PHYSICS

Paper 5054/11
Multiple Choice

Question Number	Key
1	C
2	B
3	A
4	A
5	C
6	D
7	D
8	A
9	C
10	B

Question Number	Key
11	C
12	C
13	D
14	D
15	A
16	C
17	B
18	D
19	D
20	C

Question Number	Key
21	D
22	B
23	B
24	A
25	B
26	B
27	A
28	B
29	C
30	B

Question Number	Key
31	B
32	B
33	D
34	D
35	C
36	B
37	D
38	C
39	B
40	B

General comments

Candidates should be reminded to read the questions carefully.

Comments on specific questions

Question 3

The most popular incorrect answer selected was option **C**. Candidates who made this choice most likely misinterpreted the second row in the table. If the second row were the total distance travelled from the very beginning, the car would be at rest initially as option **C** suggested. However, the second row is the incremental distance travelled in each 2 s interval and this reveals that initially the car is travelling at a constant speed. Few candidates chose an option which suggests that the subsequent acceleration is uniform.

Question 4

There were two points to consider when answering this question. The first is that the volume of a cube depends on the length of one side and the second is that density of the cube is inversely proportional to volume if the mass of the cube is constant.

Each of the four answers was chosen by a significant number of candidates but the correct option was chosen by more candidates than any other.

Question 5

In this question, the only force exerted by the surface on the block is the normal contact force, represented by arrow **C**. The surface is frictionless and so there is no force along the slope. Many candidates gave the correct answer. The most commonly selected incorrect answer was option **A**.

Question 13

The correct option was the most frequently given. Option **A** was the second most commonly selected answer. This was obtained by making the assumption that the question refers to the *useful* energy rather than to the *wasted* energy. A few candidates produced answers that were a consequence of subtracting 2.7 J from 6.0 W. This could not be correct.

Question 17

Option **A** was more often selected than the correct answer, **B**. The equation $p_1V_1 = p_2V_2$ indicates that the pressure and the volume of a gas are inversely proportional (at a constant temperature). For this question, the proportional decrease in volume determines the proportional increase in pressure.

Question 21

In this question, the first three options **A**, **B** and **C** are incorrect statements and so cannot be part of the explanation. Option **D** is an accurate comment because shiny metal foil is a poor emitter of radiation and is also a comment relevant to the situation described. Although all the options were chosen by a number of candidates, option **D** was the most popular choice.

Question 25

Only stronger candidates answered this correctly. The question asks about the effect of a converging lens on light rays that pass through it. The most commonly selected incorrect option was **C** which shows rays converging before passing through the lens and still converging, but less sharply, after having passed through the lens; the effect of the lens in **C** is to reduce the convergence and this is the effect of a diverging lens. Conversely in option **B** (the key), the rays are shown diverging both before entering and after leaving the lens; the rays are diverging less sharply after leaving the lens than before and this is the effect of a converging lens.

Question 28

In answering this question, some candidates may have interpreted the word *eleventh* to mean that sound waves travel from the source to the wall and back to the source eleven times in 9.4 s. However, there are only ten intervals between the first clap and the eleventh clap and so the double journey between the source and the wall is only completed ten times. Some candidates may have ignored the fact that the distance travelled in each time interval is twice that of the distance between the source and the wall. The most commonly chosen incorrect option, **C**, is a consequence of making both errors and the second most commonly chosen incorrect choice, **A**, is a result of misinterpreting the meaning of the word *eleventh*.

Question 29

The majority of candidates selected an option that correctly identified pole X as an N pole. While many of these candidates chose option **C** (the key), a significant number selected option **A**. In order to point in a consistent direction, the needle of a compass has to be a permanent magnet.

Question 32

To obtain the correct answer in this question, candidates needed to know that the resistance of an LDR decreases as the intensity of the light incident on it increases. This knowledge can be used to eliminate options **C** and **D**. In both of these cases, an increase in light intensity leads to a greater current in the lamp and so the circuit does not behave in the way described by the question. To decide which of **A** and **B** is correct requires an understanding of the operation of a variable potential divider circuit.

Question 37

This question concerns the alpha-scattering experiment and the conclusions that can be made from its results. The four options are all correct statements in themselves; candidates needed to be aware which correct statement **cannot** be deduced from the experiment described. Option **D** is correct as although the nucleus of a gold atom does contain protons and neutrons, it is not possible to reach this conclusion from the alpha-scattering experiment.

Question 40

Most candidates chose either option **A** or **B**. It is possible that some candidates who chose option **A** did not read any further than the first option and because it was familiar, selected it.

PHYSICS

Paper 5054/12
Multiple Choice

Question Number	Key
1	C
2	A
3	A
4	B
5	A
6	D
7	C
8	B
9	C
10	D

Question Number	Key
11	D
12	C
13	A
14	B
15	A
16	D
17	C
18	C
19	B
20	A

Question Number	Key
21	C
22	A
23	D
24	A
25	A
26	C
27	D
28	C
29	A
30	C

Question Number	Key
31	B
32	A
33	C
34	C
35	D
36	C
37	B
38	C
39	A
40	C

General comments

Candidates should be reminded to read the questions carefully

Comments on specific questions

Question 2

Although most candidates chose an answer that suggested that vector addition was well understood, there were many candidates who did not fully understand what was being asked for. The forces that the two ropes exert on the boat produce a resultant force that could be represented by option **B** but this is not what was being asked for. The boat is travelling at a constant velocity and so there is no resultant force on the boat. The forces exerted by the ropes are balanced by the force due to the drag as the boat moves through the water. This question asks for the vector that represents the drag force and this is in the opposite direction to the resultant of the forces in the two ropes. A large number of candidates selected option **B** rather than the correct option, **A**.

Question 7

This question was usually answered well with a majority of candidates giving the correct option, **C**. A small number of candidates gave option **B** and a few gave **A** or **D**.

Question 11

Most candidates were aware that the direction of the force on the satellite was from the satellite towards the centre of the planet. Only arrow **D** indicates this direction. Almost as many candidates chose arrow **B** as chose arrow **D**.

Question 14

One way to approach this question is to do the calculation in two stages by first calculating the time for the ball to drop to the ground and then use the time to calculate the distance travelled. The two most commonly selected answers were option **B** and **C**. Candidates who calculated the time accurately but then used the final speed to calculate the distance travelled would have obtained answer **C**. The correct answer was obtained by using the average speed which, in the case of the uniform acceleration provided by gravity, is half of the final speed. More candidates supplied the correct answer than any other but almost as many candidates gave option **C**.

Question 15

Many candidates chose the correct option **A** and very few chose option **B** which was perhaps more obviously incorrect than the other incorrect options. However, some candidates chose either option **C** or **D**. Perhaps some candidates did not fully recognise the way in which tidal energy is used.

Question 16

The correct option was most frequently given but some of the other choices were also popular. In particular, option **A** was the second most commonly selected incorrect option. This is an answer based on the assumption that numbers in the question detail the *useful* energy rather than the *wasted* energy.

Question 17

The majority of candidates answered this correctly but there were significant numbers of candidates who selected one of the incorrect answers and selected a quantity that is measured using the unit the joule (J) and is therefore an energy. The correct answer, C, is a rate of transfer of energy and therefore has the unit of J / s.

Question 19

Most candidates gave the correct answer, option **B**, for this question. A very few candidates gave option **D** but the most common error was to give answer **C**. This showed that some understanding of the mixing of gases had been acquired but not of the fact that the mixing is on a particulate level, with no significant forces holding the particles of either of the gases together. The particles of one gas penetrate through the spaces between the particles of the other and although there may be a brief period when a darker colour on the left and a paler colour on the right remains, after a long time the coloration will be uniform throughout.

Question 26

Few candidates chose an option that suggested that the definition of magnification was not known. The most frequently supplied answer was the correct one but there were a significant number of candidates who clearly knew the definition of magnification but did not know that the image produced by a magnifying glass is virtual.

Question 27

Although most candidates selected the correct answer **D**, there were those who suggested other answers. It is possible that some candidates did not notice the word '**not**' when reading the options.

Question 31

The power value needs to be converted to kW and the time from minutes to hours. Once this is done, the answer can be obtained fairly easily and most candidates did this and selected the correct option. Candidates who used time in minutes may have obtained either option **A** or **C** and those that multiplied the e.m.f. of the supply by the time would have obtained, to 2 significant figures, answer **D**. There were small numbers of candidates who made each of these errors.

Question 34

Although the application of a rule that relates the relative directions of force, magnetic field and current is not always straightforward, most candidates were able to supply the correct answer (option **C**) to this question. The knowledge that the direction of the force is perpendicular to both the magnetic field direction and to the current direction eliminates both option **A** and option **B** immediately and this may explain why these options were only very rarely selected. The second most commonly chosen answer was option **D**.

PHYSICS

Paper 5054/21
Theory

Key messages

Candidates should be advised to start questions involving a calculation by writing down the relevant formula, inserting data and only then calculating the final result.

Units do not have to be stated where they are already given on the answer line but where prefixes are present in the data, care must be taken that they are used correctly in the calculation.

Candidates should use the acceleration of free fall (gravitational field strength) *g* as 9.8 m/s^2 rather than 10 m/s^2. The weight of 1.0 kg is stated as being 9.8 N on the front of the question paper.

Candidates should not give more than one answer where only one is required.

General comments

Candidates should read through each question carefully. It is helpful to read to the end of a whole question before starting to write the answer so that the answers to later parts of the question are not given in the wrong section.

Where the question specifies a place for an answer, candidates should give their answer in the correct place rather than in a blank space elsewhere on the question paper.

The final answer should be given on the answer line to at least as many significant figures as were given in the data for the question, usually two. If the answer is exact to one significant figure, e.g. in **Question 2(b),** then the answer can be given to one significant figure.

Where a graph is required, candidates should consider that the graph is not always a straight line. They should think carefully about the correct curvature and whether the graph starts at the origin.

Comments on specific questions

Question 1

(a) (i) In this question point P was very often marked correctly in the range from 0 to 0.8 s but some answers also correctly suggested it was between 2.0 and 2.5 s. Point Q was more often marked correctly than point P. The positioning of the marked points needed to be clearly in the correct range, ideally, with a labelled dot or cross on the curve. A large letter alone did not indicate a point on the curve very clearly. The best approach was to actually mark a point on the graph and label it either P or Q.

(ii) Most candidates used the correct formula for calculating speed. However, the calculation was usually of the average speed of the ball in the first second rather than the speed of the ball at X. To calculate the instantaneous speed at X, the best approach was to draw a tangent and determine the gradient of the tangent, but readings from a short section of the curve either side of X could be used since a short section was close to a straight line.

(b) Some candidates gave the exact reversed order or, while recognising that the ball was faster at B than at A, did not recognise that it was slowest at A.

(c) The force involved was most commonly given as weight or the force of gravity but sometimes the name of this force was omitted or stated to be friction. The energy transfer was well known as being from gravitational potential energy to kinetic energy. As there are several different forms of potential energy, candidates should be careful to state to which form of potential energy they are referring. In this case, gravitational potential energy should have been mentioned rather than just potential energy.

(d) The resultant force on the ball at B is upwards. Many candidates incorrectly drew an arrow in the direction of the motion of the ball.

Question 2

(a) (i) Most candidates recognised that the pressure is created by particles hitting the piston. Weaker answers lacked detail, for example, that each hit creates a force on the piston or that pressure is the force on unit area of the piston. Some stronger answers mentioned the change in momentum of a particle hitting the piston and the force this created.

(ii) Most candidates recognised that the particles move faster or have greater kinetic energy. Many answers also explained that this led to a higher frequency of collision between the particles and the piston. Many answers used the term ‘successful collision’. This was not appropriate in this context.

(b) The formula relating pressure, force and area was well known and usually used. The two pressures needed to be subtracted. Only a few candidates added the pressures instead.

(c) (i) The formula for momentum was very well known.

(ii) The easiest approach to calculating the time was to divide the momentum change by the force. A more commonly seen correct approach was to use the force to calculate the acceleration and then to use the acceleration to calculate the time. Weaker candidates used the equation speed = distance/time. Where candidates also wrote down acceleration = change in speed/time, this sometimes meant they could also calculate the acceleration and so the time.

Question 3

(a) Stronger candidates described the role of free or delocalised electrons in conduction, with such electrons moving from the hot to the cold area or colliding against atoms or molecules of the metal. The most common answer involved vibration of the particles (molecules) so the particles passed on the energy by collision in some way. Weaker answers described convection within the water in the metal pan rather than conduction in the metal.

(b) (i) The melting point of water as 0 °C was well known by most candidates but the value 273 K was not always given. Candidates need to remember the conversion factor between the two scales correctly.

(ii) Most candidates recognised that a change in state was involved as ice melts. The strongest candidates recognised that energy is needed to break bonds as the particles become separated and that the potential energy of the particles increases while their kinetic energy is the same at the melting point.

(iii) There was often an understanding of the equation involving energy, mass specific heat capacity and temperature rise. The most commonly seen mistake was to use 30 °C rather than 15 °C for the temperature change.

(iv) The relationship between power, energy and time was well known and usually stated at the start of the calculation. The warming of the ice to the melting temperature took 2 minutes or 120 seconds; weaker answers used the full 24 minutes shown on **Fig. 3.2** instead.

(v) The most direct answer seen was a statement that water has a higher specific heat capacity than ice. There was some confusion between specific heat capacity and latent heat. Candidates needed to be clear about the differences between these two quantities.

Question 4

(a) (i) Most candidates gave an acceptable statement explaining what is meant by frequency. These included the number of crests passing a point per second or the number of oscillations per unit time. In general, this definition was well known.

(ii) The necessary formula was well known but the wrong answer of 0.33 m/s was commonly seen. Candidates should look carefully at the prefix involved with any quantity and use the prefix correctly in their calculations.

(iii) Prenatal scanning was the most commonly stated use of ultrasound, but sonar and the detection of cracks were also seen. Weaker candidates gave answers such as "ultrasound is used in hospitals" while stronger answers described a specific use, for example "to check a foetus". Some weaker candidates gave uses of types of electromagnetic radiation rather than ultrasound.

(b) (i) The strongest answers made it clear that a particle in the wave is oscillating and that this oscillation is either parallel to or perpendicular to the direction of travel of the wave or energy. Weaker answers stated, for example, that "the direction of travel of the wave is perpendicular to the direction of travel of the wave". Diagrams were useful in demonstrating understanding in answers, particularly where the movement of the particles and the movement of the wave or energy were labelled.

(ii) A number of sources of both longitudinal and transverse waves were seen, usually of sound and light. The most common answer was earthquakes or seismic waves but other sources were also seen.

(c) The larger wavelength of the wave shown in A was widely recognised but only stronger candidates suggested that a larger wavelength produces greater diffraction. Candidates need to know the difference between diffraction and refraction.

Question 5

(a) Many candidates drew the incorrect symbol for a fuse. Candidates should be able to recognise all the symbols given in the syllabus.

(b) (i) Only the strongest candidates were able to sketch a current-voltage graph for a filament lamp with the correct curvature. The most commonly seen answer was a straight line through the origin.

(ii) Even if the sketched graph was incorrect, the strongest candidates recognised that the filament lamp increases in temperature as the current increases and related this to an increase in the resistance of the lamp.

(c) Most candidates used the correct formula linking voltage, current and resistance to calculate a current in at least one of the heaters. Many stronger candidates then added the two currents together, while others calculated the total resistance of the two heaters in parallel and used that value to calculate the current. Weaker candidates incorrectly calculated the total resistance by adding the resistance of both heaters.

(d) (i) The rating of a suitable fuse rating should be slightly higher than that of the current that passes through the circuit. In this case, the current is 11.5 A (10 A plus the current in the lamp). Most candidates gave a fuse rating slightly larger than the current in the lamp, overlooking the far larger current in the heaters.

(ii) If a higher fuse rating is used, the fuse will not melt when there is a current sufficient to damage the circuit or the components in the circuit. Many candidates recognised that the circuit itself might overheat or the heaters might be damaged but only the strongest candidates were able to give the full detail and described why this happens.

(iii) Stronger candidates recognised that the live wire is the wire that has a high voltage. The strongest candidates recognised that this high voltage was dangerous and can cause electrocution.

Question 6

(a) (i) The simplest effect of using a stronger magnet, that the motor rotates faster, was the most common answer.

(ii) An arrow drawn from the N-pole to the S-pole was most usually an indication of the direction of the magnetic field. The strongest candidates made the direction of the current at one point in the circuit clear, often from the right-hand terminal of the battery but sometimes it was correctly drawn in the coil. Weaker candidates tended to draw arrows that could not be used to decide on the direction of the current as the arrow was not near a wire carrying the current.

(iii) A common misconception was that induced currents are responsible for the turning effect in a motor. Candidates should be confident in knowing the difference between a generator and a motor and the different principles involved in the operation of each. The strongest answers described the application of the left-hand rule to each side of the coil, producing an upwards force on the left and a downwards force on the right. Weaker answers merely stated that the coil becomes an electromagnet.

(b) (i) Correct circles were often drawn around each wire to show the magnetic field and the direction was often also correct according to the right-hand rule. The correct shape of the field between the wires was the most common mistake, as the field lines should become slightly elliptical with a stronger field between the wires than at the same distance on the other side of each wire.

(ii) Only the strongest candidates recognised that the current in one wire produces a magnetic field at the other wire or that both wires produce magnetic fields which interact. The interaction between the wires was often poorly described in terms of "like poles repel" by weaker candidates. Stronger candidates stated "one current experiences a force in the magnetic field from the other wire".

Question 7

(a) Candidates recognised that the subscripts have to be the same and that the two uranium isotopes have the same number of protons.

Slightly fewer candidates suggested the correct isotopes in parts **(ii)** and **(iii)** and weaker candidates gave isotopes with the same number of nucleons rather than the same number of neutrons in **(ii)**. Candidates need to be confident of the difference between a neutron and a nucleon.

(b) (i) There were many sensible suggestions on background radiation, often involving the environment, natural causes, radiation that is always present or a particular type, including cosmic rays or radon gas.

(ii) The simple subtraction of 20 from 420 proved straightforward but weaker candidates divided 420 by 20.

(iii) Stronger answers showed two half-lives occurring from 400 to 200 to 100. The very strongest candidates then added on the background to obtain the reading on the counter. Weaker candidates did not include background or gave the answer as 105.

(iv) This was often answered successfully using the word 'random'. Weaker candidates suggested that the background radiation was in some way responsible or that there was an error in reading the counter.

(c) Most candidates recognised that gamma radiation is used in the sterilisation of equipment or irradiating food to kill bacteria. Fewer answers recognised that beta radiation is used for measuring paper thickness.

Question 8

(a) Some candidates worked out and stated the fraction of a complete rotation of the Sun made by each planet in 88 days. Having made the calculation, the position of the planets were then drawn. The position of Venus was most often correct.

(b) (i) The closeness of the Sun to Mercury was often incorrectly stated as causing the smaller gravitational field strength on the surface of Mercury. Stronger candidates correctly stated that it is the smaller mass of Mercury that is responsible for the smaller gravitational field strength. Since the average densities of the two planets are similar, the smaller size of Mercury was also accepted.

(ii) Most candidates were able to apply the idea that the weight of an object is the product of mass and gravitational field strength and that the mass of the object is constant. Weaker candidates gave an incorrect final value, often merely quoting the formula $W = mg$ without calculating the mass of the object.

(c) Stronger answers stated that a moon is a natural object that orbits a planet. Weaker answers referred to the Earth's moon alone. The effect of a moon in providing light to a planet was not relevant to the answer but was often included.

(d) The two most common terms to be awarded credit were red giant and white dwarf. Only a few candidates showed a sense of the sequential transitions in which the core of the Sun collapses, the temperature rises, leading to the fusion of helium and other heavier elements outside the core and an expansion to a red giant and the formation of a planetary nebula. Many answers stated that the final outcome of the star would be as a white dwarf. Candidates could have improved their answers if they had described what happens at the various stages, in order. Weaker candidates confused the various stages and some incorrectly suggested that a supernova or a black hole would be the final stage for our Sun.

PHYSICS

Paper 5054/22
Theory

Key messages

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Candidates should not give more than one answer where only one is required.

General comments

Candidates should read through each question carefully. It is helpful to read to the end of a whole question before starting so that the answers to later parts of the question are not written in the wrong section

Where the question specifies a place for an answer, candidates should give their answer in the correct place rather than in a blank space elsewhere on the question paper.

The final answer should be given on the answer line to at least as many significant figures as was given in the data for the question, usually two. If the answer is exact to one significant figure, e.g. in **Question 1(a)(iii)**, then the answer can be given to one significant figure.

Comments on specific questions

Question 1

(a) (i) The majority of candidates recognised that uniform acceleration is shown in **Fig. 1.2**. A few candidates explained what is meant by uniform acceleration but did not link their explanation to **Fig. 1.2**. A few candidates confused constantly increasing gradient with constant gradient.

(ii) Candidates were asked to describe how the motion graph shows that the magnitude of the acceleration of trolley B is larger than the magnitude of the deceleration of trolley A. The majority of candidates correctly compared the steepness of both graph lines, or the gradients for A and B. Candidates demonstrated a good understanding of the question by writing “steeper line”, “larger gradient”, by using calculated values for the gradients, or by using the changes in velocity to distinguish between the trolleys. A few candidates simply stated quantities from the graph, e.g. “the starting and final velocities are 0.7 and 0.4 m/s” without explaining the relevance of these values, e.g. by stating that trolley B has a larger change in speed in the same time. These candidates could not gain credit.

(iii) In this question, candidates are asked to calculate the acceleration of trolley B when t = 0.40 s. The equation $a = (v - u)/t$ was well known and was often used. However, many candidates used the change in speed of 0.20 m/s but divided this by the time (0.40 s) rather than by the change in time (0.10 s).

(b) Candidates are required to show that the momentum is conserved in the collision. The idea that momentum is the product of mass and velocity was well known. The values of the masses of the trolleys are given in this question, and candidates were expected to read the velocities from the motion graph provided. Most candidates showed a good understanding of the question and correctly calculated the total momentum before and after the collision, showing that these values were identical. Some candidates attempted to use the impulse or change in momentum of each trolley but did not show that the impulse on one trolley is equal and opposite to the impulse on the other.

(c) The most direct answer given in the strongest responses to this question was that there is a smaller time of contact and since $F = m\Delta v/t$, with the same change in momentum, the force will be larger. Other sensible suggestions mentioned the larger acceleration but often did not suggest why the acceleration is larger. Weaker candidates often based their responses on less mass, less inertia, less friction, less impact or more kinetic energy. There were some reasonable suggestions given in terms of energy changes, the deformation of the modelling clay and the loss of energy in the modelling clay as it deforms.

Question 2

(a) (i) The most direct method of answering this question is first to calculate the volume and then to multiply by the density of water. Stronger candidates set their explanation out well, explaining the two steps. Most candidates demonstrated good relevant knowledge by using the correct formula, substitution and arriving at a value of 6720 kg. The formulas $P = dgh$, $P = F/A$ and $F = mg$ were also sometimes seen.

(ii) The majority of candidates provided an accurate and concise definition of pressure.

(iii) Most candidates demonstrated a good understanding of the question, using the equation $P = dgh$ correctly, with the right substitutions. However, some candidates gave the equation correctly but used g as 10 m/s^2 rather than 9.8 m/s^2. A few candidates used *mgh* to find a pressure.

(iv) The formula $E = mc\Delta T$ was well known, although not all candidates substituted correctly into the equation. Some candidates gave the formula as $C = mc\Delta T$, which may have contributed to confusion. Some candidates simply found the change in temperature rather than the asked-for final temperature of the water.

(b) (i) Most candidates successfully explained the cooling effect of evaporation in terms of particle movement, using their knowledge of the relationship between temperature and the average kinetic energy of the particles to explain that the remaining particles had less average kinetic energy. Weaker candidates needed to take more care when explaining that the particles which escape from the water have higher kinetic energy or that the particles left behind have lower kinetic energy.

(ii) Candidates demonstrated a good understanding of changes to environmental factors affecting the amount of evaporation from the surface of the water. The most frequently seen responses were increase in temperature, increase in wind speed and lower humidity. Weaker answers simply mentioned temperature and humidity without describing the change to these factors that increased evaporation, as required by the question. A few candidates demonstrated misconceptions by stating that the cooling of the water or an increase in the humidity increases the amount of evaporation.

Question 3

(a) (i) Most answers correctly stated that chemical energy is found in the battery; however, most candidates had difficulty in naming the energy store in the Sun. Stronger responses gave nuclear, thermal or internal energy; weaker responses gave heat, fusion, solar, light, and kinetic energy.

(ii) Responses to this question were very often correct. Weaker answers contained no sensible reference to energy e.g. “no rays hit the charger” or “there is no heat”. Most answers stated that there is less light reaching the charge or that there is less electrical current produced.

(b) Candidates needed to name and describe the three processes by which thermal energy is transferred as the cell phone cools down. Many candidates correctly named conduction, convection and radiation. Stronger candidates gave a brief account of how each process applied to the situation, e.g. "convection occurs as hot air rises", "radiation is emitted as infra-red" or "conduction occurs as molecules vibrate passing on energy". Weaker candidates gave vague descriptions which did not include any relevant detail.

(c) Most candidates correctly applied the formula $Q = It$ to calculate the quantity of charge. Some candidates were struggled to change 300 mA to 0.30 A, and/or 4.5 hours to seconds, while a few candidates were unable to state the unit or occasionally gave the wrong unit.

Question 4

(a) (i) The majority of answers incorrectly suggested that the angle of incidence is 90° rather than 0°.

(ii) Answers to this question showed a good attempt to draw the normal at R, with only a few answers where the normal was clearly at the wrong angle or drawn at the wrong place. The angle of incidence was sometimes labelled incorrectly and the angle marked was the angle of reflection rather than the angle of incidence.

(iii) This question asks for the conditions needed so that no light refracts into the air. Only a few candidates realised that these are the conditions for total internal reflection to occur. The most commonly seen correct answer was that the angle of incidence should be greater than the critical angle. Fewer candidates stated that the light must pass from the optically denser medium to an optically less dense medium.

(b) (i) That infrared is the other type of electromagnetic radiation used to transmit information through glass fibres was known by stronger candidates. A few candidates gave more than one type of electromagnetic radiation.

(ii) Many candidates gave simple, sensible suggestions, for example "faster transmission" of the information. Stronger answers referred to increased bandwidth or to a reduced chance of information being 'hacked'. Weaker answers were vague, with mention of less security or less safety. It was sometimes suggested that the insulation property of glass meant that electrocution was not a problem. It was also suggested that it is the speed of light which means the information passes faster through the glass fibres, whereas the electrical signal passes at a very similar speed in the copper wires.

Question 5

(a) (i) The majority of candidates correctly recognised that electrons were transferred, and that the woollen cloth now has a positive charge.

(ii) Many candidates found this question challenging. Some candidates suggested that the balloon is made from an insulating material and that, as a consequence, electrons or charge cannot move from the surface of the balloon. A few stronger answers suggested that the air is not conducting or even that ionisation in the air is very weak and so no charge can be transferred to the balloon. Some suggested that the balloon is not connected to earth or another conductor, but even if the balloon were connected to earth, being an insulator, the charge would still remain on the balloon.

(b) Most answers were satisfactory. It was well known that the speed of molecular movement increases with increased temperature. The mechanisms by which the volume of the ballon increased were not always explained. Stronger answers described the increased frequency with which air particles strike the surface of the balloon. Weaker answers simply suggested that the distance between air particles increases. Some candidates did not realise that molecules are already moving before heating occurs and that air particles do not vibrate.

Question 6

(a) Ohm's law was well known and often expressed carefully with the correct condition that temperature must be constant. A number of candidates incorrectly suggested that voltage, or potential difference, is proportional to current only until temperature is constant. Some answers confused Ohm's law with the formula $V = IR$ and suggested, for example, that "current is inversely proportional to resistance". Candidates should know that Ohm's law does not mention resistance.

(b) Although most candidates recognised that the law applies because each line is straight, it is only because the straight line also passes through the origin that there is a proportional relationship. Not every straight line shows a proportional relationship. The strongest answers mentioned that the line passes through the origin as well as having a constant gradient.

(c) The majority of answers correctly suggested that an increase in the light reduces the resistance of the LDR. The question states that values from **Fig 6.2** should be used in the explanation. The most commonly used values were the currents at 8V and the voltages at 0.06 A and 0.10 A. Many answers included much irrelevant detail.

(d) (i) Many candidates attempted to answer this with a calculation. Candidates need to recognise that the current is equal throughout a series circuit.

(ii) The formula $V = IR$ was well known. Most candidates correctly used the value of the current in **(i)** multiplied by the resistance of the fixed resistor. The most direct approach was then to add on the p.d. across the LDR obtained from the graph at a current of 0.050 A. A more complicated alternative to calculate the total resistance of the circuit was also sometimes used.

Question 7

(a) (i) Most candidates marked the poles of the bar magnet correctly, but a noticeable minority either marked the poles the wrong way round or omitted the question.

(ii) Weaker candidates used the compass to find out which pole on the magnet was the N-pole and which the S-pole in order to determine the direction of the arrowheads on the lines, which were drawn freehand. Most candidates described making a mark at one end of the compass needle, with stronger candidates going on to describe how the compass is moved so that the other end of the needle is placed against a previous mark, continuing this process from one pole to the other and joining the marks.

(iii) Some candidates gave a clear indication that the direction of the magnetic field at point P is the direction in which the north pole of the compass needle points. Many candidates simply stated that the directions of field lines of a bar magnet are from North to South and did not involve the use of the compass in their answer. Some candidates were unable to gain full credit as their answers did not differentiate between the north pole of the compass needle and the north pole of the bar magnet.

(b) (i) The responses to this question were generally very good. Cutting of the magnetic field was generally stated as being the cause of the current produced, but candidates did not always make it clear that the magnetic field of the magnet cuts the coil. A significant number of answers suggested that a field of the coil was involved, for example by stating that "the field of the coil cuts the field of the magnet". The whole process was usually described correctly as involving induction, with the strongest answers suggesting that a voltage or e.m.f. is induced, which then produces the induced current.

(ii) Many candidates found this question challenging. The question stated that the magnet is moved inwards and outwards and most candidates merely repeated this, sometimes just adding 'quickly' or 'slowly'. Candidates should realise that their answers should not simply repeat the question itself but should give substantial additional detail. Where candidates mentioned the time involved, they were often correct in suggesting one complete movement occurs in 2.0 s, but many candidates suggested two movements per second.

(iii) Only stronger candidates gave answers that clearly described that the ammeter needle deflects from one side of the centre zero to the other. Many candidates referred only to the changing direction of the current and did not mention the ammeter or its needle, despite the fact that the question asks how the centre-zero ammeter is involved. Some candidates suggested only that the reading of the ammeter varies and did not give detail mentioning different directions or positive and negative in any way.

(iv) The question asked for an explanation of why increasing the frequency of the a.c. also increases the magnitude of the a.c. produced. Explanations should have involved the physics of the situation, and the strongest answers were clear in referring to the increased rate of change of the magnetic field or the increased rate of cutting of the magnetic field lines. Many answers simply stated that frequency and magnitude were proportional and did not explain using any of the physical principles involved.

Question 8

(a) There were many good answers. Most candidates referred to an explosion or gave a similar description, with stronger answers mentioning the explosion of a red supergiant or a massive star. Many candidates included more detail than was needed. Some candidates included content answering **(b)** here.

(b) The most direct approach in describing the formation of a protostar is to state that a cloud of dust and gas collapses due to gravitational attraction. There were several alternative answers that were relevant, for example that temperature and pressure increase, and these were very commonly suggested. Many candidates included unnecessary further detail, describing the subsequent nuclear fusion and the balanced forces that act as the protostar becomes a main sequence star. The unnecessary further detail sometimes meant that the description of how a protostar forms was too brief.

(c) (i) In the great majority of answers, the Milky Way was named as the galaxy containing our Sun. Occasionally candidates suggested Solar System, Earth or even Andromeda,

(ii) Three solid points are needed in this answer to adequately define what is meant by a light-year and these are that a light-year is the *distance* that is travelled by *light* over the time of *one year*. Most candidates gave a good description. The main misconception that was seen is that a light-year is a time rather than a distance. Weaker candidates did not always give all three elements of the definition, for example “a light-year is the distance travelled by light”.

(iii) This is a challenging calculation, involving a number of steps. Many candidates answered well and explained their working to produce the correct final answer. The idea that speed = distance/time was widely known. Weaker answers simply divided 26 000 by the time. Many candidates did not understand the difference between the orbital distance (the circumference) and the orbital radius.

Question 9

(a) ‘Spontaneous’ was often confused with ‘random’. Few candidates were able to describe correctly what is meant by ‘spontaneous emission’. Stronger answers clearly suggested that spontaneous emissions occur without an external cause. The most commonly seen correct answer was that “temperature has no effect on the emission”.

(b) There were many good answers that were awarded full credit for a description of the composition of an alpha particle. Some candidates included additional unnecessary detail about an alpha particle in their answers, for example that it is “stopped by paper”. A significant number of candidates included incorrect extra detail, such as that the alpha particle contains two electrons or is the same as a helium atom.

(c) (i) The description of the detection of alpha particles using a cloud chamber or a spark counter was often lacking. Candidates generally appeared more familiar with the workings of a Geiger–Müller tube, and there were attempts to relate this tube to a spark counter, which were sometimes partly successful. The cloud chamber was described more often than the spark counter, with descriptions including the need for alcohol to act as a vapour and some method indicated to lower the temperature, e.g. dry ice. A few answers described the Geiger–Marsden experiment.

(ii) The random emission can be random in time, random in place or random in direction and the strongest answers gave a description of how one of these can be observed. Many candidates used the word ‘random’ to explain what was meant by ‘random’. It was also not always easy to relate the answer to the structure described in **(i)**, especially when the answer given there was confusing.

(iii) This calculation of a half-life was commonly answered correctly and, even when the final answer was not correct, there was often an attempt to show successive halving of 120 or showing 3 half-lives. There were also attempts to use the equation for half-life using indices, e.g. 120 = $\left(\frac{1}{2}\right)^{n}$ *n*.

These were often not successful. Candidates found it easier to use the simpler idea that $120 \rightarrow 60 \rightarrow 30 \rightarrow 15$ involves three halvings in 6.0 hours, so each half life is $\frac{6}{3}$ = 2.0 hours.

PHYSICS

Paper 5054/31
Practical Test

There were too few candidates for a meaningful report to be produced.

PHYSICS

Paper 5054/32
Practical Test

Key messages

- It is important that Supervisors send in 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 that would otherwise not be awarded credit, especially when the equipment used has not conformed exactly with the specifications made in the Confidential Instructions.
- Measurements and final answers should be rounded to an appropriate number of significant figures with readings from analogue instruments such as ammeters and voltmeters recorded to the precision of the instrument being used. 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 measurements that appear to be unrealistically large or small.
- The ability to produce a good line graph and to use it to calculate the gradient or find values for points along the graph are valuable skills for candidates to develop.
- For the planning question, candidates should ensure the experiment they describe is relevant to the investigation featured in the question and then focus on giving details addressing the bullet points.

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 clearly. They were able to use their sets of results and processed them by performing calculations and making judgements, drawing relevant conclusions, and writing relevant comments about their results and conclusions.

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. Some responses to questions involving the plotting of graphs included impractical scales such as those based around multiples of 3. Using a non-integral scale makes it difficult and time-consuming to plot the points and also makes it difficult to use (for example, to derive further information or calculate the gradient). Candidates who use non-integral or other difficult scales are far more likely to make errors in plotting and interpretation of their graphs. It is better to choose a scale which produces a graph that may be a little smaller but still occupies over half the grid in the x and y directions, and is based on a scale of 2, 5, or 10 units corresponding to 10 small grid lines.

The plotted points on graphs should be marked with small, fine, but visible crosses and placed accurately to within half the length of the side of the smallest square made by the thinnest grid lines.

The Cartesian axis system should be used, with increasing positive values from left to right along the x-axis and upwards along the y-axis. The best-fit straight line or curve should be a carefully drawn single, thin, smooth line, suitably placed with, as far as possible, equal numbers of points either side of the line and vertical distances of points from either side which compensate one another. A line drawn from the first plot to the last plot is rarely suitable.

Comments on specific questions

Question 1

(a) The majority of candidates gained credit here. If candidates found that a measurement was zero, they should have been suspicious and should have checked the circuit as there would have been a loose connection somewhere or a faulty switch. Some candidates did not recognise when a value of current was several orders of magnitude larger or smaller than which could reasonably be expected.

(b) Most candidates correctly stated the reading of current to two decimal places.

(c) Most candidates correctly recorded the voltmeter and ammeter readings using a consistent number of decimal places throughout the table. Weaker responses did not have a complete set of readings.

(d) Stronger responses showed a consistent number of significant figures for all calculated values of resistance with three significant figures being the most appropriate although four was acceptable. Weaker responses did not have a complete set of calculations or candidates did not appear to recognise when a value did not follow the trend of resistance increasing as current decreased.

(e) (i) Many candidates read the question carefully and recognised that they needed to state the direction of current change as well as the associated change in voltage for their comment to be meaningful unless they commented that the voltage remained constant (to one decimal place). Weaker responses simply stated 'decreased' with no additional detail or made statements which could not be supported without further processing of data, which was not shown. in the table.

(ii) Many candidates read the question carefully and recognised that they needed to state the direction of current change as well as the associated change in resistance for their comment to be meaningful. Weaker responses were often incomplete, stating that there was a change in resistance but giving no further details, or linking the change in resistance of the diode to the resistance between X and Y which is not what the question asks to be considered.

(f) Only stronger candidates were able to suggest that the diode had been connected in the reverse direction. Commonly seen insufficient answers referred to ammeters being placed in parallel or connecting leads being loose or not connected. Candidates needed to relate their knowledge to the specific context rather than making generic comments about faulty circuits or apparatus.

Question 2

(a) (i) Most candidates correctly recorded the temperature to the nearest degree or 0.5 degree. Weaker responses gave values to two decimal places or showed that they had not allowed the thermometer time to adjust so that this value was not the highest value in the column.

(ii) Most candidates were able to produce a full set of readings which showed a clear decrease in temperature with time.

(b) The strongest responses stated that parallax errors are avoided by ensuring that the readings on the thermometer are viewed perpendicularly. Weaker responses stated that the readings should be taken from eye level and while this statement was also awarded credit, candidates are encouraged to give more detailed descriptions. Other acceptable precautions to obtain accurate results included stirring the water before taking a temperature reading or ensuring that the thermometer did not touch the sides or base of the test tube. The question asks what the candidate does to make sure that the temperature measurements are as accurate as possible; answers that refer to measures beyond the control of the candidate (keeping the room temperature constant or turning off the air conditioner) should be discouraged.

(c) Most candidates correctly recorded a full set of temperatures to the nearest degree or 0.5 degree.

(d) The question asks for the decrease in temperature to be calculated and many candidates were able to process data in the table correctly. Weaker responses often stated a maximum or minimum value or transposed the values for warm and cold water.

(e) (i) The question asks candidates to use their answers from **(d)** to draw a conclusion about the rate of cooling. The majority of candidates were able to make a simple statement about rates or which beaker of water showed a greater temperature decrease in the same time. The strongest candidates calculated a rate and supported their conclusion using data and so were able to access full credit. Candidates should be encouraged to justify their conclusions by referring to data.

(ii) When stating improvements candidates should be encouraged to write specific improvements instead of making vague comments and to consider whether their suggestion could easily be implemented. Stronger candidates gave specific improvements, such as ensuring the initial temperature of water in the test tube was the same or ensuring equal volumes of water. Insulating the beaker was a commonly seen acceptable response.

Question 3

(a) The question asks for the distance to the moveable mass to be recorded. Candidates should be reminded to look carefully at any diagram given. In this example, this would have prevented some candidates from giving distances greater than 50 cm by simply reading the scale on the ruler and ignoring the distance labelled. Weaker responses did not give the reading to the nearest 0.1 cm as required by the question.

(b) Only stronger candidates were able to provide a clear description of their technique. A commonly seen response which did not gain credit was stating that this was when the ruler balanced for the longest period of time, which did not describe the technique but the outcome. Some candidates attempted to describe how to find the position of the centre of the mass and stated that measurements at either end of the mass should be taken. In order to gain credit from this approach, candidates needed to describe how these measurements would be processed to obtain the central value.

(c) (i) Most candidates correctly recorded a full set of readings for *d*. A common mistake seen in weaker responses was the omission of the value from **(a)** in the table despite the instruction in the question to include it. Candidates should remember to use the same number of decimal places for all values recorded in the table. In this case, this was 0.1 cm as instructed in **(a)**. Candidates should be encouraged to record values in the order specified by the instruction. In this case, this was as the mass increased from 50 to 100 g. Recording the results in this order made it easier to spot any patterns in the data or any anomalous readings which needed to be repeated.

(ii) Most candidates correctly calculated and rounded *1000/d* and stated their values to 3 or 4 significant figures. Candidates should be reminded that the same number of significant figures should be used for all values in a table even when a whole number value is obtained.

(d) Only a few candidates incorrectly reversed the axes or plotted an incorrect variable such as *d*. Candidates should be reminded of the need to ensure that the plotted data covers at least half of the available grid space in both the *x* and *y* directions. A common mistake 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. 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. The strongest candidates evidenced this by drawing a large gradient triangle and using it to obtain two sets of coordinates for calculating the gradient. A triangle did not have to be drawn and two distinct marks on the best straight line which identified the exact ends of the hypotenuse of the gradient triangle were sufficient, but a triangle is 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 credited for accuracy by obtaining a value for the gradient within the stated range. Candidates should be reminded to show all of their working and to state whole number values to more than one significant figure. Credit was given to candidates who incorrectly reversed the axes on the graph but obtained a gradient in the range 0.42 to 0.50.

(f) Many candidates obtained a value within the acceptable range.

(g) The question asks candidates to suggest a reason why the method is unsuitable if a smaller mass of 40 g was used. Stronger candidates referred back to their data in their answers and stated that it would be impossible to balance the rule or that the balance point would be beyond the end or the rule. Weaker candidates often provided insufficient reasons, such as being more difficult to balance or stated that the mass is too small but did not explain why.

Question 4

Candidates were required to plan an experiment to enable an accurate value of the focal length of a lens to be obtained. Most candidates who attempted the question were able to gain at least partial credit and there were few blank or irrelevant responses. Some candidates appeared to be rushing or finished mid response which may indicate that candidates would benefit from opportunities to practise time management skills.

Marking point 1 was awarded if candidates mentioned the use of a metre rule and a screen either in their plan or shown on a labelled diagram. Some weaker candidates incorrectly used the label line for the bench in **Figure 4.1** as a screen and referred to images being formed on the bench through the response.

Marking point 2 was awarded for drawing a correctly labelled diagram of the apparatus clearly showing *u* and *v*. Candidates should be reminded that clear end points should be shown when labelling distances such as using double headed arrow lines touching the lens (or lens holder) and the screen for *v*. Weaker responses often had lines which finished at an undefined end point or which extended further than the correct position. As a diagram showing a partial set up of the apparatus was given in **Figure 4.1**, it was acceptable for candidates to add to this diagram rather than copying this out and adding to it. Some candidates produced unnecessarily elaborate or detailed three dimensional diagrams and weaker responses were often drawn without using a ruler or had no labels.

Marking point 3 was awarded for making a correct reference to moving the object, lens or screen to obtain a focused image. Most candidates who attempted a method for the experiment were able to gain credit here.

Marking point 4 was awarded for candidates referring to the measurements to be taken or recorded. A table with column headings of *u* and *v* with no unit specified was insufficient for credit. If candidates chose to specify values for *u* such as 20 cm, 30 cm etc. then it was sufficient for them to only refer to measuring *v*.

Marking point 5 was awarded for a suitable step to obtain a sharp image. Many candidates gained credit here alongside marking point 3 for referring to the object, lens or screen being moved backwards and forwards or moving them slowly until a sharp image was obtained. Many candidates also referred to carrying out the experiment in a darkened room which was another creditworthy step.

Marking point 6 was awarded for detailed explanation of how to obtain the focal length using the formula. Candidates should be reminded to avoid generic statements such as ‘use the formula’. Strong answers described what to do with their results e.g. ‘substitute the values obtained for *u* and *v* into the equation given’. Another creditworthy answer was to state that the experiment would be repeated for different values of *u* and an average value of *f* obtained. Weaker answers were insufficiently detailed to gain credit from either route.

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 graduated in millimetres should be given to the nearest half-millimetre. If a measured length is, for example exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidate should take care 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 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 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 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.
- 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:

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

The level of work was generally good. Most candidates attempted all questions; 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. Some candidates did not round their numerical answers correctly or to give an answer to a sensible number of significant figures. The standard of graph drawing was poor in some scripts.

Some candidates struggled to suggest where improvements could be made to practical methods.

Comments of specific questions

Question 1

(a) Candidates were expected to describe how to take readings from a scale to find the diameter of a small ball. Most candidates had no difficulty in following this method through to get a sensible answer A small number of candidates did not read the scale on the ruler correctly to the nearest 0.1 cm.. Candidates should consider whether the recorded readings or answers from manipulation of data are sensible within the context presented.

(b) A few candidates had difficulty in reading from the scale of the measuring cylinder correctly, but most followed the method through and gained credit.

(c) Candidates were asked to suggest which method would give the most accurate result. This question was answered well by the strongest candidates, who realised that the first method was better because a ruler can measure to the nearest 0.1 cm but a measuring cylinder can only be measured to the nearest 1.0 cm^3. Many candidates thought that reading the volume directly from the measuring cylinder would give a more accurate value.

(d) Candidates were then asked to describe how to use the glass balls and a small beaker to find the mass of one ball using a top pan balance. This was very well answered by most candidates. A few candidates found the mass of one ball rather than six and found the average. A very few candidates did not use the beaker at all or forgot to subtract the mass of the beaker.

Question 2

(a) (i) Candidates were asked to read a temperature from a thermometer scale. Some candidates had difficulty in reading a scale and read it as 70.2 °C.

(ii) Most candidates could correctly explain why the water was stirred after each reading.

(iii) Candidates were expected to use the data given to find the cooling rate of hot water over 90 s using the equation given. The answer came to 0.20 °C / s. Some candidates gave their answer to one significant figure and could not be awarded credit here. Candidates should be advised to ensure that their answer matches the number of significant figures in the data used in the calculation. There was also credit available for a correct unit. Many candidates did not give a unit or gave an incorrect unit. The correct answer could be deduced from the units of the data used in the calculation.

(iv) Candidates were expected to repeat the calculation for the final 90 s of the experiment and they did this well.

(v) This was not well answered. The question asked for a comparison of the values for the first and final 90 s and an explanation of the difference. Most candidates only answered the first part of this question and ignored the explanation. Few candidates realised that the drop in temperature decreased as the temperature approached room temperature.

(b) (i) This time the beaker was placed within a larger beaker of iced water and the experiment was repeated. Candidates were usually able to correctly calculate the new cooling rate.

(ii) Candidates were again asked for a comparison of values and an explanation of the difference. Most candidates did not give an explanation, although this was better answered than **(a)(v)** with some candidates explaining that the water would cool faster in the iced water.

(iii) Candidates were asked why the experiment was not a valid comparison. They were expected to notice that the initial temperature of the hot water was not the same in each case. Stronger candidates were able to do this.

(iv) Candidates were asked for one other variable which should be kept constant. Control variables are those that should be kept constant throughout the experiment so that they do not change the relationship between the variables being investigated. This was often answered well, with most candidates stating that the volume of water should be constant.

Question 3

(a) (i) Those candidates who did not have a ruler were unable to measure a distance given on a diagram. There were several very inaccurate answers.

(ii) Candidates were told that the measurements were to a scale of 1 : 5 and then asked to give the actual length in centimetres, using their answer to **(a)(i)**. Most candidates did this correctly.

(iii) Candidates were then asked to deduce the image distance. Given that they had calculated the object distance as 24 cm and they knew from the diagram that the two distances added up to 60 cm, this was expected to be a simple 60 – 24 = 36 cm. However, many candidates went through the measuring process again and sometimes produced inaccurate measurements. Stronger candidates had no problem in gaining credit here.

(b) This was very well answered, with nearly all candidates able to describe the differences between the object and the image shown in the diagrams.

(c) (i) Candidates were asked to complete a table of data giving all values correct to 3sf. Most candidates completed the table correctly but very few gave their values to 3sf.

(ii) The standard of graph drawing was often not strong. Candidates were given a page of A4 graph paper and so they had to work out a suitable scale. Many candidates found this difficult. Scales which go up in multiples of 3 or 7 are not suitable and a number of candidates used these. Most scales did not use a suitable width or height of the graph paper. Despite being told that they did not need to start their axes at (0,0), many candidates did so.

(iii) Some candidates were able to use the data to gain credit here to find the gradient of their graph, as their best-fit line went through these data points, but many of these candidates simply quoted data points from the table, did not show their working on the graph and so could not access all of the available credit.

(d) Candidates were expected to compare their value for the focal length of the lens (the gradient in **(c)(iii)**) with the manufacturer's value of 15.0 cm. This meant calculating the manufacturer's range, which gave values in a range from 13.5 to 16.5 cm and stating whether their value was in this range. There were some excellent calculations here. Many candidates simply ticked one of the boxes and gave no calculation and so could not be awarded credit.

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Question 4

Candidates were asked to describe an experiment to see how the thickness of a wire affects its resistance. The strongest candidates gained full credit here. Most candidates scored partial credit, with only a few candidates leaving the question blank.

Candidates were expected to draw a suitable circuit diagram, showing a wire (or a resistor) in series with a power source and an ammeter. A voltmeter was expected in parallel either across the wire or across the power source. The quality and presentation of the diagrams were variable.

The second step was to find the thickness (diameter) of the wire using the micrometer. Some candidates did not know what a micrometer was.

Further credit was given for simply taking readings of current and voltage for each thickness of wire. The equation for calculating resistance was provided.

Candidates then needed to suggest a variable which needed to be controlled. The obvious one to choose was the length of each piece of wire but the material of the wire was also accepted for credit.

The results table needed to show at least two columns – one for the thickness of the wire and one for the resistance. Units are required in table headers, but many candidates did not include these.

Finally, a conclusion was required. Candidates were not expected to say what that conclusion of the experiment would be as they had not carried out the experiment. They were expected to say how they would use their readings to reach the conclusion. Acceptable answers included comparing the results in the table or drawing a suitable graph of their data, stating which variable goes on each axis. The simple statement "plot a graph of the data" was not sufficient.

PHYSICS

Paper 5054/42
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 graduated in millimetres should be given to the nearest half-millimetre. If a measured length is, for example exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidate should take care 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 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 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 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.
- 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:

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

The level of competence shown by the candidates was good. Most candidates attempted all questions; 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, recorded observations clearly and performed calculations accurately. Units were well known and usually included where needed, writing was legible, and ideas were expressed logically. The standard of graph plotting was generally good.

Comments on specific questions

Question 1

(a) Most candidates drew the correct symbol for a voltmeter and drew it connected in parallel with the diode on the circuit diagram provided. Common errors were to connect the voltmeter in parallel with the resistor, or to connect the voltmeter in series into the circuit.

(b) The reading on the scale of the ammeter was almost always correct. The reading on the scale of the voltmeter proved to be more difficult. The smallest scale division on the given voltmeter scale was 0.4 V, but the majority of candidates thought that it was 0.2 A.

(c) The resistance of the diode was usually calculated correctly. The requirement to record the answer to an appropriate number of significant figures was often not followed. Since the other resistance values in the table were given to 2 significant figures, candidates were expected to round their answers to 2 significant figures before recording them in the table.

(d) The missing values of current and resistance were usually calculated correctly. The most common error was that the values entered in the table were not always rounded correctly.

(e) Stronger candidates were able to use the results they had collected in the table to describe the relationship between the current in the diode, the potential difference across it and the resistance of the diode. Other candidates found it difficult to express in words what was indicated by the numerical values in the table. Many responses were vague, referring to increases or decreases without any mention of increasing/decreasing current. Responses simply stating 'they are directly/inversely proportional' were not enough to gain credit. Many candidates did not answer the question asked, and instead described the relationships between the potential difference across the diode or the resistance of the diode with the resistance connected between X and Y.

(f) Many candidates were unable to make a sensible suggestion as to what the student may have done incorrectly. The most common incorrect answer was that the switch had not been closed. The most common correct answer was that the diode or the power supply had been connected the wrong way around. Another acceptable answer sometimes seen was that the voltmeter had been connected in series into the circuit.

Question 2

(a) The temperature shown by the thermometer scale was read and recorded correctly by almost all candidates. When the reading was incorrect, 70.3 °C had usually been recorded.

(b) The column headings were usually completed with correct, appropriate units being added. Candidates should be reminded that sec(s) is not an appropriate unit for time. The only unit accepted for second is 's'. The time values were almost always correct.

(c) Many candidates gave a list of precautions which did not specifically apply to ensuring that the temperature measurements were accurate. Of those candidates who listed an appropriate precaution, credit was usually gained by a description of how a parallax error could be avoided when reading the thermometer. Other acceptable answers were to stir before reading, or to ensure that the thermometer is not touching the sides or base of the test-tube.

(d) Most candidates identified the anomalous reading in the table at 35 °C, but answers of 52 °C were also common. Sensible explanations of how the anomalous value was detected were usually seen. The most popular explanation was that the reading at 35 °C did not follow the trend of the decreasing temperatures. The temperature decrease of the water in the test-tube whist cooling in cold and warm water was usually calculated correctly from the values given in the table.

(e)(i) Candidates found this question challenging. There were some excellent answers, but many candidates used the words 'cold' 'warm' and 'hot' inappropriately and produced answers which were confused. The instruction to use data to back up their conclusions was often not followed. Only stronger candidates gained full credit here.

(e)(ii) Stronger candidates did well on this question suggesting that the initial volumes of water in the test-tubes and the initial temperature of this water should be the same so that a more valid comparison could be made between the two rates of cooling. Commonly seen incorrect answers were to repeat and average, stir the water or reduce the time between the readings taken.

Question 3

(a) Candidates were required to take readings from a diagram to determine the position of the centre of a mass balanced on the rule. This exercise required careful reading of the ruler scale on the diagram, preferably by drawing tangents to both edges of the circular mass to find the exact readings on the ruler. Many candidates took approximate readings by eye. Some candidates who correctly identified the ruler readings at either side of the mass were then unable to calculate the position of its centre. Many candidates showed no working and simply wrote down where they considered the centre of the mass to be; if this was incorrect, they were not able to gain part credit for correct working. Most candidates were able to proceed and deduce the distance from the centre of the mass to the 50.0 cm mark on the rule.

(b) Only stronger candidates answered this correctly. The difficulty in obtaining an exact balance, and a technique that can be used to obtain an accurate value for the position of the pivot at balance was not known.

(c) Graph-plotting skills were of a reasonable standard, but many responses failed to score full credit. The most common sources of error were:

- awkward scales, such as 3 or 7. Choosing such scales makes the points much harder to plot and more difficult for plotted points to be clearly identified
- missing labels and/or units on the axes, even though they were included in the table of results
- choosing scales so that the plotted points did not span at least half of the given grid
- not using linear scales
- poor choice of a best-fit line.

However, there were some excellent, carefully plotted and drawn, best-fit lines produced by candidates. The calculation of *M* was almost always correct, but the occasional rounding error was made.

(d) Candidates who drew a large triangle to determine the gradient of their graphs obtained the most accurate values for the gradient of the line. Some candidates showed no clear indication on the graph of how the information used to determine the gradient had been obtained, despite the instruction given to do so.

(e) Stronger candidates answered this thoughtfully, explaining their reasoning carefully. Few other candidates realised that if a movable load of mass 40g was used, then it would be impossible to balance the rule. This can also be deduced by studying the trend of the *d* values in the table of results.

Question 4

There were some very good attempts at this question and most candidates understood the brief and described a suitable method. The most comprehensive approach for candidates is to address each of the bullet points in the question in the order given.

Marking point 1 was awarded for identifying additional apparatus needed to do the experiment. Most candidates realised that a ruler would be needed to measure the object and image distances, but far fewer mentioned that a screen would be needed to capture the image of the triangular object. In the strongest answers, candidates gave the additional apparatus information by labelling the diagram. Many candidates simply listed all the apparatus that they could see in the diagram provided on the question paper.

Marking point 2 was awarded for a diagram of the arrangement of the apparatus, indicating the object and image distances *u* and *v*. Many candidates drew correct diagrams of the actual experimental set-up, but a minority drew ray diagrams and described the paths of different rays as they passed through the lens. Most candidates knew where *u* and *v* should be but the arrows they had drawn on their diagrams to indicate these distances were not drawn precisely enough for credit to be awarded. Stronger candidates used a ruler to indicate these distances.

Marking points 3 and 4 were awarded for a brief description of how to do the experiment. It was evident that some candidates had no experience of this kind of experiment. Many candidates thought that when the lamp was switched on, a focused image would appear on the screen. There was no mention of moving the object/lens/screen slowly backwards and forwards until such an image was obtained. The strongest candidates produced detailed, well-written accounts of how to obtain a sharp image and of how to take the required measurements.

Marking point 5 was awarded for stating the steps needed to produce a sharp focused image.

Marking Point 6 was awarded for explaining how the candidate would use the readings obtained to calculate a value for the focal length of the lens. Candidates needed to give more than a simple suggestion of using the equation provided. Answers such as ‘substitute the measured values of *u* and *v* into the given equation’ were expected. Candidates who made up their own values and did a calculation to show how the focal length was calculated were awarded full credit.