time 24 hours was not converted to seconds.
- (ii) This question was not well answered and few candidates made any reference to the smaller values of the diameter or circumference of the path followed by object further from the equator. Candidates often produced explanations in terms of the gravitational field strength of either the Earth or the Sun.
- (b) (i) Many candidates gave answers that correctly referred to the gravitational field of the Sun as being responsible for the force that causes the Earth to orbit the Sun.
- (ii) Some candidates correctly related the size of the force on the Earth to the varying distance from the Sun but other answers were vague and imprecise. In such cases credit could not be awarded.
- (iii) This question was not well answered. Few candidates related the variation in the energy in the kinetic store of the Earth to the variation in the energy in its gravitational potential store.

PHYSICS

Paper 5054/31 Practical
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Key messages

It is important that Supervisors submit a complete set of results for the three practical questions. In some situations, the Supervisor's results may assist in candidates being awarded credit for work which could not be awarded without them, especially when the equipment used has not conformed exactly with the specifications made in the Confidential Instructions.

Candidates should read the questions carefully to check if a specific level of precision, such as to the nearest gram or 0.1 cm, is stated in the question as this must be followed in order to be awarded credit.

When recording readings in a table, data should be recorded to a consistent number of significant figures or, when appropriate, a consistent number of decimal places. Units should be given if not already given on the answer line of the question paper.

Candidates are advised to check all their calculations and in particular calculations and measurements that appear to be unrealistically large or small.

Candidates should be able to demonstrate whether two values are within 10 per cent of each other and so equal within the limits of experimental accuracy.

The ability to produce a good line graph with a suitable line of best fit, and the ability to calculate the gradient of the line or to find values for points intermediate to those plotted, are necessary skills for candidates to develop.

For the planning question, candidates should ensure the experiment they describe will actually describe the exact investigation featured in the question. They should focus on giving details addressing each of the bullet points in turn. Candidates should not spend too much time drawing detailed labelled diagrams and so leave themselves too little time to write the remainder of the plan.

General comments

Stronger candidates demonstrated that they were able to read and understand the questions and performed the required tasks by following the instructions closely, making accurate, careful observations and measurements and recording them to the required degree of precision. They were able to use their sets of results and process them by performing calculations and making judgements, drawing relevant conclusions, and writing relevant comments about their results and conclusions.

Attention is drawn to the advice on plotting graphs issued by Cambridge. Candidates should remember that graphs are intended to make the interpretation of their experimental results clearer and that data should occupy at least half of the available grid on both the x and y axes.

Comments on specific questions

Question 1

- (a) (i) Most candidates were awarded credit for recording a length in the correct range to the nearest millimetre.
- (ii) Most candidates gained credit for recording the length to 0.1 cm.

- (iii) Most candidates were able to correctly divide their answer to (ii) by 5 but some candidates did not state the value to 2 or 3 significant figures and so were not awarded credit.
 - (iv) Stronger candidates were awarded credit for drawing clear, accurate and well labelled diagrams of a set square at each end of the five straws and with the set square bases resting flush to the edge of a ruler. Weaker responses had gaps between the straws or positioned the set squares so that they were not clearly perpendicular to the scale or straws.
 - (v) The strongest responses showed the full substitution of the variables into the equation given and the evaluation of the volume before correctly rounding this to the 2 significant figures required by the question. However, many candidates stated the answer to three significant figures and so did not gain full credit.
- (b) (i) Some candidates recorded the value read from the measuring cylinder to the nearest 0.1 cm^3 which was an inappropriate degree of precision for this instrument and so were not awarded credit.
- (ii) Most candidates correctly attempted to divide the volume in (i) by six. Weaker, non-creditworthy responses included those that stated an answer to one significant figure.
- (c) Most candidates found it challenging to give two distinct reasons why the values for the volumes found were different. Many tried to explain which method was more accurate or referred to calculation errors rather than suggesting inaccuracies with the experimental technique. Credit was most often awarded for suggesting air bubbles in the straw or water spilling on transfer.

Question 2

- (a) (i) The voltmeter reading was recorded across a fixed resistor X as well as the ammeter reading in the series circuit. Accurate responses had a value of potential difference about 1.0 V (less than 1.2 V was acceptable), written to at least one decimal place and an ammeter reading of less than 0.5 A recorded to at least two decimal places. The majority of responses gained credit here.
- (ii) Most candidates were able to calculate the resistance and record it to two or three significant figures.
- (iii) Many candidates gave vague responses, such as suggesting overheating but not linking this to wires or the resistors. Candidates needed to relate their knowledge to the specific context rather than making generic comments about faulty circuits or apparatus.
- (iv) Most candidates were able to measure the potential difference and calculate the resistance and record it to two or three significant figures.
- (b) (i) The strongest candidates completed the diagram using pencil and ruler and drew the resistor combination in parallel, and then the voltmeter across it. Some candidates drew a wire between W and Z, effectively short-circuiting the resistors.
- (ii) Candidates who understood how to connect resistors in parallel usually gained credit for values within the acceptable ranges.
- (c) (i) The strongest candidates showed values substituted into the equation and recorded the total resistance to at least two significant figures. A common error was substituting in an incorrect value for one of the resistances. Some candidates did not manage to process the numbers correctly using their calculators.
- (ii) Only stronger candidates were able to provide evidence of a full calculation to determine whether the values for resistance were within 10 per cent of each other. The easiest way to demonstrate this is to calculate the range of values for the larger reading (for example if the resistance is 5Ω then the range using 10% of this value is from 4.5 to 5.5Ω), and then to state whether the second reading falls within this range. Credit was given to candidates who worked out whether the difference between the values was within 10 per cent of one of the values. Weaker candidates often worked out 10 per cent of each value but then did no comparisons with the actual resistance values or attempted to work out the difference as a percentage of the average resistance.

Question 3

- (a) (i) The distance of the 20 g mass from the pivot was recorded. Candidates should be reminded to look carefully at any diagram given as well as reading the question carefully as this would have prevented candidates from stating the reading on the rule rather than the distance from the pivot. Responses that did not give the distance to the nearest 0.1 cm could not gain credit.
- (ii) Only the strongest candidates were able to provide a clear description of their technique. A common response, which could not gain credit, was to state that the balancing point was when the ruler balanced for the longest period of time, which did not describe the technique but the outcome. Some candidates simply stated that the principle of moments was used but no reference was made as to how the 20 g mass was moved.
- (iii) Most candidates recorded a full set of readings for d but common mistakes from weaker candidates were not having a decreasing trend in d , or not recording all values to one decimal place. A common error in recording $1/d$ was to use an inappropriate number of significant figures. Candidates should be reminded to use two or three significant figures unless otherwise instructed by the question. Candidates should also be reminded of the need to use a consistent number of decimal places or significant figures for all the readings within a column in a table.
- (iv) Candidates were asked to suggest a reason why the method would be unsuitable if a smaller mass of 10 g was used. Stronger candidates referred back to their data and stated that it would be impossible to balance the rule or that the balance point would be beyond the end of the rule. Weaker responses often provided insufficient reason, such as the statement 'it is more difficult to balance' or that 'the mass is too small' without explaining why. Candidates should be encouraged to follow their line of reasoning through to a conclusion by asking themselves questions such as 'why is this a problem?' so that they provide a clear and relevant answer rather than a vague one.
- (b) (i) A graph of $1/d$ against mass should have been plotted and very few candidates incorrectly reversed the axes or plotted an incorrect variable such as d . Candidates should be reminded of the need to ensure data covers at least half of the available grid space in both the x and y directions. A significant number of candidates did not attempt to plot the graph or only labelled the scales but did not plot any points. Weaker candidates often used inappropriate scales such as using increments of multiples of 3 and some very weak responses used all of the calculated values as the scale readings. Candidates should be reminded that scales need to start from and use sensible values e.g. 20, 25, 30... and not start from their first reading such as 22.4, leading to labels such as 27.4, 32.4 etc. Candidates should be encouraged to use sharp pencils to draw small crosses for each point and not to use circled points or blobs where the points cover over half a square in either direction. Stronger candidates drew good lines of best fit which showed an equal number of points above and below the line. Weaker candidates forced the line to go through the origin or their first and last points.
- (ii) The strongest candidates followed the instruction in the question and clearly indicated the values selected for determining the gradient on the graph, often by drawing a large gradient triangle and using it to obtain the two sets of coordinates needed to calculate the gradient. Two distinct marks on the best straight line which identify the exact ends of the hypotenuse of the gradient triangle were sufficient for credit, but a triangle was preferable. In many weaker responses, the gradient triangles drawn were too small or marks on the graph were omitted or candidates used values from the table, not from their line of best fit. Candidates should be reminded to show *all* of their working and to state whole number values to an appropriate number of significant figures.
- (iii) Only stronger candidates gave a value that was in the acceptable range. Other candidates demonstrated poor graph plotting skills and so gave an inaccurate value for the gradient.
- (c) Candidates were required to find a value for d for the unknown mass and then calculate $1/d$ before using the line of best fit on their graph to determine a value for the mass. Full credit was only awarded if candidates recorded their values and showed how the graph was used. Credit was given for using the graph correctly even if the graph had not been well plotted.

Question 4

Candidates were required to plan an experiment to investigate the time taken for different masses of ice to melt when placed in water. Candidates who attempted the question were often able to gain at least partial credit but a number of blank responses or other responses where the question was simply restated were seen. Some candidates seemed to spend a lot of time drawing overly detailed diagrams.

Marking point 1 was awarded for measuring the mass of the ice cubes and placing them into a beaker of water. Weaker candidates often omitted any reference to placing the ice in water or placed the ice into an empty beaker which was then placed in an ice bath.

Marking point 2 was awarded for recording the time taken for the ice to melt and this was usually done well.

Marking point 3 was awarded for repeating the measurements for different masses of ice. Weaker responses often simply suggested repeating some steps in the method and it was unclear whether the same mass of ice was being retested or a different mass of ice used. Candidates should be reminded to be clear about each step in a method even if they think they are stating something which is obvious.

Marking point 4 was awarded for referring to a relevant control variable. This was most commonly awarded for the same initial temperature of the water or the same volume of water being used in each trial. The control variable needed to be explicitly stated and simply stating a volume of water to use was insufficient unless it was made clear that this was being controlled and repeated for each beaker.

Marking point 5 was awarded for drawing a results table with columns for mass and time with correct units. Candidates should be reminded to check the question so that they identify the key dependant and independent variables and associated units. Candidates should be reminded that acceptable units for time are seconds, s and minutes but not secs or m.

Marking point 6 was awarded for suggesting how to process results to draw a conclusion. The simplest way to gain this credit was to state that a graph of time (to melt) against mass should be plotted. It was insufficient to just suggest plotting a graph of results. The variables needed to be stated even if this followed on from a correct table. Candidates should be reminded that predictions such as 'the larger the mass, the longer the time' are not creditworthy and also that they must refer to the key variables being tested.

PHYSICS

Paper 5054/32 Practical 32

Key messages

It is important that Supervisors submit a complete set of results for the three practical questions. In some situations, the Supervisor's results may assist in candidates being awarded credit for work which could not be awarded without them, especially when the equipment used has not conformed exactly with the specifications made in the Confidential Instructions.

Candidates should read the question carefully to check if a specific level of precision, such as to the nearest gram or 0.1 cm, is stated in the question as this must be followed in order to be awarded credit.

When recording readings in a table data should be recorded to a consistent number of significant figures or, when appropriate, a consistent number of decimal places. Units should be given if not already given on the answer line of the question paper.

Candidates are advised to check all their calculations and in particular calculations and measurements that appear to be unrealistically large or small.

Candidates should be able to demonstrate whether two values are within 10 per cent of each other and so equal within the limits of experimental accuracy.

The ability to produce a good line graph with a suitable line of best fit, and the ability to calculate the gradient of the line or to find values for points intermediate to those plotted, are necessary skills for candidates to develop.

For the planning question, candidates should ensure the experiment they describe will actually describe the exact investigation featured in the question and they should focus on giving details addressing each of the bullet points in turn. Candidates should not spend too much time drawing detailed labelled diagrams and so leave themselves too little time to write the remainder of the plan.

General comments

Stronger candidates demonstrated that they were able to read and understand the questions and performed the required tasks by following the instructions closely, making accurate, careful observations and measurements and recording them to the required degree of precision. They were able to use their sets of results and process them by performing calculations and making judgements, drawing relevant conclusions, and writing relevant comments about their results and conclusions.

The mathematical processing of results and rounding of values was generally good but weaker candidates often then incorrectly add a trailing 0, for example 28.4 is stated as rounding to 28.0 rather than 28 to 2 significant figures.

Attention is drawn to the advice on plotting graphs issued by Cambridge. Candidates should remember that graphs are intended to make the interpretation of their experimental results clearer and that data should occupy at least half of the available grid on both the x and y axes.

Comments on specific questions

Question 1

- (a) (i) Many candidates did not gain this credit as they did not follow the clear instruction to record the mass of the test-tube to the nearest gram and instead recorded the full reading displayed on the balance.
- (ii) Most candidates gained credit for recording the length to 0.1 cm.
- (iii) Most candidates gained this credit for recording the external diameter to 0.1 cm.
- (iv) This was generally done well with candidates recognising that the full length of the test-tube needed to be positioned between and touching the longest sides of both blocks. Some candidates had diagrams with clear gaps between the sides of the test-tube and blocks or had the test-tube standing on its rim with blocks either side.
- (b) Most candidates correctly calculated the external volume using their values from (a) and rounded their value to an appropriate number of significant figures.
- (c) Many candidates recorded the value read from the measuring cylinder to the nearest 0.1 cm³ which is an inappropriate degree of precision for this instrument. A few candidates measured an internal volume greater than their calculated value of the external volume.
- (d) Most candidates gained credit for subtracting values correctly.
- (e) Many candidates stated that parallax was an issue but did not give sufficient detail. The strongest responses stated that parallax errors result from not reading the scale on the measuring cylinder perpendicularly. Some responses stated that the readings were not taken from eye level and this statement was also awarded credit. Another commonly seen response, which was not credited, was the statement that the test-tube was not full.
- (f) Many candidates gained credit for the numerical value of density based on their values of mass and volume. Some candidates who calculated the value correctly only gave their answer to one significant figure and so did not gain credit. Many candidates gave the appropriate unit of g/cm³; commonly seen incorrect units were Pa, m/cm³, J or cm³. Candidates should be reminded to look at the units for the quantities within the equation to enable them to select a unit if they cannot recall the standard unit for a physical quantity.

Question 2

- (a) The voltmeter reading was recorded across a fixed resistor placed between X and Y in the circuit. Accurate responses had a value of potential difference about 2.5 V (between 2.0 and 3.0 V was acceptable) written to at least one decimal place. The majority of candidates gained credit here. Candidates finding that a measurement was zero or negative needed to check the circuit to ensure that the voltmeter had been connected with the positive terminal connected to X as instructed.
- (b) The voltmeter reading was recorded across the LED placed between Y and Z in the circuit. Most candidates gained credit here for recording a value less than that in (a) stated to at least one decimal place. The strongest responses stated the potential difference to the same degree of precision as (a).
- (c) Most candidates correctly recorded a full set of voltmeter readings to a consistent number of decimal places.
- (d) The question asked for the potential difference across X and Z to be calculated and most candidates were able to process data in the table correctly. Weaker candidates used one set of voltmeter readings which was negative, resulting in zero or very small values. These candidates did not recognise this as being unrealistic given that this was also the potential difference across the power source.
- (e) The question asked candidates to calculate the value of current in the circuit for each fixed resistor. Stronger candidates showed full working on the paper in the space provided and values recorded

to two or three significant figures in the table. Common errors were only stating current to one significant figure or having power of ten errors so that currents were far too large or too small.

- (f) Many candidates gained credit for correctly calculating the resistance of the LED for each fixed resistor placed between X and Y. A common error was to calculate one or more of the values using $V_{(XY + YZ)}$ rather than V_{YZ} , resulting in an incorrect set of values.
- (g)(i) The expected response was that the voltmeter reading remained constant when given to one decimal place, but credit was given to candidates who correctly described the trend based upon their readings which had been recorded to two decimal places. Weaker responses, which did not gain credit, often referred to a change in potential difference with resistance rather than current or simply stated 'increased' or 'decreased' without reference to the direction of change in current.
- (ii) The strongest responses stated that as current decreased the resistance increased. Weaker candidates made no reference to current or made comments on the trend that were based on the resistance of the LED compared to the fixed resistance. Candidates should be encouraged to refer only to the quantities stated in the question within their answers. They should also avoid making statements about proportionality which cannot be supported without further processing of data.
- (h) Stronger candidates described the direction of the LED with respect to the positive terminal of the power source or the direction of conventional current or referred to it being reverse biased. Many candidates recognised there was an issue with polarity but made vague uncreditworthy statements such as that a positive terminal was incorrectly connected without referring to which specific component was incorrectly connected and at which point in the circuit. Some candidates made generic remarks such as referring to broken or loose wires or that there were broken components which was specifically ruled out in the question. Candidates need to relate their knowledge to the specific context rather than making generic comments about faulty circuits or apparatus.

Question 3

- (a) The question asked candidates to obtain a value for the focal length of the lens using a distant object and to state this to the nearest 0.1 cm. Weaker, non-creditworthy responses stated a value beyond the acceptable range or did not give a reading within the acceptable range to the nearest 0.1 cm as required by the question.
- (b)(i) Most candidates gained credit for stating the image distance to the nearest 0.1 cm. A lack of precision was the most common reason for credit not being awarded.
- (ii) Most candidates were able to process the values correctly by adding twenty to their value of v for $(u + v)$ and then multiplying by twenty for (uv) . Weaker responses used values from (a) or multiplied $(u + v)$ by twenty instead of v .
- (c) Many candidates were able to give correct units for $(u + v)$ and (uv) . Weaker candidates were unable to work out a unit for (uv) . Many candidates did not include their readings from (b) in the table as instructed in the question and so were not awarded credit for recording all values. Candidates should be reminded that the same number of significant figures, or decimal places if more appropriate, should be used for all values in a table even when a whole number value is obtained. Some candidates did not choose a range of values for u between the values specified in the question resulting in readings beyond the range or a set of readings clustered at one end of the range which made plotting the graph more difficult.
- (d) A graph of uv against $(u + v)$ should have been plotted and very few candidates incorrectly reversed the axes or plotted an incorrect variable such as u . Candidates should be reminded of the need to ensure data covers at least half of the available grid space in both the x and y directions. A common mistake which prevented credit being awarded for selecting an appropriate scale was starting the y axis scale from 0 despite the reminder in the question that axes did not need to start from the origin. Weaker, non-creditworthy responses often used inappropriate scales such as using increments of multiples of 3 and some very weak responses used all of the calculated values as the scale readings. Candidates should also be reminded that scales need to start from and use sensible values e.g. 20, 25, 30... and not start from their first reading such as 22.4, leading to labels such as 27.4, 32.4 etc. Candidates should be encouraged to use sharp pencils to draw small crosses for each point and not to use circled points or blobs where the points cover over half a square in either direction. Many candidates simply chose two points to put on the line or did not

indicate any anomalies which were being ignored. Stronger candidates drew good lines of best fit which showed an equal number of points above and below the line. Weaker candidates forced the line to go through the origin or their first and last points.

- (e) Many candidates followed the instruction in the question and clearly indicated the values selected for determining the gradient on the graph. Stronger candidates drew a large gradient triangle and used it to obtain two sets of coordinates for calculating the gradient. Two distinct marks on the best straight line which identify the exact ends of the hypotenuse of the gradient triangle were sufficient for credit, but a triangle was preferable. In many weaker responses, the gradient triangles drawn were too small or marks on the graph were omitted or candidates used values from the table, not from their line of best fit. Many candidates were awarded credit for accuracy by obtaining a value for the gradient which was equivalent to the focal length, within the stated range. Candidates should be reminded to show *all* of their working and to state whole number values to an appropriate number of significant figures..
- (f) Only stronger candidates were able to provide evidence of a full calculation to determine whether the values for focal length were within 10 per cent of each other. The easiest way to demonstrate this is to calculate the range of values for the larger reading (for example, if the focal length is 15 cm then the range using 10% of this value is 13.5 cm to 16.5 cm), and then to state whether the second reading falls within this range. Candidates were awarded credit for working out whether the difference between the values was within 10 per cent of one of the values. Weaker candidates often worked out 10 per cent of each value but then did no comparisons with the actual focal lengths or attempted to work out the difference as a percentage of the average focal length.
- (g) Candidates were asked to suggest how to avoid parallax errors. As the rule was flat on the desk the easiest way to gain credit here was to say that the rule was read at right angles or from directly above it.

Question 4

Candidates were required to plan an experiment to investigate if the time taken for water in a beaker to boil is dependent on the diameter of the beaker. Most candidates who attempted the question were able to gain at least partial credit. Many candidates drew overly detailed diagrams when time could have been better used addressing the bullet points. Some candidates gave a method based on the introductory sentence alone and did not include all of the required bullet points. Candidates were able to score the final marking point by stating or drawing the axes for an appropriate graph.

Marking point 1 was awarded if the use of a metre rule and a stopwatch was mentioned either in the plan or shown on a labelled diagram. Many weaker responses omitted the metre rule and gave no acceptable alternative such as measuring tape or callipers.

Marking point 2 was awarded for explicitly stating that the diameter of the beaker should be measured. Candidates should be reminded that stating a quantity in the heading of a table is insufficient as an instruction to measure the quantity. Some candidates seemed to assume that beakers had their diameters printed on them.

Marking point 3 was awarded for measuring the time for the water to boil in all of the different beakers. Weaker responses only referred to one beaker or suggested repeating some steps in the method without making it clear whether the same beaker was being retested or a different beaker used. Candidates should be reminded to be clear about each step in a method even if they think they are stating something which is obvious.

Marking point 4 was awarded for referring to a relevant control variable. This was most commonly awarded for the same initial temperature of the water or the same volume of water being used in each beaker. The control variable needed to be explicitly stated and simply stating a volume of water to use was insufficient unless it was made clear that this was being controlled and repeated for each beaker.

Marking point 5 was awarded for giving suitable table headings for the experiment. Candidates should be reminded to check the question so that they identify the key dependant and independent variables and associated units. Many candidates referred to the size of beaker rather than the diameter of the beaker or gave additional unnecessary columns such as initial and final temperature. Candidates should be reminded that acceptable units for time are seconds, s and minutes but not secs or m.

Marking point 6 was awarded for suggesting how to process results to draw a conclusion. The simplest way to gain this credit was to state that a graph of time (to boil) against diameter should be plotted. It was insufficient to just suggest plotting a graph of results. The variables needed to be stated even if this followed on from a correct table. Candidates should be reminded that predictions such as 'the larger the diameter, the longer the time' are not creditworthy and also that they must refer to the key variables being tested.

PHYSICS

Paper 5054/41 Alternative to Practical

Key messages

- Candidates should be reminded to include units when quoting the values of physical quantities. They should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, for example, exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidates should ensure they are careful and pay attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams could be greatly improved by using a sharp pencil and a ruler.
- Candidates should be advised to avoid using set phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. These comments need to be linked to the practical situation being considered, and candidates should state why the accuracy has improved or how parallax error was avoided.
- Candidates should be reminded that, when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.
- Candidates should have as much personal experience of carrying out experiments themselves as possible, including reflection and discussion on the precautions taken to improve reliability, and control of variables.
- Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations need to be based on data from the question, and practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit where applicable. Candidates should know that these techniques will be tested at some point in the paper.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:

- handling practical apparatus and making accurate measurements
- tabulating of readings
- graph plotting and interpretation
- manipulating data to obtain results
- drawing conclusions
- understanding the concept of results being equal to within the limits of experimental accuracy
- dealing with possible sources of inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

The level of competence shown by candidates was generally good. Most candidates attempted all the questions and there was no evidence of candidates suffering from lack of time. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately. However, some candidates were unable to round their numerical answers correctly or to give an answer to a sensible number of significant figures.

Question 1

- (a) (i) Candidates were asked to take two length measurements from a diagram and give the answer correct to 0.1 cm. Only stronger candidates were able to do this correctly. Some responses suggested that candidates did not have a ruler to use in the examination room.
- (ii) The majority of candidates could use their value of length from (i) to correctly deduce the actual length of the straw by multiplying their answer by 5. A small number of candidates divided by 5 or could not use a calculator correctly.
- (iii) Here candidates needed to divide their value of diameter in (i) by 5. Again, most candidates did this correctly.
- (iv) Candidates were then asked to describe how to use a ruler and set square to find the measurement of D (diameter of five straws in a row) in (i). A significant number of candidates did not attempt the question and only a few candidates answered this correctly. The best way to address the question was by drawing a diagram. It was clear that some candidates did not know what a set square was.
- (v) Many candidates were able to use the equation given to find the volume of the straw and most gave the answer to 2 significant figures as required.
- (b) (i) Most candidates could take a correct reading of volume from the measuring cylinder but a significant minority read the volume as 20.4 instead of 24 cm³.
- (ii) Candidates were then asked to use their answer to (i) to find the volume of water in one straw (rather than 5 straws). Many candidates could do this correctly.
- (c) The final part of the question asked why the two methods of finding the volume of the straw might give different values and very few candidates could suggest a practical reason here. Candidates did not seem to understand that one method measured the internal volume of the straw whilst the other measured the external volume and that these values would differ. Credit was also available for considering how the volume of water might be incorrect due to inaccuracies in the method.

Question 2

- (a) (i) Candidates were asked to take readings from a voltmeter and from an ammeter. This was answered well, with most candidates scoring at least partial credit. Stronger candidates gained full credit.
- (ii) Most candidates could use the equation given to find the resistance of the resistor.
- (iii) Candidates were asked why the switch in the circuit should be opened between readings. Only a few responded that this was either to prevent the overheating of the resistor or to prevent the cell from running down.
- (iv) Candidates were expected to use the equations given to find the potential difference across a second resistor and the corresponding value of its resistance. They did this well, using the values that they had obtained previously.
- (b) (i) Candidates were asked to draw a circuit diagram showing the two resistors arranged in parallel and a voltmeter placed to measure the potential difference across both. A significant number of candidates were unable to draw the position of the voltmeter correctly (usually placing it in series). Other candidates drew lines through the voltmeter, meaning that the voltmeter symbol was incorrect. Some candidates drew correct diagrams scoring full credit.
- (ii) The majority of candidates could use the equation given and their previous values to find the combined resistance of the resistors in parallel.
- (iii) Candidates were asked to compare their value of the combined resistance with the given manufacturer's value and state whether these could be considered equal within the limits of experimental error (within 10% of each other). The response here depended on their previous

answer, but the two values should have been significantly different, i.e. more than 10%, for them not to be considered equal. Many candidates gained at least partial credit here but a few candidates left the question unanswered. Some candidates tried to adjust their previous answer to make it equal to the manufacturer value. A clear calculation needed to be seen for full credit to be awarded.

Question 3

- (a) (i) Candidates needed to use the diagram of a 20 g mass on a rule to determine where the centre of the mass was positioned at the balance point. They then needed to subtract the position of the pivot (at 25 cm) from this value. Only stronger candidates did this correctly.
- (ii) Candidates were asked to describe a technique used to balance the metre rule. Only stronger candidates did this well.
- (iii) Candidates were expected to complete a table of results to give $1/d$, where the value of d was given. Most candidates gave their answers to 1 significant figure which meant that full credit could not be awarded as all values in the table were given to 2 significant figures. Two or three significant figures were expected for full credit.
- (iv) Only stronger candidates could explain why a value for d would not be found for a mass of 10 g. Stronger candidates realised that the ruler would not balance as the balance point would be off the end of the rule.
- (b) (i) Candidates found the plotting and drawing of the graph very challenging. Candidates were given a sheet of A4 graph paper and so they had to work out a suitable scale. They found this difficult and very few scored all the available credit. Scales should **not** be in multiples of 3 or 7 for example, and a number of candidates used such scales. Most scales did not use a suitable width or height of the graph paper.
- (ii) When calculating the gradient of a graph it was expected that points used should be on the graph line and be positioned so that at least half of the graph line is between them. Few candidates gained credit for this and a number of candidates left the question unanswered.
- (c) Candidates who gained a sensible value for the gradient were able to use the equation given to find a value for the mass of the metre rule.
- (d) Many candidates were able to score at least partial credit for this question. They were told that a piece of modelling clay balanced the rule 40 cm from the pivot. They needed to calculate that $1/40$ is equal to 0.025 and then use this value on their graph to find the mass of the piece of clay.

Question 4

Candidates were asked to describe an experiment to see how the mass of ice cubes added to water affected the time taken for all the ice to melt. Writing a plan for an investigation is a relatively new skill and very few candidates scored full credit here. Some candidates left the question blank or gained no credit.

Initial credit was given for measuring the mass of the ice cubes and adding them to water. The second step was to measure the time taken for ice to melt. Further credit was awarded for repeating the experiment for different masses of ice. Few candidates mentioned these three basic points, all of which could be deduced from the information given in the question. They were also expected to name the apparatus needed to make these measurements.

Credit was also awarded for suggesting a variable which needed to be controlled. There were several possibilities for this and most candidates gained credit here.

The results table needed to show at least two columns – one for the mass of ice cubes and one for the time taken for them to melt. Appropriate units were required but many candidates did not put these in their column headings.

Finally, a conclusion was expected. However, candidates were not expected to describe the outcome of the experiment. They needed to compare the results in the table or possibly to draw a suitable graph of their

data stating which variable goes on each axis. Some candidates stated “plot a graph of the data” which was not sufficient.

PHYSICS

Paper 5054/42 Alternative to Practical

Key messages

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General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:

- handling practical apparatus and making accurate measurements
- tabulating of readings
- graph plotting and interpretation
- manipulating data to obtain results
- drawing conclusions
- understanding the concept of results being equal to within the limits of experimental accuracy
- dealing with possible sources of inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

The level of many responses was good but some candidates approached this paper as they would a theory paper, and not from a practical perspective. Only a very small number of candidates failed to attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with the range of practical skills being tested.

Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included where needed, writing was legible, and ideas were expressed logically.

Comments on specific questions

Question 1

- (a) (i) The height h of the test-tube was recorded correctly in centimetres to the nearest millimetre by some candidates. The height h was usually recorded as 15 cm instead of 15.0 cm. Occasionally, an extra zero was added to the recorded dimension, and the answer recorded as 15.00 cm and this could not be credited. Many candidates did not recognise the significance of adding an extra zero to the measured value of a length.
- (ii) The measurement of the diameter d of the test-tube was almost always recorded correctly as 1.5 cm.
- (b) Only a few candidates were able to explain why it is important to ensure that the blocks holding the test-tube between them must be parallel to each other when the height h is measured. Most candidates did not understand that if the blocks are not parallel to each other, then the distance between the blocks, and therefore h , will not be constant.
- (c) The external volume of the test-tube was calculated correctly by the majority of candidates.

- (d) The reading of the water level in the measuring cylinder was recorded correctly by stronger candidates. The correct scale reading was 21 cm^3 , but many candidates wrote down 21.0, which gained no credit because the precision of the given measuring cylinder was 1 cm^3 . Common incorrect answers were 20.1 and 19.
- (e) The simple subtraction to calculate the volume of glass in the test-tube was almost always correct.
- (f) Some candidates were able to suggest one source of inaccuracy in the measurement of the internal volume of the test-tube. Creditworthy suggestions included that the test-tube could be overfilled, that water may have been spilled on transfer, or that water droplets remained stuck to the side of the measuring cylinder or test-tube.
- (g)(i) Few candidates were able to convert the balance reading given in kg to a reading in g, and even fewer recorded the mass to the nearest gram as requested.
- (ii) The density of the glass was usually calculated correctly, and the unit of density was well known. Common incorrect units of density seen were cm^3/g , N/cm^2 and N/m^3 .

Question 2

- (a)(i) The majority of candidates knew the symbol for a voltmeter and showed a correct parallel connection on the diagram.
- (ii) The reading on the scale of the voltmeter was almost always recorded correctly.
- (b)(i) The value of $(V_{XY} + V_{YZ})$ was calculated correctly by the majority of candidates.
- (ii) The current I in the circuit was usually calculated correctly. Occasionally candidates used the wrong value of V in the equation provided.
- (iii) The majority of candidates proceeded to calculate a correct value for the resistance of the LED.
- (c) The missing value for V_{XY} in the table was deduced by the majority of candidates.
- (d) Some candidates were able to examine the results in **Table 2.1** and described how the change in current in the circuit affected the values of $(V_{XY} + V_{YZ})$ and R_{LED} . Stronger candidates were able to express in words what the numerical values in **Table 2.1** indicated, but other candidates found this challenging. There were a lot of ambiguous responses such as 'increases' or 'decreases' which did not link this to any mention of increasing/decreasing current.

Responses simply stating directly / inversely proportional could not be awarded credit.

- (e) Only the strongest candidates were able to make a sensible suggestion as to what the student may have done incorrectly when the circuit that they had set up did not work. The most common incorrect answer was that the switch had not been closed, despite being told that the circuit was complete. The most common correct answer was that the LED or the power supply had been connected the wrong way around. Another acceptable answer occasionally seen was that the voltmeter had been connected in series into the circuit.
- (f) Few candidates named a variable resistor as the single device that can be used to change the current in the circuit without the need to connect different resistors into the circuit. Even fewer candidates who named the correct device were able to draw the correct symbol for a variable resistor. Commonly seen incorrect symbols were those for a resistor, a thermistor, an LDR, an LED and a cell.

Question 3

- (a)(i) The image distance x from the centre of the lens to the screen was measured correctly by most candidates. Most candidates followed the instruction to give their measurements to the nearest 0.1 cm. Occasionally answers of 5.10 cm were seen, which could not be credited.

- (ii) Most candidates understood what was meant by a scale of one-third full size and multiplied their value of x by three to calculate the actual image distance. Some weaker candidate divided their value of d by three.
- (b) The values of $(u + v)$ and uv were almost always calculated correctly.
- (c) Many candidates supplied correct units for the quantities $(u + v)$ and uv . The most common error was to give the unit of uv as cm instead of cm^2 .
- (d) The graph axes were almost always labelled and were the correct way around. There was little evidence of the use of scales that increased in inconvenient increments, such as 3 or 7. Choosing such scales makes the points much harder to plot. Despite the instruction that there was no need to start either axis from the origin, candidates often did so. This resulted in the drawn straight line graph only occupying a small portion of the grid. Candidates must attempt to choose scales that allow at least half of the grid to be filled. Point-plotting was accurate, with most candidates placing their dot or cross within one-half of a small graph square of the exact location of the point. There were many excellent, carefully drawn, best-fit straight lines produced by candidates. However, there were also many graphs where attempts at a best-fit line resulted in all points which did not lie on the drawn line being on the same side of the line. There were also some graphs where the points were joined dot-to-dot. The concept of best fit was not well understood by all candidates.
- (e) Most candidates obtained a value for the gradient of the graph that was within the allowed tolerance. The coordinates of the points chosen to calculate the gradient were usually far enough away from each other to ensure an accurate value for the focal length. Most candidates followed the instruction to indicate on the graph the points that were used.
- (f) Candidates were asked to state whether their values of focal length from (a)(ii) and (e) could be considered to be equal within the limits of experimental accuracy, having been told that this is true if their values are within 10% of each other. Many candidates made a good attempt at a calculation. The easiest way to show this was to calculate the ratio of the smaller of the two values to the larger. If the value obtained was 0.9 (90%) or greater, then the quantities could be considered to be equal. Another equally acceptable method was to calculate the ratio of the difference between the two values to either of these values. If the answer obtained was 0.1 (10%) or less, then the quantities could be considered to be equal. Other acceptable methods of doing this were also seen. If both values of focal length recorded by candidates were equal, it was sufficient to state just that to obtain full credit.
- (g)(i) Some candidates were able to state how parallax errors can be avoided in experiments of this type. Many candidates wrote about how to avoid parallax errors when reading the volume of water in a measuring cylinder, when the question was specifically about taking readings from a ruler in an optics experiment.
- (ii) Stronger candidates were able to describe a technique that they used to ensure that the image on the screen was as clearly focused as possible. The most popular correct answer was to move the screen slowly, or to move the screen backwards and forwards until the image was as sharp as possible. Many candidates stated that they would move the object or the lens slowly, or backwards and forwards. Such answers gained no credit because in the experimental arrangement used, the object and the lens were fixed in position.

Question 4

Initial credit was available for stating any other apparatus, apart from the apparatus listed in the question, that they would need to do the experiment. Most candidates realised that they would also need a stopwatch, but only a few stated that they would also need a ruler / measuring tape to measure the diameter of the beaker.

Credit was also available for giving a brief explanation of how the investigation would be carried out. Most candidates gained only some of the available credit here because they neglected to state that they would first measure the value of the independent variable, namely the diameter of the beaker. Further credit was usually scored by giving a description of a method where the time taken for water to be heated to boiling in a beaker is measured, and then the process repeated with beakers of different diameters.

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Candidates had little trouble in suggesting a key variable to control during the experiment. The most popular answers were the mass/volume of the water or the initial temperature of the cold water in the beaker.

Most candidates drew a table of results with clear columns for diameter $/d$ and time $/t$ with appropriate units and gained credit here. It should be noted that 'secs' is an inappropriate unit for time and 'm' is an incorrect unit for minutes.

Fewer candidates explained satisfactorily how they would use their results to reach a conclusion because they made predictions about the outcome. An answer such as "compare the results to see if/how the diameter of the beaker affects the time taken to boil the water" was required. Many stronger candidates also suggested plotting a graph of diameter against time.