

PHYSICS

Paper 5054/11 Multiple Choice
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<i>Question Number</i>	<i>Key</i>	<i>Question Number</i>	<i>Key</i>
1	A	21	A
2	B	22	B
3	D	23	C
4	C	24	D
5	C	25	D
6	A	26	A
7	B	27	A
8	D	28	C
9	C	29	D
10	B	30	A
11	B	31	D
12	B	32	B
13	A	33	D
14	D	34	B
15	C	35	B
16	C	36	B
17	B	37	C
18	C	38	B
19	A	39	C
20	A	40	C

General comments

A thorough and profound acquaintance with all the topics and a detailed understanding of the fundamental principles of the subject is the starting point if a high score is to be obtained.

Candidates need to be clear that any answer given corresponds to what the question asks for, and that any calculations are performed properly.

For questions requiring calculation, the calculations are best performed on spare paper before looking at the answer options given for a question; if the answer obtained is not one of the options, then this is an indication that an error has been made.

For other questions, it is essential that candidates read all of the options given before selecting the correct answer.

Comments on specific questions

Question 11

Many candidates realised that the arrangement of forces in options **C** and **D** could not produce a force of size 4.0 N and most candidates selected the correct option, **B**. Option **A** was also popular, despite the length of the appropriate diagonal being even longer than that of the diagonal in **C**. These candidates may have been considering the other diagonal of the parallelogram.

Question 13

Nuclear power stations usually differ from other types of power station, such as the oil-fired power station mentioned in the question, in the way in which the water is heated in the boiler. The generation of the electricity from the heated water is effected in an almost identical manner.

Whilst most candidates gave the correct option **A**, each of the incorrect options was chosen by many other candidates.

Question 14

The majority of candidates gave the correct answer but a few made errors. **C** was the most commonly selected incorrect option.

Question 15

Option **D** was the most commonly selected answer amongst the candidates, despite the reference made to the car having four tyres.

Question 18

The correct option was the most frequently chosen, but more than half of the candidates incorrectly chose answers **A** or **B**, suggesting that a number of candidates did not really know what the terms *sensitivity* and *range* mean.

Question 19

Both options **B** and **C** proved attractive for a minority of candidates. It is the size of the spaces between the molecules that increases when a solid is heated, rather than the size of the molecules themselves.

Question 24

Many candidates struggled with this question.

In order to determine the location of the image, it is necessary to trace the emergent rays back so that the point from which they seem to come can be deduced. The ray through the optical centre does not deviate on passing through the lens and so tracing it back is very straightforward. When this is done, it is clear that the image is smaller and upright.

Question 26

This question was answered correctly by just less than half of the candidates. Candidates needed to recall that a sound wave is longitudinal and apply a correct understanding of the motions of a particle in a longitudinal wave to a particle at point P.

Question 28

Most candidates correctly deduced the direction of the magnetic field but rather more candidates chose option **A** than chose the correct option, **C**. Whilst the direction in option **A** is correct, the uniform spacing does not represent a magnetic field that becomes weaker as the distance from the vertical, current-carrying wire increases.

Question 29

The correct answer was the most commonly selected but all of the other options attracted a few candidates. Options **B** and **C** were equally popular.

Question 32

The correct option **B** was chosen by more candidates than any other option but each of the three incorrect options was chosen by a significant number of candidates. The negative charge on the electrons results in the direction of the current being in the opposite direction to their velocity, and this effects the direction of the force on them.

Question 34

There were two stages here; first the trace on the oscilloscope screen needed to be interpreted and then the distance travelled by the sound calculated. Some candidates omitted to divide by the factor of two and gave an answer that was double the correct answer. A very similar number of candidates divided by four and gave option **A**.

Question 35

The majority of candidates selected the right answer from this two stage question.

A significant number of candidates had the effects on the two voltmeters the wrong way around, and a few candidates gave options **A** or **D** where the effects on the two meters were the same and where the total voltage would have had to change.

Question 36

Most candidates realised that only a beta source could be used for this purpose, but nearly as many chose option **A** as chose the correct answer, option **B**.

Not only would a source with a half-life of one hour prove unsatisfactory because of the frequency with which it would need to be replaced, but the rapid decrease in the radiation that would be detected over several minutes could very well be misinterpreted as being due to a change in the thickness of the aluminium.

PHYSICS

Paper 5054/12 Multiple Choice
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<i>Question Number</i>	<i>Key</i>	<i>Question Number</i>	<i>Key</i>
1	C	21	A
2	B	22	C
3	C	23	B
4	A	24	C
5	D	25	A
6	A	26	C
7	D	27	B
8	B	28	D
9	B	29	B
10	B	30	D
11	D	31	A
12	D	32	C
13	B	33	A
14	A	34	A
15	A	35	C
16	D	36	D
17	C	37	D
18	C	38	B
19	D	39	C
20	C	40	C

General comments

A thorough and profound acquaintance with all the topics and a detailed understanding of the fundamental principles of the subject is the starting point if a high score is to be obtained.

Candidates need to be clear that any answer given corresponds to what the question asks for, and that any calculations are performed properly.

For questions requiring calculation, the calculations are best performed on spare paper before looking at the answer options given for a question; if the answer obtained is not shown as one of the options, then this is an indication to the candidate that he or she has made an error.

For other questions, it is essential that candidates read all of the options given before selecting the correct answer.

Comments on specific questions

Question 7

Although the correct option **D** was chosen more commonly than any of the others, a significant number of candidates opted for each of three incorrect choices. Option **A** was the second most frequently chosen answer. It is the case that the rod does not move vertically or horizontally, as the forces in these directions cancel; these forces, however, do produce a moment about the centre of the rod and consequently the rod exhibits rotational motion. There may have been candidates who, reading option **A** first, decided that **A** was the correct answer and did not read any of the other options.

Question 15

This question was very poorly answered by most candidates, including the otherwise better-achieving candidates. Candidates were distracted by the incorrect answer **B**. Both **B** and **A** correctly calculate the work done that increases the gravitational potential energy but the option **B** gives the total work done on the block, and not W , the work done against friction.

Question 16

The majority of candidates gave the correct answer but a few made errors. **C** was the most commonly selected incorrect option.

Question 22

The correct option was the most frequently chosen, but more than half of the candidates incorrectly chose answers **A** or **B**, suggesting that a number of candidates did not really know what the terms *sensitivity* and *range* mean.

Question 23

A significant minority of candidates selected option **D** rather than the correct option **B**. This is the answer that would have been correct had the resistance at 0°C not been $100\ \Omega$ but zero.

Question 26

Here the wavelength was given in cm rather than m, whereas the speed was given in m/s. Candidates who did not convert before calculating the answer did not obtain the correct answer.

Question 31

This question was answered correctly by just less than half of the candidates. Candidates needed to recall that a sound wave is longitudinal and apply a correct understanding of the motions of a particle in a longitudinal wave to a particle at point P.

Question 33

Although many candidates supplied the correct answer, there were significant numbers who chose one of the incorrect options. Perhaps ultrasound was confused with ultraviolet radiation.

Question 36

Transformers, which operate as a consequence of electromagnetic induction, only induce an output when the magnetic field is changing and thus do not induce an output when the input is from a direct current (d.c.) supply. A minority of candidates gave the correct answer.

Question 38

The majority of candidates selected the right answer from this two stage question.

A significant number of candidates had the effects on the two voltmeters the wrong way around. Only a few candidates gave options **A** or **D** where the effects on the two meters were the same and where the total voltage would have had to change.

Question 39

This was well done, but a few candidates appeared to be unfamiliar with the effect on the trace of adjusting the oscilloscope controls.

PHYSICS

Paper 5054/21
Theory

Key messages

- Candidates should set out and explain each stage in their working clearly when completing questions requiring calculations. If no working is shown, candidates cannot gain credit for working when the answer is wrong.
- Numerical answers should be shown to at least two significant figures and the unit given.

General comments

- There is no need for candidates to repeat the question in their answer.
- Candidates should be able to give definitions clearly in words as well as being able to recall related formulae.
- Candidates should be reminded to use the number of marks given for each question as a guide to the detail they should give in their answers.

Comments on specific questions

Section A

Question 1

- (a) The formula for calculating average speed was well known and the measurement of time reasonably well described. The most common error was omitting the use of an instrument to measure distance, e.g. a measuring tape, trundle wheel or even a metre rule.
- (b) The majority of candidates recognised that deceleration is a decrease in speed or velocity, although some answers suggested that it is a decrease in acceleration. The formula for acceleration in terms of change in speed and time was well known in part **(b)(ii)**.

Answer: **(b)(ii)** 4.5 m/s

Question 2

- (a) Most answers to part **(a)(i)** suggested that the forward and backwards forces are equal or that there is no resultant force. A number of answers were imprecise in specifying the necessary conditions for the forces to cancel or did not make clear that the two forces that cancel are in opposite directions. Part **(a)(ii)** was less well done, with fewer candidates making it clear that the box must be moving or rubbing over the surface for a heating effect. There were also comparatively few correct answers to part **(a)(iii)**, with many answers simply suggesting that there should be constant motion rather than describing that this means a constant speed and direction or a constant velocity.
- (b) The calculation in this question was well done. Most candidates used the resultant force rather than the applied force to calculate the acceleration and the correct unit was given.

Answer: **(b)** 0.60 m/s²

Question 3

- (a) The majority of candidates recognised that pressure is caused by the molecules hitting the sides of the bag. Fewer answers gave sufficient additional detail, linking the force and the area with the pressure created.
- (b) The calculation of pressure was well done. There were some errors in understanding what is meant by kPa but these usually did not affect the final result. The assumptions made in part **(b)(ii)** were often just restatements of the question, for example that the pressures were as given rather than that the temperature has stayed constant or that no gas has escaped from the bag

Answer: **(b)** 400 cm^3

Question 4

- (a) Although many candidates recognised that work is force times distance, only a few mentioned that this distance must be the distance moved in the direction of the force. Many answers were vague such as “work is done when energy is transferred into a system”.
- (b) The formula for gravitational potential energy was well known but there were a number of wrong units, for example N instead of J.
- (c) The most commonly-seen answer was that friction had occurred. The best answers followed this by explaining that the presence of friction means that more work must be done on the rope itself because a larger force has to be applied.

Answer: **(b)** 21 J

Question 5

- (a) Candidates often knew the basic circuit with the correct position for a voltmeter and ammeter but did not include the variable resistor asked for as well as the resistor under test. Sometimes the variable resistor was drawn as a thermistor or was the only resistor in the circuit.
- (b) The formula and calculation of resistance was almost always correct in part **(b)(i)**. Many candidates calculated the power of the heater in **(b)(ii)** correctly, using the formula $P = VI$. Sometimes the notional value of 3.9Ω was used instead of the resistance already calculated. A significant number of candidates stated, in part **(b)(ii)**, that the resistor overheats because either voltage or current is greater than resistance, rather than calculating the power. In part **(b)(iii)**, a number of candidates stated that when the resistors are connected in series they share the current, rather than sharing the voltage. The most successful answers quoted the new voltage across each resistor as half the original voltage. Some even calculated the new value of power, although such detail was not required.

Answer: **(b)(i)** 3.5Ω

Question 6

- (a) The majority of answers correctly showed the rod within a coil or solenoid. Some scripts showed the current in the coil as alternating current, confusing the process of magnetisation with demagnetisation. A few answers showed a current flowing through the rod itself.
- (b) The best answers used repulsion from one end of a permanent magnet as a test to see if the rod was magnetised. Many scripts suggested the attraction of unmagnetised iron samples as a test but it was sometimes not clear that, for example, a paperclip used in the test must be itself initially unmagnetised.

Question 7

- (a) Many answers simply stated that the person becomes “induced with charge” without explaining how this happens as a result of friction when he walks across the carpet. The idea that the charge

on the person is neutralised when the person touches the door handle, as electrons flow from or to the person, was often also missing.

- (b) Most candidates realised that like charges repel and unlike charges attract but they did not always apply this idea to the whole of the electrostatic spray painting pattern shown in the question. The diagrams show that the drops spread out more as they leave the positively charged nozzle; this is caused by the repulsion between the drops. Most answers give in (ii) however did usually clearly explain the effect of the negative charges on the back of the leg in attracting the positive paint drops.

Question 8

- (a) The idea that the transformer is a step-down transformer and that coil A has the larger number of turns was generally recognised.
- (b) Many candidates simply quoted facts about iron in response, for example, that it is easily magnetised and demagnetised, rather than asking what other purpose it serves in the transformer. Some candidates did realise that its function is to transport the magnetic field to the secondary coil. The question itself states that the iron core increase the magnetic field inside the primary coil and therefore the repetition of this could not gain credit.
- (c) The question asks for a description of the induction of voltage. A description of change in magnetic field or flux, or the cutting of the field lines was not often given coherently. Many candidates suggested that the voltage flows from the primary to the secondary coil.
- (d) The environmental and cost implications of underground power transmission compared to overhead lines are mentioned in the syllabus. There were many sensible advantages and disadvantages suggested, although answers sometimes needed more detail. For example, the statement “electrocution could not occur because the line was high up and above people” is better than “it is safer” as an advantage. The statement that electrocution could occur if someone “dug into the ground and hit the line by mistake” is better than the statement “it is unsafe” as a disadvantage. Good common-sense answers were often seen.

Section B

Question 9

This was the most popular question in **section B**.

- (a) Candidate found problems in establishing the truth or falsehood of all four statements, with the most common errors being to suggest that infra-red is used in sun-beds or that radio waves have the highest frequency.
- (b) The diagrams of dispersion almost always showed refraction in the correct direction on entering the glass prism but the different colours often only appeared as the ray left the glass rather than at the point that the light enters the glass. Some candidates attempted to show different colours splitting from the ray at different stages as it moved through the glass.
- (c) The statement of the speed of light and the calculation in this section was done well. There was some confusion over units; the speed of light and the distance from the Sun to the Earth used in the calculation needs to have the same distance unit, either km or m.
- (d) There was a good general knowledge of the formula relating current, charge and time in part (d)(i) and it was unusual for a candidate not to convert the time correctly into seconds. In part (d)(ii) it was common that candidates recognised that alpha particles were stopped by paper and gamma rays by thick metal or lead, or never completely stopped. Knowledge of the charge on the particles and the nature of an alpha particle were less well known. The question attempts to show what is meant by the “nature” of a particle by giving the nature of a proton and a gamma ray but many candidates incorrectly suggested that an alpha-particle was, for example, an electron, a helium atom, a positively charged particle or even a wave.

Answer: (c)(i) 3.0×10^8 m/s (ii) 500 s (d)(i) 1.5 A

Question 10

- (a) Some very good answers were produced in part (a)(i) that correctly described evaporation and boiling, usually in terms of the temperatures involved or where the change of state occurred. The question clearly required the candidates to give two separate and different differences. A number of candidates chose only to describe one difference, giving a statement about boiling in **1** and a statement about evaporation in **2**. In part (a)(ii), a very good knowledge was shown about the thermal energy needed to break the bonds between molecules to boil a liquid, and many strong answers described the molecules moving further apart
- (b) Most of the calculations in this section showed a good general knowledge. Some candidates failed to recognise initially that they should use the volume and density of water to calculate the mass in part (b)(i) but, even then, were able to use the specific heat capacity successfully in (b)(ii) with the mass they had calculated in part (b)(i). Candidates found later sections of this question more of a challenge. Many correct statements of efficiency were given, but many candidates had not recognised that the value in part (b)(ii) is the output energy of the heater and that the input energy to the heater is required. A considerable number of answers to part (b)(iv) recognised that earthing the metal pipe allows charge to flow to earth or avoids electrocution but only the strongest answers suggested how this might happen, for example if the live wire in the heater should touch the metal case or the water directly.

Answer: (b)(i) 0.077 kg/(s) (ii) 6800 J

Question 11

This was the least popular question in **Section B**.

- (a) A reasonable number of candidates were able to draw labelled diagrams of a ripple tank that contained an obvious method for generating wavefronts and a method of viewing them, often by shadows cast on a screen. In general, where a candidate had knowledge of the construction of a ripple tank, the diagrams were neat and well produced. Many candidates simply used a floating object that was made to move when a wave travelled across the tank for part (a)(ii). However a considerable number of answers stated that the object moves in the direction that the wave propagates, rather than up and down.
- (b) The difference between the waves was often given in terms of the amplitude and the similarity as the same time for one wave. Although the same wavelength cannot be deduced from the diagrams this was also accepted, since the frequency is the same. The calculations in part (b)(ii) proved to be the most challenging calculations on the paper for those who answered this question. The formula relating frequency, wavelength and speed was very well known but candidates often failed to calculate the frequency correctly from the time for one wave.

Answer: (b)(i)1 3.3 Hz (ii)2 0.060 m

PHYSICS

<p>Paper 5054/22 Theory</p>

Key messages

- Candidates should set out and explain each stage in their working clearly when completing questions requiring calculations. If no working is shown, candidates cannot gain credit for working when the answer is wrong.
- A unit should be given for the answer to each calculation and answers, when rounded, should be rounded correctly.
- Candidates should use rulers to draw or add straight lines to a diagram. This will help improve the quality of diagrams.
- Candidates need to make sure that their numbers are written clearly and unambiguously. The intent of an overwritten answer is often unclear and the answer therefore ambiguous. Candidates should cross out an incorrect numerical answer and completely rewrite it, rather than trying to change it.
- Candidates should read the question thoroughly before starting and avoid repeating the question in their answers; answers should provide information that is not present in the question stem. For example, the answer 'it can be renewed' is not sufficient when asked what is meant by a 'renewable energy source'.
- When a question asks for *one* or *a* point or feature, candidates should give what they consider their best answer. An answer including a mix of correct and incorrect statements is considered incorrect.

General comments

- Candidates appeared to have sufficient time to complete all the questions in the examination.
- Most candidates answered only two questions from **section B** but a small proportion of candidates answered all three. This is not advisable.

Comments on specific questions

Section A

Question 1

- (a) The majority of candidates were able to score full marks on this question by plotting the points accurately and drawing a smooth curve through the plotted points. A few candidates did not start their graph from the origin or simply joined adjacent points with a succession of straight lines.
- (b) (i) This section was also answered well. Most answers started by referring to the straight section of the graph and then described that this meant that there was an equal distance covered in the same time interval. Weaker candidates tended to define speed without making use of the graph or describing the general motion of the object. Some of the strongest answers stated clearly that the gradient was constant and then explained that the gradient is equal to the speed, although others failed to explain that the gradient is equal to the speed.
- (ii) Most candidates understood the concept of balanced forces. The best answers identified the downward force as being the weight of the object and recognised that this was equal to the upward

force due to the oil. The most common error was to answer this question in terms relating to free-fall in air, suggesting that air resistance is equal to weight or to state that the forces are equal, without stating the names of these forces or their directions.

Question 2

- (a) Most candidates were successful in this question. The most common incorrect answers were 140 and 175, which continued the trend of the extension for loads from 0–3N. These candidates had not realised that the spring had passed the limit of proportionality.
- (b) Candidates dealt well with proportionality in this question. Some answers made use of the formula $\text{force} = k \times \text{extension}$. The most common incorrect answers occurred when values for load and extension were used that were beyond the limit of proportionality. The unit of the final answer was occasionally omitted.
- (c) Less than half of the candidates recognised that the energy stored in the spring is larger at B and the gravitational potential energy is larger at A in part (c)(i). Many answers suggested that the load had more gravitational potential energy when it was closer to the ground.

Many candidates found part (c)(ii) challenging. Only the most able candidates were able to state that the increase of the elastic energy in the spring is equal to the decrease in gravitational potential energy of the load added to the loss in chemical energy of (or the work done by) the candidate. A large number of answers simply restated the information that had already been given in the question about the law of conservation of energy, or stated that gravitational energy changes to kinetic energy. In many answers the candidates did not state the energy forms being considered.

Answer: (a) 150 and 220 (mm) (b) 1.4 N

Question 3

- (a) Most candidates recognised that air was the material that expanded the most, although a significant number suggested that metal expands most.
- (b) A number of candidates did not answer this part. Of those who did, almost all recognised that the outer surface of the metal becomes larger but a significant number drew the hole as becoming smaller, even though this would mean that the metal on the inside is contracting on heating. Weaker candidates drew strange bubble formations that may have represented atoms in the material.
- (c) Many correct definitions for density were seen in (c)(i), although weaker candidates gave a more general description with reference to thickness. The calculation in (c)(ii) was not straightforward, as it involved the manipulation of the equation, the use of standard form and sensible rounding of the answer. The question also asks for the answer to a suitable number of significant figures. Ideally this answer should be given to two significant figures, the same number as given in the data. However three figures were accepted. A significant number of candidates were content to write down a large number of figures from their calculator and, even when they recognised that they should write down two or three, they failed to round correctly and gave, for example an answer of 0.000666 m^3 .

Answer: (c)(ii) $6.7 \times 10^{-4} \text{ m}^3$

Question 4

- (a) The question itself refers to a change in state. The relevant two extra pieces of information, that unit mass and no temperature rise are involved, were evident in only a minority of answers. A significant number of incorrect answers effectively gave a definition of specific heat capacity by mentioning both a unit temperature rise and unit mass.
- (b) The calculation in part (b)(i) is straightforward but a number of candidates failed to recognise that the mass and the specific latent heat have different mass units. The formula $L = mL$ is not ideal as it is not clear which term in the equation is the specific latent heat. Those candidates who wrote Q or $E = ml$ seemed less likely to make a mistake in applying the formula.

In part **(b)(ii)** most candidates recognised that the process involved was either conduction, convection or radiation but the descriptions did not really refer to the situation itself, where the air is not in contact with the ice at all, or described the process of melting within the ice. The strongest answers described conduction through the glass of the funnel. Descriptions of convection did not answer the question as it asks how the thermal energy passes from the air to the ice and not how thermal energy passes around in the air.

Answer: **(b)(i)** 1650 J

Question 5

- (a)** The formula relating speed, distance and time was well known but a significant number of candidates did not account for the reflection and calculated the total distance travelled by the signal rather than the distance to the satellite.
- (b)** In part **(b)(i)** a number of candidates did not seem to understand that a wave can be both transverse and electromagnetic. A good proportion of the answers to part **(b)(ii)** were correct, usually describing the higher pressure present at a compression but sometimes that the particles are closer together. There was some confusion among weaker candidates who suggested that the waves were closer together or that the wavelength was smaller at a compression.

Answer: **(a)** 3.6×10^7 m

Question 6

- (a)** It was unusual to find an answer where *none* of the three possible rays from the top of the object were drawn correctly through the lens. A few answers had *some* of their rays passing incorrectly through the lens. The ray parallel to the principal axis should be drawn bending at the central axis of the lens and the unbent ray drawn passing through the exact centre of the lens. Rulers should be used to draw the rays.
- (b)** There were two possible correct answers; either of them appeared to be equally likely to be presented. A number of candidates offered more than one feature, and some of these were a mixture of right and wrong features. The answer 'enlarged' is repeating information given in the question stem.
- (c)** The calculation of magnification proved to be more of a challenge. Either image height \div object height or image distance \div object distance was accepted, but sometimes candidates needed to measure these distances more carefully.

A significant number of candidates gave a unit for the value of magnification (usually cm), which was not accepted. Some candidates did not quote the formula used for magnification and used wrongly measured values. Unfortunately the lack of explanation meant that credit could not be given.

- (d)** Less than half of the candidates gave an optical device that produces a magnified real image. A *projector* or *photographic enlarger* was often given correctly as the answer but a *magnifying glass* was not accepted as this produces a magnified virtual image.

Answer: **(c)** 1.5

Question 7

- (a)** The question asks for a test to find out if a sample is magnetic rather than being magnetised and there was some confusion evident in the understanding of the difference between a magnetic material and a magnet. Some candidates thought that the test was whether the material was a magnet and mentioned only repulsion. However, a magnetic material such as iron is likely to be attracted to both ends of another magnet. Weaker answers suggested that magnetic materials were attracted to the magnet and non-magnetic materials were repelled.
- (b)** Although most candidates correctly stated that like poles repel, the direction of this force was often not clear and a statement such as 'from the N-pole to the S-pole' may have been describing to the left or the right depending on which N-pole and S-pole were being described. The strongest

answers gave a clear direction, for example to the left. Weaker candidates appeared to be confused about the 'direction of the magnetic force', confusing this force of repulsion with the direction of the magnetic field. Many stated that it followed the field lines. A small number of responses suggested that Fleming's left-hand-rule shows the direction of the force or confused magnetic repulsion with electrostatic repulsion and stated that like charges repel.

In **(b)(ii)** the majority of answers showed the direction of the field correctly, emerging from the N-poles at the boundaries of region 1 and region 2. The majority of candidates gave reasonable explanations of why a voltage is induced in **(b)(iii)** despite the situation likely being a novel context for them. Some candidates did not realise that the magnetic field cuts the coil or that the magnetic flux within the coil changes and incorrectly stated that the magnetic field of the coil itself is involved.

Question 8

- (a)** Earthing, double insulation and a circuit/contact breaker were all popular choices for other forms of protection. A number of other suggestions such as having a neutral wire, a relay, a 3-pin plug and even that the wires are insulated were not accepted, the latter because it was felt that such insulation was so basic to the working of the lighting circuit as not to count as a form of protection. Some weaker candidates gave an answer of 'fuses' which suggested that they had not read the question carefully.
- (b)** The great majority of answers in **(b)(i)** correctly stated that the live wire is connected to the fuse. A number of candidates in **(b)(ii)** failed to mark the position of the switch at all on the diagram. Others drew the switch in the neutral wire or even drew a switch connecting the live and neutral wires. The majority of answers correctly described the action of the fuse although a number stated that the rating indicated that current in the circuit was 5 A rather than that the maximum current is 5A.

Section B

Question 9

This was the most popular question in **section B**.

- (a)** The majority of answers to the first part recognised that renewable energy sources do not run out or are continually being replaced. There were many answers that suggested such sources can be "used again" or "recycled", which is repeating the information in the question stem. The most popular acceptable answers to the second part were solar or geothermal energy. A significant number of answers referred to "water", without specifying how the water was used, e.g. as water waves or in a hydroelectric power station. The most common acceptable answer in **(a)(iii)** was the burning of fossil fuels and the production of carbon dioxide as a greenhouse gas. A popular misconception was that the waste heat from power stations causes global warming. There was also confusion with the effect of the ozone layer or the production of toxic or hot gases.
- (b)** A good number of candidates successfully negotiated the calculations in this question and the formulae used were generally well understood. In particular, the formula for kinetic energy was well known in the first part, although candidates should be sure to square the velocity in any calculation. The question in the second part asks for energy, not power. Most scripts gave the correct equation for the third part, but many did not convert the time into seconds. Some weaker candidates used their value from the the previous part and subtracted this from the turbine power. Many candidates were able to state the formula for efficiency for use in the third part, or show some form of efficiency calculation. A common error was to state that efficiency is the input energy or power over the output. Many answers expressed the efficiency as percentage, which is not essential but when the answer is expressed as a percentage, the % sign is needed.
- (c)** This section was answered well. The graph in the first part was usually sketched correctly, with care taken over plotting the peak voltage and time period. Weaker candidates took less care in drawing the graph, which resulted in peaks and troughs varying across the diagram. It was particularly encouraging that many sketches showed the correct time period of 0.02 s.

In part **(c)(ii)**, most candidates stated correctly that electricity is transmitted at higher voltage in order to reduce energy or power loss but a significant number of answers suggested that this reduced or increased resistance rather than stating that the current is reduced. When explaining why a transformer is needed between the transmission line and a house, stronger candidates

explained the need for the voltage to be stepped down so that it was safe to use but there were a number of general answers that did not make clear which type of transformer was being used or that the voltage is being reduced, particularly in answers that described both step-up and step-down transformers.

Answer: (b)(i) $4.7 \times 10^9 \text{ J}$ (ii) $1.5 \times 10^9 \text{ J}$ (iii) 0.32

Question 10

- (a) Less than half of the candidates gave a sensible definition of potential difference in terms of energy change per unit charge. A number of answers suggested it is the energy change when a charge passes through a resistor but most answers were given in terms of the product of current and resistance or just that potential difference is a change in voltage, which was not accepted.
- (b) The large majority of candidates successfully calculated the resistance in (b)(i) but fewer were able to calculate the e.m.f. of the battery. This was most often done by calculating the p.d. across the 10Ω resistor and adding it to 9.6 V but other candidates successfully calculated and used the total resistance. It helps if candidates explain their calculations, in the latter case by stating total resistance = 50Ω and the formula being used to calculate the e.m.f.
- (c) Most candidates recognised that the $0\text{--}20 \text{ V}$ voltmeter is the best meter to use in this instance. Explanations as to why the other meters were not as suitable were often too brief and ambiguous.
- (d) The calculation of power in (d)(i) was successful in most cases with the correct unit usually being given. A number of candidates, however, found the power produced in the 40Ω resistor.

The answers to (d)(ii) often suggested that using a resistor of a lower maximum power changes the current in the circuit, despite the fact that the question suggests that the resistor has the same resistance. Only a few candidates were able to explain that using a resistor with a power rating of $\frac{1}{2}P$ means that the resistor would overheat in this circuit.

- (e) Many of the answers to this question started from the incorrect premise that adding another resistor R in parallel to the 40Ω resistor increases rather than decreases the total resistance of the circuit. This then led candidates, when deciding upon and explaining the effect on the p.d. across the 10Ω resistor, to suggest that the p.d. across the 10Ω resistor decreases, even though the question clearly states that the current in the 10Ω resistor increases and candidates should know that p.d. is proportional to current. Only a few candidates were able to think through these changes logically and achieve full marks.

Answer: (b)(i) 0.24 A (ii) 12 V (d)(i) 0.58 W

Question 11

This was the least popular question in **Section B** but, overall, the marks obtained were as high as for **Question 9**.

- (a) The diagrams drawn in the first part were often of a lower standard than the subsequent explanations, omitting necessary detail. Many candidates merely discussed the conclusions or analysis of the results without stating what was actually measured or how the apparatus was used in the second part.

Most successful answers were either based on the use of paper as an absorber, by the shape and length of tracks in a cloud chamber or by the deflection of the particles in an electric or magnetic field. Where a cloud chamber was described, there were many good attempts with the source inside the chamber and with some additional detail such as alcohol vapour and dry ice that would allow tracks to form. With absorption methods, a detector and a counter were needed for completeness, and where deflection was used, some type of detector was also needed to be able to demonstrate deflection in a field. This detector was most commonly a GM tube and counter.

In the second part, the described use of the apparatus specified in the first part could not always prove that proved that the particles emitted are alpha-particles.

The most common and straightforward described use was to obtain a count with the source alone and then with paper between the source and the detector, specifying in the third part, that a decrease in the count proves the emission of alpha particles.

Some described uses involving a cloud chamber required some method of producing a deflection in a field for the second part. Such deflection is actually very small and difficult to observe for alpha particles but it is possible to show and was accepted.

- (b) Answers to this section almost always showed the right comparison, with, for example, alpha-particles having the highest ionising effect and gamma the weakest. Some answers did not distinguish between particles with the weakest effects and simply stated that alpha-particles have a greater ionising effect than beta particles and gamma rays.
- (c) A number of answers simply stated that americium has a longer half-life with no further detail, which is repeating the information given in the stem. Candidates needed to explain why this longer half-life makes americium-241 more suitable. Stronger answers stated that the americium source would not need to be replaced as often, as it would take longer to decay. Some weaker answers suggested that, as the half-life was short in radium-224, it would be more dangerous as it decayed quickly.

The second part was very well done, with almost all candidates attempting to halve the initial number of atoms, although sometimes the answer was left as just 3 or as 3 half-lives without converting these half-lives back into years.

- (d) The harmful effects of radiation in (d)(i) were well known. The most common answer was 'cancer'. The explanations in (d)(ii) usually recognised that the source would be held further from the hand if a long-handled tool is used but often did not explain that this decreases the amount of radiation striking the hand because either the particles are stopped by air or that they spread out in all directions. Many answers merely relied on a statement that the source was less likely to come into contact with the body, but even a short-handled tool keeps the source from contact with the body.

Answer: (c)(ii) 1290 years

PHYSICS

Paper 5054/31
Practical Test

Key messages

The aim of this paper is to test practical physics skills, such as: following instructions safely, using simple equipment to obtain sets of data, processing data to produce sets of results, and judging the validity of results in order to draw conclusions from them.

In order to produce good responses, candidates needed to have mastered basic practical skills enabling them to handle equipment safely, to work carefully and methodically, and to make observations and record obtained results (with repeat measurements when possible). Readings taken from an instrument such as an ammeter or voltmeter should be recorded to the precision shown by the instrument.

The working for calculations should always be shown, the units for quantities should always be stated, and final answers should be given to a number of significant figures consistent with the raw data.

In the case of answers where the unit required is printed on the answer line, candidates should ensure that their responses are given in that unit.

General comments

Good responses demonstrated that the candidates are able to:

- read the question and perform the tasks requested
- make careful observations and take measurements carefully to an appropriate degree of precision, with repeat measurements whenever appropriate and practicable
- construct tables of results
- perform calculations by substitution into equations
- plot line graphs
- make comments, predictions or comparisons using their results.

Some weaker scripts gave comparisons that were not specific enough. Candidates should note that, when making comparisons, the terms 'change' and 'vary' are too vague and terms such as 'increasing', 'decreasing' and 'stays the same' should be used, as they are more specific.

It is in the interests of the candidates that a complete set of results for all of the experimental tasks given in the paper is provided with the Supervisor's report. It is also important, and beneficial to the candidates, that the apparatus used by them complies as closely as possible with the specifications for equipment given in the Confidential Instructions sent to centres.

The plotting of graphs continues to improve.

There are an increasing number of otherwise good scripts demonstrating bad practice by using very difficult scales on plotted graphs. In these scripts, candidates seem to be choosing their axis scale by finding difference between the first and last values and comparing this with the number of squares on the grid. This should be avoided, as it can result in axis scales where 3, 6 or 7 units are matched to 10 small grid lines. The best scales have 2, 5 or 10 units corresponding to 10 small grid lines and are easy to use. Scales based on 3, 6, or 7 should be avoided where possible.

The plotted points on a graph should be clearly but finely marked and the best-fit line drawn carefully.

Comments on specific questions

Section A

Question 1

(a) The unstretched length of the coiled part of a spring was measured. The measurement was expected to be in cm but millimetres or metres would have been accepted provided the value was given to the nearest millimetre (or better). The best responses listed repeat measurements.

(b)(i) The spring was attached to a mass holder using a string which was passed over a rod so that the string was in contact with one quarter of the rod's circumference. As the spring is held horizontally and pulled gently, a critical point comes where the mass holder starts to move. Candidates were asked to measure the length of the string at the point where the mass holder starts to move.

This measurement was designed to be challenging. There should have been a noticeable increase in the length of the spring over the unstretched length. The best responses recorded several repeat measurements. A precision better than the nearest millimetre was unrealistic, given the challenges of the measurement. Responses giving a higher precision were not awarded the mark.

(ii) The string was then wound around half the circumference of the rod and the measurement repeated, and again with the string wound around three-quarters of the circumference. Each time, the length of the spring was measured at the point when the mass holder was just starting to move. There should have been an increase in the length of the spring at the critical point with the increase in the fraction of the circumference in contact with the string.

(c) A correct set of results would have indicated that, as the string was in contact with more of the rod's circumference, the spring was extended more. The best responses suggested that this was due to increased friction between the rod and the string. Weak responses simply quoted the results or quoted Hooke's law and made no reference to friction.

Question 2

(a) Weak responses made no mention of the harm that could be caused by careless handling.

(b) Good responses described how the rate of temperature decrease was initially rapid but the rate decreased with time. Weaker responses stated that the temperature simply decreased and this was insufficient to be awarded the mark.

(c) Candidates were asked to determine the time taken for the temperature on the thermometer to decrease from 60 Celsius to 40 Celsius and to repeat and then average the measurement. Good responses had times between 20 and 90 seconds and showed the raw values and the working for the average as well as giving results to a precision of up to two decimal places.

(d) The experiment was repeated but with an aluminium cover placed over the bulb of the thermometer as soon as it had been lifted out of the hot water. Candidates were asked to determine an accurate value for the time taken for the same reduction in temperature. Good responses listed repeated measurements of the time in seconds (two or three were sufficient), correct averaging, precision of up to two decimal places and values that were considerably longer than the value obtained in part (c). Weaker responses usually omitted the repeats.

(e) Weaker responses were often too vague, just quoted results without a valid explanation or referred to the aluminium being a conductor without answering the question (i.e. with no reference to convection).

Question 3

Many candidates gave good responses to this question

- (a) Candidates were asked to record the potential difference (in volts) across a resistor as they added 50 cm^3 portions of salt solution to a beaker containing two electrodes attached to the circuit. The potential difference should have increased each time but by decreasing amounts. Good responses should have obtained voltages in the range 0.20 to 2.6 Volts and given their values to at least one decimal place (preferably to 2 decimal places).
- (b) Good responses used two sets of readings and calculated the current in the circuit for each set. Most calculations showed agreement with the statement that the greater the volume used, the greater the current. Some weaker responses confused volume with voltage and consequently gave incorrect calculations. Some responses referred to Ohm's law and explained that as the volume increased the voltage increased and therefore the current would increase, but omitted calculations to demonstrate this and therefore did not answer the question which specifically asked for two calculations to be carried out.

Question 4

- (a) The time taken for 30 cm^3 of water to drain through the hole in a can was measured. The best responses showed repeated measurements and obtained values over 10s recorded to at least 1 decimal place, using correct decimal notation. Weaker responses simply copied the stopwatch display, including colons.

There were many good responses to the third part, giving the answers to 2 or 3 sig. figs. and stating the correct unit.

Candidates found the fourth and fifth parts more challenging. Most of the times recorded for the collection of 60 cm^3 of water were larger than the time for 30 cm^3 , as expected, but were too large, so that the calculated flow rate was smaller than the value obtained for the first calculation of the flow rate.

- (b) Good responses had table headings completed with the correct units (time in seconds), using the second and third columns for the first and second sets of times and the fourth column for the average of those two times. Weaker responses sometimes listed times in minutes and mixed units. Some gave calculated flow rates even though the question clearly stated that the flow rates were not required for this part of the question.

Good responses listed 8 sets of results distributed over the whole range of volumes specified, with averages correctly calculated and times given to a consistent precision. A good set of results would show the average times taken increased by increasing amounts as the volume in the measuring cylinder increased. Weak responses provided fewer sets of data, or no repeats and/or erratic precision.

- (c) Candidates were asked to plot the (average) time (on the y-axis) against the volume (on the x-axis). A number of otherwise good responses showed some very poor choices for the scales, particularly for the volume. A perfect set of results would have produced a smooth curve with increasing gradient, but perfect results would hardly ever be obtained and it was expected for plots to be scattered and the best-fit curve drawn based on those scattered points. A line joining one plot to another by straight lines (dot-to-dot) or without effort to make a best fit was not accepted.
- (d) Good responses showed a well-judged tangent drawn to make point contact with the curve at the point where the volume was 70 cm^3 and extending a good length either side of that point. Good responses also showed their working and gave the final answer to a precision of 2 or 3 sig figs. Weaker responses often drew a gradient triangle but went on to incorrectly use values from the table which were not on the tangent or used small inaccurate gradient triangles or misread coordinates.

PHYSICS

Paper 5054/32
Practical Test

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PHYSICS

Paper 5054/41
Alternative to Practical

General comments

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

- graph plotting;
- taking measurements;
- tabulation of readings;
- manipulation of data to obtain results;
- drawing conclusions;
- dealing with possible sources of error;
- control of variables.

The level of competence shown by the candidates was sound. Candidates need to make sure that they bring the appropriate equipment with them to the examination e.g. pencils, rulers and protractors as well as pens.

Only a very small number of candidates failed to attempt all sections of each question, and there was no evidence of candidates suffering from lack of time. The more able candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly, although many were unable to give an answer to the correct number of significant figures. Units were generally well known and usually included where needed. The standard of graph drawing could be improved.

Comments on specific questions

Question 1

- (a) An experiment to compare the conductivity of different metals was described. It was hoped that the candidates would have seen this experiment or a similar one performed. They were then asked to state two features of the apparatus which ensured the experiment was carried out fairly.

Most candidates could name at least one e.g. 'same length of rod' or 'same amount of wax' but a number gave responses such as 'same amount of heat', which could not be deduced from the diagram, and was not a feature of the apparatus.

- (b) The majority of candidates could explain how the apparatus determined which metal was a better conductor and this question was well answered.

Question 2

(a) (i),(ii) In this question, candidates were expected to compare a stretched spring with an unstretched spring. In **(a)(i)** they were asked to show the difference in length on the diagram. This was poorly answered in many cases. Candidates need to unambiguously show the distance from the same point on each spring – a sharp pencil and dotted lines at the points to be measured make this clearer. In **(a)(ii)** they were asked to describe how this was done. Examiners were looking for a practical explanation here which would give reliable measurements and candidates found this challenging.

(b) In **(b)(i)** the majority of candidates explained that the wooden rod needed to be horizontal in order to ensure that the load was evenly shared.

(ii) In **(b)(ii)** some candidates suggested the use of a spirit level to ensure that the rod was horizontal and this was given credit. The more expected answer of taking measurements at each end of the rod from the floor or from the metal bar to the rod was rarely seen. A few candidates suggested taking these measurements but omitted to say that they should be equal and so failed to gain the mark.

(iii) In **(b)(iii)** it is pleasing to see that the standard of graph plotting continues to improve and most candidates were awarded at least three marks out of the available four.

Axes were generally labelled with the quantity and unit and sensible scales were used. The points were mostly plotted correctly although a few candidates continue to lose marks by making their plotting points larger than half a small square.

Most errors arose in the drawing of a smooth curve. Many candidates assume that their line must go through every point and this is not the case – this is real practical data and it is rarely that perfect. Consequently, many lines were not smooth.

(iv) In **(b)(iv)** the majority of candidate were awarded the mark for the general trend of their graph but only the more able candidates realised that this relationship showed an inverse proportionality.

Question 3

(a) (i), (ii) In **(a)(i)** the majority of candidates could name a piece of apparatus used to accurately measure a small diameter. Candidates could also measure the diameter of the bead given in **(a)(ii)** accurately. However, explanations of good practice in taking this second measurement were rare.

(b)(i) This part-question required the candidates to find the average density of glass beads.

In **(b)(i)** they were asked to find the total volume of the beads. Many candidates gave good responses here using either a method using a measuring cylinder or a displacement can. Some marks were lost through the use of beakers rather than measuring cylinders to find the displaced volume of water, as a beaker would not be accurate enough.

Some candidates suggested finding the volume of each bead individually, which would be time consuming and inaccurate. This method was not given credit. Other candidates described a method of finding the mass rather than the volume.

(b)(ii) Candidates found **(b)(ii)**, which required a precaution to ensure an accurate value, challenging. The mark was accessible to the more able candidates. A simple statement of ‘avoid parallax’ is not enough; candidates need to explain specifically how a parallax error might be avoided in the context given.

(b)(iii) In **(b)(iii)** the calculation was generally performed without difficulty. Some candidates lost the mark by not giving their answer to three significant figures.

Question 4

- (a) Only a few candidates named the apparatus needed to carry out this experiment, with the ruler being the most common omission.
- (b) The majority of candidates did well here by describing how to trace a ray of light through a glass block. Weaker candidates simply copied the diagram from 4(c), which did not gain credit. The use or placement of pins or crosses to trace the ray of light needed to be seen. The most common omission was failing to explain that the plotted ray needs to be extended to the boundary of the block.
- (c) This was generally answered well by those candidates who had brought a protractor with them to the examination. A number of candidates guessed the size of the angles; others failed to measure the correct angles.
- (d) Candidates struggled with this question. Candidates are expected to be able to draw up the skeleton of a suitable results table. Many did not include all the required measurements with units in their tables and others lost a mark for not suggesting a suitable range of incident angles between 10° and 80° .

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

- Candidates should be made aware that it is important to record measurements to a precision appropriate to the measuring instrument used. In particular, measurements made with a ruler with a scale marked in millimetres should be given to the nearest millimetre. If the length measured by such a ruler is, say, exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidates often lose credit for lack of care and attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams can be greatly improved by using a sharp pencil and a ruler.
- Candidates should be advised to avoid using rote 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 improves or how parallax error is 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 best-fit line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.
- Candidates should be advised to read the questions through carefully and ensure that they are answering the question that is being asked rather than recalling the answer to a different question.
- Candidates will need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability, and control of variables.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations will need to be based on data presented in the question from the related practical, rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where the unit is not given. 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 the candidates was sound, although, as in previous years, some candidates continue to approach this paper, as they would a theory paper, and not from a practical perspective. Only a very small number of candidates did not 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. The 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. The standard of graph plotting continues to improve.

Comments on specific questions

Question 1

- (a) Most candidates drew the correct symbol for a voltmeter and placed it correctly in parallel with the lamp. Occasionally the voltmeter was connected across the variable resistor or the cell. Very rarely did it appear in series in the circuit.
- (b) The scales of both meters were usually read correctly, but a sizeable minority of candidates have trouble reading analogue scales. The easier of the two scales to read was that of the voltmeter and this was rarely read incorrectly.
- (c) Rounding errors were fairly common here, especially for the second calculation of the resistance of the lamp. Despite being asked to record their answers to a number of significant figures consistent with the data in the question, many candidates ignored this and consequently lost this mark.
- (d) Very few candidates realised that they were being asked to compare the numerical values of the resistance of the lamp at the two different voltages and make a sensible comment as to whether the resistance of the lamp remained constant, or not. It was expected that candidates would compare the two values and make a comment to the effect that the values were too far apart for the difference between them to be attributed to experimental error.
- (e) Most candidates ignored the instruction to look at the observations in the given table of results and to use these observations to decide whether the resistance of the filament of the lamp had increased when it got hot. Only the most able candidates established the link between brightness, temperature and the resistance of the filament.

Question 2

- (a) Most candidates used a ruler and protractor and drew neat diagrams. The use of protractors still causes difficulty and many candidates did not draw the ray incident on the mirror with an angle of incidence of 40° , but had an angle of 50° instead.
- (b) The reflected ray was almost invariably drawn correctly, but a surprisingly large number of candidates measured the angle of reflection as 40° . The results given in these questions are drawn from the likely set of results obtained 'in practice'. Candidates should realise that, in practice, the measured angles of incidence and reflection are not always exactly equal because of

the limits of the accuracy involved in drawing lines and measuring angles. In the diagram provided, the angle of reflection was actually 42° .

- (c) Instead of describing a precaution that the candidate should take when placing the pins, many candidates simply described the method of performing such an experiment. Others gave answers that were too vague to award credit e.g. 'place the pins straight'.

Question 3

- (a) Most candidates measured the length and width of the given block accurately, but a sizeable proportion of these did not record the length of the block to the nearest millimetre.
- (b) The scale of the newton meter was usually read correctly.
- (c) The calculation of the pressure exerted by the block on the table was done well.
- (d) Only the most able candidates gave satisfactory. Candidates were asked to suggest a practical reason as to why the pressure exerted by the block on the table would be greater than the value they had calculated. Very few candidates realised that the outline traced around the block would be slightly larger than the actual area of the block.

Most candidates focused on explanations in terms of poor experimental practice, for example, parallax errors.

Question 4

- (a) Only about half of the candidates scored both marks here. Many candidates did not read the question carefully and take readings from the given diagram. Other candidates did not take their measurements to the nearest millimetre; many also failed to give a unit with their answers.

Despite the clear instruction that candidates should show their working, there were many instances of a number, often without a unit, written on the answer line with no working shown.

- (b)(i) Many candidates lost this mark because they did not enter the distances into the table with an appropriate precision. The missing value for y was usually entered into the table as 30 instead of 30.0, despite the fact that all the other values of y already in the table were to three significant figures.
- (ii) The graph proved to be straightforward for candidates to plot from data provided in the question, with many scoring 3 or 4 marks.

There was an ambiguity in the processing of the raw data to create the points in the third column, used for plotting the graph. The full range of potentially correct answers was allowed by the mark scheme, including answers where candidates had recalculated the data used to plot the graph. The overwhelming majority of candidates did not recalculate data, and simply plotted the points given in the table.

The units of the plotted quantities were often missing from the labels.

A choice of scales involving multiples of 3, 7 etc. was much less evident this year than in previous years. There were many very good attempts at drawing the best-fit line through the points. The standard of plotting and of line drawing continues to improve and the incidence of large dots or thick lines is far less common. The most common plotting error was the mis-plotting of the final point at 56 and not 50.6.

- (iii) Marks were most commonly lost here because the points chosen to make the gradient calculation were too close to each other. Candidates should be taught to use at least half the space between the extreme plotted points when calculating the gradient of a line.

Many candidates did not make it clear on their graphs which points they chose, despite being asked to do so in the stem of the question, and consequently could not gain the mark.

- (iv) The mass of the cylinder was usually calculated correctly, but many candidates did not record their answers to the nearest gram.
- (c) Most candidates read the scale of the measuring cylinder correctly and performed the correct subtraction. Occasionally, the scale of the measuring cylinder was read as 50.7 and not 57.
- (d) The simple division required to find the density of copper was usually performed correctly but some candidates lost the mark through incorrect rounding.
- (e) Only a very small proportion of candidates gained marks here.

Most candidates focused their attention on poor experimental procedure, such as parallax errors, splashing the water, misreading the meniscus, or even 'human error'. A minority of the candidates thought that part of the copper cylinder had dissolved in the water.