PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

There were several questions which were answered well by a large number of candidate. These included **Questions 1**, **26**, **34** and **40.** Candidates found **Questions 3**, **6**, **12**, **15**, **20**, **25**, **27**, **29**, **35**, **37**, **38** and **39** more challenging.

Comments on specific questions

Question 3

Although most candidates chose the correct option, a number selected option **A** which is a reading given to a tenth of a centimetre. Candidates needed to read the question more carefully.

Question 6

Most candidates deduced that the two vertical forces were equal and that the balloon is neither rising nor falling in the vertical direction. However, many candidates selected the incorrect option **C,** indicating that they believe that resultant force is required to cause a movement at constant speed in a straight line.

Question 12

Many candidates chose the correct option. The other candidates were equally divided amongst the three incorrect options.

Question 15

Some candidates gave the correct answer here. These candidates correctly used the vertical height moved by the car in the calculation. Many other candidates used the distance along the slope. The other incorrect options were chosen only by a small number of candidates.

Question 20

Many candidates answered this question correctly. However, some candidates chose option **A**. Perhaps the change in direction of the movement of the small volume of water led some candidates to incorrectly think that both a contraction and an expansion were required.

Question 25

A large number of candidates chose the incorrect option **B**. In this diagram, a ray is traced back from the lens to the point F on the principal axis. However, this cannot be correct as this ray does not enter the lens parallel to the principal axis. A second error in option **B** concerns the ray passing through the optical centre of the lens that shows deviation. Rays through the optical centre do not change direction. The correct answer is **C**. Here two rays that are parallel as they enter the lens emerge so that they seem to come from a point that is the same distance from the lens as the point F; that is, they seem to come from a point in one of the focal planes of the lens.

Question 27

Both option **B** and option **D** show a wave of increasing amplitude and hence, a wave that gets louder. Most candidates chose one of these answers. The relationship between the pitch of the sound and the diagram is rather less direct. A decreasing pitch implies an increasing time period for the oscillation and this is shown by the trace in the diagram of option **B**. Although this was the most popular choice, option **D** was also frequently chosen.

Question 29

The first three options **A**, **B** and **C** were all nearly equally popular. Option **D** was only slightly less so. At the location of the compass, the directions of the magnetic fields due to the two wires were both from right to left and so the compass needle points in this direction. The directions of the magnetic fields can be deduced using a rule such as the right-hand grip rule although other rules can be used. It is possible that candidates who incorrectly deduced that the two magnetic fields cancelled, may have concluded that the needle pointed up or down the page.

Question 35

Many candidates knew what was happening in the electric cable and chose correctly. Each of the other options was chosen by a small number of candidates.

Question 37

Many candidates selected the correct option by indicating the correct direction of the conventional current and the correct direction of the force on the wire. Option **B** was also popular. This suggests that most candidates could deduce the direction of the motor-effect force, but fewer knew that the conventional current was in the opposite direction to the motion of the electrons.

Question 38

The most popular choice here was option **D**, rather the correct option **C**. The other two incorrect options were chosen by very few candidates.

Question 39

The correct answer **A** was chosen by more candidates than any other but all the options were selected by some candidates. This question was challenging for many candidates.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

There were several questions which were answered well by a large number of candidate. These included **Questions 3**, **8**, **16**, **24**, **29** and **40.** Candidates found **Questions 2**, **4**, **17**, **22**, **23**, **25**, **33**, **36**, **37**, **38** and **39** more challenging.

Comments on Specific Questions

Question 2

The question asked for an average velocity and not for an average speed. Velocity is a vector quantity that is equal to the rate of change of displacement with time. More candidates gave an answer that was calculated using the distance travelled rather than the option that used the total displacement of the athlete.

Question 4

Some candidates gave the correct answer, but many candidates chose an incorrect option. Candidates needed to interpret a distance-time graph which is not dissimilar in shape to a speed-time graph for an object falling through the air and reaching terminal velocity and many failed to do this.

Question 17

Some candidates gave the correct answer here as they used the vertical height moved by the car in the calculation. However, many candidates used the distance along the slope. The other incorrect options were chosen by a small number of candidates.

Question 22

The correct definition of latent heat was widely known but a few candidates chose the other options.

Question 23

Only the strongest candidates answered this question correctly. The question concerned the motion of a hydrogen molecule in the time after one collision and before the next. During this time there are no collisions and the molecule moves in a straight line at constant speed. The majority of candidates chose an option where there was a continuous change of direction of motion.

Question 25

This question was challenging for many candidates. The most commonly selected option was the correct one **A** but a number of candidates chose the incorrect option **C**.

Question 33

Although many candidates answered this question correctly, there were some who believed that the motor would speed up or that the brightness of the lamps would not be changed.

Question 36

A number of candidates selected the incorrect option **A** suggesting that a current of the same magnitude as before would now be shared by the two heaters. The current supplied doubles when the switch is closed and it is this current that is then shared equally. The larger current is the source of the problem and it explains why option **C** is correct.

Question 37

There were many correct answers here. A significant minority gave answer **A** which suggests that they had not considered that increasing the rate of rotation of the coil, increases the rate at which magnetic flux is being cut and hence the magnitude of the electromotive force induced.

Question 38

The most popular choice here was option **D**, rather the correct option **C**. The other two incorrect options were chosen by very few candidates.

Question 39

The correct answer **A** was chosen by more candidates than any other but all the options were selected by a few candidates. This question was challenging for many candidates.

PHYSICS

Paper 5054/21
Theory

Key messages

- Candidates should show all relevant working in a calculation so that credit can be given for all parts of the question answered correctly. In questions with a great deal of data, for example **Question 9**, it is important to start the calculation with the relevant formula.
- Candidates should ensure that they give the unit to any final calculated value.
- Candidates need to plan their answers and take time to read the question thoroughly before starting their answer.
- In ***Section B*** it is important to read through all questions before starting and not to waste time starting an optional question which cannot be finished.

General comments

A few items tested familiarity with the use of practical equipment, such as the variable resistor and the use of different ammeter scales A significant number of candidates found these sections difficult.

In several questions, candidates are asked to give a specified number of responses. It is advisable to only give the same number of responses as the question asks for, as only these responses are marked.

There appeared to be no evidence that candidates were short of time in completing the paper.

Comments on specific questions

Section A

Question 1

(a) The majority of candidates gave the correct response in **(i)**, although a number of weaker candidates gave the distance travelled between the resting place and town B. The answers to **(ii)** showed that the majority of candidates could interpret the distance-time graph correctly. One common error was for the time of the cyclist starting the rest period to be taken as 2.02 rather than 2.2 hours.

(b) Most candidates correctly answered this question by commenting on the gradient or slope of the graph. Some correctly suggested that the cyclist travels a larger distance in the same time. Answers such as ‘travels less distance in less time’ or ‘distance and time are higher at the end of the journey’ were not specific enough to be awarded credit.

(c) The formula relating speed, distance and time was well known. Average speed was usually calculated correctly. A significant number of candidates used the total time shown on the graph in their calculation, rather than the time for the journey, or calculated the two speeds and averaged them or failed to give a unit for their final answer.

Answers ***(a)(i) 58 km*** *7.8 g/cm*^{3} ***(a)(ii)*** *0.8(0) h* ***(c)*** *15 km/h*

Question 2

(a) The majority of candidates recognised that coal and oil are the sources of energy that will run out first.

(b) (i) The idea that thermal energy is used to turn water into steam in the rocks was well known. Less well known was that the steam is at high pressure and this provides the force to turn the turbines.

(ii) The formula relating heat, specific heat capacity and temperature rise was well known. Weaker candidates sometimes made mistakes in the calculation or failed to give the correct unit. A number of candidates, whilst writing the formula as H or $E = mc\theta$, interpreted H or E as the specific heat capacity.

Answer ***(b)(ii)*** *4.9×10^7 J*

Question 3

(a) It was encouraging that most candidates gave the correct forms of energy, with chemical energy widely known as the form of energy stored in muscle. Weaker candidates gave answers as kinetic or potential energy. Elastic energy and chemical energy are both forms of potential energy but 'potential energy' alone was not accepted.

(b) Most answers described what happens after the elastic limit rather than what happens after the limit of proportionality. The elastic limit is not mentioned in the syllabus but, because these two points are usually very close, a description of what happens after the elastic limit was accepted.

(c) (i) The majority of candidates stated or used the correct formula for work, although a number of weaker candidates confused this with that of the spring constant. A large number of candidates failed to convert the distance given in cm into metres before calculating the work done.

(ii) Although the majority of answers recognised that power is work or energy divided by time, fewer recognised that the athlete must count the number of times he stretches the spring in 60 s and calculate the total work done in 60 s before dividing by the time taken.

Answers ***(c)(i)*** *92 J*

Question 4

(a) Most answers stated that the distance between molecules is less in a liquid but did not go on explain why this is so by referring to the forces between the molecules.

(b) (i) The formula was stated correctly by the majority of candidates.

(ii) The majority of candidates made a good attempt at this question but used the final volume of the gas as 40 cm^3. A good proportion of the more able candidates, however, used the correct value for the final volume, 60 cm^3.

(iii) Approximately half of the candidates gave an adequate response as to why the pressure of the gas changes, usually by referring to the increased frequency of collision of molecules with the walls. Some weaker candidates suggested that kinetic energy increases, whereas the question states that the temperature is constant.

Answers ***(b)(ii)*** $2(.0) \times 10^5$ Pa

Question 5

(a) This question requires candidates to suggest that the resistance of the variable resistor can be changed, or the voltage of the battery . Other commonly seen answers were to 'change the resistance of the resistor R' or simply to 'repeat the readings'. The role of the variable resistor in the circuit was not recognised by many candidates.

(b) (i) Ohm's law was correctly stated by most candidates and, indeed, the role of constant temperature was also well known by the candidates as a whole.

(ii) Candidates found this question challenging as it required the use of data from the table to show that the resistor obeys Ohm's law. This is most readily done by calculating V/I and showing that this gives a constant value for different pairs of values. Most answers were simple statements along the lines of 'as voltage increases current increases' but this is not sufficient to show proportionality.

(iii) Only a few candidates recognised or stated that the first two readings, at 320 and 220 mA, should be taken on the 0–10 A range and the last reading on the 0–200 mA range. A few stronger candidates gave the generic account that one should start on the highest range, 0–10 A, and reduce the range, ensuring that the value was still on the scale of the meter. This section produced the lowest average mark on the paper.

Question 6

(a) Although most candidates recognised that the fuse protects from too high a current, a number of answers failed to state how this is achieved, for example by opening the circuit or by melting the thin wire if the current rises above a certain level.

(b) (i) The calculation of the current was successful in most cases where the formula for electrical power was known.

(ii) The fuse rating chosen was intended to be slightly larger than the calculated value in **(b)(i)** and integral if larger than 1 A. Many candidates stated a value equal to their calculated value for the current, rather than suggesting a larger value.

(c) It was encouraging that many answers suggested that 'the outside case of the hairdryer is plastic' or that 'the hairdryer is doubly insulated'. Weaker candidates suggested that the hairdryer was safe to use without an earth wire because it had a fuse.

*Answers **(b)(i)** 6.2(5) A*

Question 7

(a) (i) The more able candidates had little problem in suggesting that an e.m.f. is induced because magnetic field lines cut the coil as the magnet is moved. A number of answers incorrectly suggested that current is first induced and that this current creates the e.m.f.; although this sequence is incorrect it was not penalised.

(ii) To achieve a larger e.m.f. most candidates suggested using more turns on the coil. Weaker candidates made statements such as 'shake the tube more' or 'increase the current'.

(b) (i) The correct symbol for the LED was known by less than half the candidates. Many diode symbols lacked the vertical line next to the triangular symbol or lacked arrows facing away from the diode. A circle drawn around the diode itself is optional and was not required.

(ii) Many descriptions of why an LED is more efficient than a filament lamp were merely statements that 'the LED gives out more light' or that 'it conserves more energy'. Only the more able candidates argued convincingly that 'for the same input energy the LED produces more light output' or that, 'for the same amount of light, the LED requires less input energy'.

Question 8

(a) (i) The potential divider can be considered a challenging topic, but encouragingly, just under half of the candidates answered this question correctly.. Weaker candidates tended to calculate the current in the circuit first. This was only successful if they used the total resistance in their calculation.

(ii) Explanations by stronger candidates as to why the p.d. increases when temperature increases often started by stating that the 'resistance of the thermistor falls' leading to 'an increase in current in the circuit'. A significant number of answers stated that 'resistance increases or is proportional to temperature' and did not recognise that the p.d. across the 2000 Ω resistor is not the p.d. across the thermistor. To be awarded credit here, the candidates need to show that they were considering the pd across each component separately and then together.

(b) Slightly more candidates opted to describe what happens inside the relay rather than in the transistor circuit. Those who answered the transistor alternative to this question often showed a considerable amount of knowledge.

In the relay alternative, candidates readily understood that the relay switch closes but did not always explain that this was because there is now a magnetic field inside the relay coil which attracts iron or part of the switch, to cause the switch to close.

In the transistor alternative it was encouraging that many answers used ideas about the base, collector and emitter. It was often recognised either that there is small current into the base of the transistor that switches on the transistor or that produces a larger current in the collector. Fewer answers mentioned that there has to a voltage between base and emitter to switch on the transistor.

Question 9

(a) Definitions of mass sometimes confused mass and weight but in general the definition was well known and expressed. The definitions of weight were less successful and statements such as 'weight is the force acting on a body' omitted the idea that weight is the force due to gravity.

(b) The calculation of acceleration from mass and force showed that the formula was well known and most candidates successfully subtracted air resistance from the weight of the parachutist. It was encouraging that most candidates gave the correct unit for acceleration.

(c) (i) The speed-time graph produced a variety of answers. A constant terminal speed of 44 m/s, lasting for 10 s, was shown correctly by most candidates. The drop in terminal velocity to 5.0 m/s was not always plotted correctly. The initial shape of the graph was meant to show a decreasing acceleration as the parachutist approached terminal velocity. Many graphs drew initial straight lines or the shape was markedly incorrect for a falling object.

(ii) This calculation was also successfully answered by most candidates, although the values used for the initial and final speeds were sometimes not those given in the data.

(d) (i) The idea that, at terminal velocity, forces balance was well known. Candidates successfully gave the names of the forces involved as well as stating that the relevant forces are equal.

(ii) Many answers suggested that opening the parachute increases air resistance but less than half the candidates also explained that this meant that the upwards force is larger than the downwards force or that the increased air resistance produces a resultant force upwards.

(iii) Few answers correctly developed the ideas about falling at terminal velocity suggesting that, with the parachute open, air resistance is equal to weight at a lower speed.

Answers ***(b)*** *6.7 m/s*^{2} ***(c)(ii)*** 9.7 or 9.8 m/s^2

Question 10

(a) (i) This question can be answered by measuring the distance between adjacent wavefronts or using the distance between P and Q, in both cases applying the correct scale factor. This scale factor was often applied incorrectly to the measured distance. There was a significant number of candidates who attempted to use the formula $v = f\lambda$ to find the wavelength, and this is not possible directly.

(ii) The definition of frequency was well known although definitions such as 'the number of waves in one second' are better expressed as 'the number of wavefronts that pass a point in one second'..

In some definitions it was not clear that frequency is the number of oscillations in one second or unit time and, instead, mentioned ‘in a certain time’.

(iii) The calculation of frequency can be deduced from the diagram, where, as 5 wavelengths pass through P in two seconds, there must be a frequency of 2.5 Hz.

(iv) Many descriptions of how the wave is produced merely state that ‘the bar of wood is dropped into the water’ and did not mention that the bar must oscillate upward and downward or forward and backward at a regular rate.

(v) Fewer than half of the candidates were able to answer this section successfully. The water becomes less deep and this reduces the speed. A number of candidates correctly suggested that speed is faster in deep water but then contradicted themselves to say that there was an increase in speed as the depth is reduced.

(b) (i) The most direct answer to this question is to use a stopwatch and some form of measure for the distance, for example a tape measure. This was successfully suggested by most candidates. Alternative apparatus, such as the use of a microphone and storage oscilloscope or electronic times, was also acceptable and was seen.

(ii) The question asks how the measurements are made and yet many candidates described the calculation that is made to find the speed of sound. The starting of the timer was sometimes poorly explained. The simplest strategy is for a student, standing some distance from the student who fires the gun, to start a timer as he sees the smoke from the gun. Other successful strategies for starting the timer were also seen but in a significant number of answers the timer was not started correctly. The question refers to an open space, and so reflection from a wall was not accepted for full marks.

(iii) The syllabus states that candidates should know the order of magnitude of the speeds of sound in a liquid and a solid. The range of values for the speed in sound in a liquid was made fairly large to accommodate a realistic range of possibilities and it was expected that candidate should know that the speed of sound in a solid is larger than in a liquid.

Answers ***(a)(i)*** *6.7-7.2 cm* ***(a)(iii)*** *2.5 Hz*

Question 11

(a) (i) The Geiger–Muller tube or Geiger counter was the most common detector named.

(ii) The precautions suggested were usually in the form of clothing or storage that contained lead or to keep one’s distance using, for example tongs or forceps.

(b) (i) The concept of randomness in time was generally well explained with answers that suggested either that the time between emissions varies, that they cannot be predicted or that the count rate can increase and decrease at different times. Some answers did not refer to emissions at all and were merely descriptions of the word random.

(ii) Good answers to this section involved the repeated measurement of the count in a specified time interval, often 1 minute and a comparison of the readings. Some counters record count rate and if this type of counter was clearly used then the reading will rise and fall with time. Alternatively, in some answers, the time between emissions was recorded and this is also possible and was seen.

(c) (i) The most common answer was that background radiation is radiation naturally occurring in the environment. Specific sources of background radiation, for example cosmic rays from space were not accepted on their own as they do not describe what is meant by background radiation and do not constitute all of the background radiation. Weaker candidates tended to suggest that background radiation is ‘not visible’ or is ‘in the background’.

(ii) Most candidates who understood the question suggested that background radiation is subtracted from the count rate. Fewer candidates suggested that one must first measure background radiation by measuring the count or count rate without the source being present.

(d) (i) The correct answer was given by most candidates. A value of 3.0 cm was given by a number of candidates. This value corresponds to the end of the straight line portion of the graph but does not show the maximum distance that the radiation travels.

(ii) Although most answers correctly suggested that the particles emitted by the radioactive source are alpha particles, the reasons given were often rather vague and amounted to a statement that alpha particles have a short range. Better answers actually suggested that the range of alpha was a few centimetres in air or compared the range of alpha particles with beta particles and gamma rays.

(iii) **S**tatements needed to refer to atoms in the air losing or gaining electrons. Many, for example, simply stated that 'the air becomes charged' or the 'air gains ions'.

(e) The decay graphs drawn were generally very encouraging and most curves were drawn neatly with some care being taken to ensure a smooth curve. It is possible to plot points at 0, 40, 80 and 120 minutes from the start and the majority of candidates did so. A small number of candidates plotted their first point at (40,300) rather than at (0,300)

Answer ***(d)(i)*** *4.5 cm*

PHYSICS

Paper 5054/22
Theory

Key messages

- Candidates should show all relevant working in a calculation so that credit can be given for all parts of the question that are answered correctly.
- Numerical data is given in the paper to two significant figures. Candidates should give their answers to at least two significant figures and check that any rounding is correct.
- Candidates should ensure that they give the unit to any final calculated value.
- Candidates need to plan their answers and take time to read the question thoroughly before starting their answer.

General comments

In general the majority of responses were both legible and understandable. However, a few candidates appeared to write their answer in pencil and then overwrite the pencil answers, often in ink. This practice should not be encouraged as the script is difficult to read when scanned electronically.

In several questions candidates are asked to give a specified number of responses, e.g. in **Question 9(b)** where they are asked for **two** factors that increase braking distance. A number of candidates gave more than the specified number of factors. This is not advisable as only the first specified number of factors are marked and correct factors appearing later in the list are ignored. Candidates should be advised, when asked for a specified number of responses, to give the specified number that they think are the best answers.

A number of candidates seemed unaware of the meaning of the command words used in the examination, for example ‘state’ does not mean ‘explain’. In **Question 9(b)** a number of candidates not only stated a factor that increases braking distance but gave explanations of why this increases the braking distance. Although such arguments are not penalised it does reduce the time available to answer the rest of the paper.

There appeared to be no evidence that candidates were short of time in completing the paper.

Comments on specific questions

Section A

Question 1

Most candidates in this question showed a good understanding of measurement using a measuring cylinder and of the formula for density.

(a) The majority of candidates were able to score full marks in this section. Good answers showed a methodical approach in determining the volume, giving a correct order for conducting the experiment. A number of candidates referred to the diagram, quoting the initial volume of water in the measuring cylinder as 40 cm^3. Others continued this approach to speculate on the new volume when the irregular object was added and included this in their final calculation or referred to the initial volume as V1 and the final volume as V2. Good candidates made it very clear what measurements were being taken, for example measuring the volume of water with the measuring cylinder. Many good responses also included extra features to improve the accuracy, such as fully immersing the object or ensuring that there are no splashes. Some candidates lost marks by not specifying that the initial volume is actually measured or recorded, or, alternatively, they did not include the subtraction of the final and initial volumes in their answer. Some weaker candidates referred to water being lost, measurement of the mass of the cylinder or melting the iron and pouring this into the measuring cylinder.

(b) Many candidates started with the equation, substituted the correct values and then showed their final answer with the correct units. This is a successful approach and is to be encouraged. A number of answers gave the wrong final unit, sometimes because there had been a wrong change of unit from g to kg or cm^3 to m^3. Correct changes of unit are acceptable but are often not needed and can lead to error. The conversion of g to kg was usually correct but when converting from cm^3 to m^3, candidates tended to divide by 100 rather than 10^6.

(c) Very clear working out was shown by many of the candidates who scored full marks, usually with the density of copper calculated first and then the rearrangement of the density formula shown correctly. Many candidates, however, used the density of iron rather than copper in their calculations.

(d) This question provided a variety of answers. Correct answers tended to be concise stating that density decreases as volume increases. Others gave much more detail, often with a molecular interpretation of expansion in terms of motion and increased separation of particles. Weaker answers suggested that mass decreases on heating, or failed to explain why density decreases sometimes giving incorrect or insufficient reasons, such as the particles are lighter or vibrate more. It is considered that the particles themselves do not become less dense when a substance is heated. The substance itself may become less dense but that is because the distance between the particles increases and not that the density of an individual particle decreases.

Answers: **(b)** 7.8 g/cm^3 **(c)** 460 g

Question 2

This was a question on the manometer.

(a) Many correct definitions were produced for pressure, either in terms of the force per unit area or the force on an area of 1 m^2. Some definitions referred to a 'certain' or a 'specific' area which was not accepted.

(b) This proved a challenging question and full marks were only achieved by a few. Most candidates remembered the formula for pressure in terms of density and depth and this resulted in some credit. The more able converted the distance of 16 cm into 0.16 m before calculating the pressure difference. Only the most able candidates subtracted the value obtained for the pressure difference from atmospheric pressure. Others ignored atmospheric pressure completely or added the pressure difference to atmospheric pressure rather than subtracting it from atmospheric pressure.

(c) (i) Most candidates were able to give a reasonable value for the level of mercury, realising that as the level rises on one side it falls an equal distance on the other. A number of candidates gave 0 or 16 cm as their answer.

(ii) It was encouraging to find many candidates able to describe authoritatively the increase in kinetic energy and more frequent collisions of the molecules with the walls or with the mercury. The question asks for an explanation in terms of molecules but some candidates failed to mention molecules at all or seemed unsure of whether they were describing the gas or the molecules in the gas, drifting from one explanation to the other.

Answers: **(b)** 7.8×10^4 Pa **(c)(i)** 8.0 cm

Question 3

This was a question on refractive index, total internal reflection and critical angle.

(a) Most candidates knew that the middle ray was associated with the critical angle. Just over half of the candidates were able to accurately label the critical angle correctly.

(b) Many answers correctly suggested that the angle of incidence is larger than the critical angle. A significant number of answers did not clearly identify the angle of incidence in their answer, suggesting, for example, that 'the incident ray is greater than the critical angle'.

(c) (i) The majority of candidates correctly recalled the equation for refractive index but often produced an answer less than 1, not realising that the refractive index of a substance is obtained by taking the angle in air or a vacuum divided by the angle in the substance. A few candidates used angles from the surface to the ray rather than from the ray to the normal. A common mistake was to give a unit for refractive index as °, whereas it has no unit.

(ii) Where candidates obtained an answer less than 1 for the refractive index *n,* they often found difficulty in using the equation n = 1/sin c to find the critical angle c, although others were able to calculate the angle correctly even when $n < 1$. When quoting the final angle, a common error was to omit the unit for the angle.

Answers: **(c)(i)** 1.3(2) **(ii)** 49°

Question 4

This was a question on the electromagnetic spectrum from a star.

(a) Most candidates gave a response within sensible and allowed limits for the wavelength of the peak of the curve. The unit was often omitted but in this case the lack of a unit was not penalised.

(b) This section produced the weakest response with ultraviolet being a popular but incorrect answer. The answer to **(a)** is larger than the largest wavelength in the electromagnetic spectrum and it may have been the powers of ten in the answers that led candidates to incorrectly think that 10^{-6} is smaller than 10^{-7}.

(c) Most candidates were able to recall the correct formula relating speed, frequency and wavelength and were able to rearrange it correctly. The division by wavelength, a number with a negative power led to errors with answers such as 250 Hz being common. Many candidates did not give a unit for the answer to this calculation.

Answers: **(a)** 1.2×10^{-6} m **(c)(i)** 2.5×10^{14} Hz

Question 5

This was a question on charging by induction.

(a) The majority of candidates clearly understood the physics of this question; that like charges repel, unlike charges attract and that charges can flow to and from the earth. However, many answers did not specifically mention the repulsion of the electrons on the metal sphere and a minority incorrectly suggested that positive charge moves towards the dome. A few candidates suggested that charge physically moves between the dome and the metal sphere.

(b) Candidates appeared to find this question difficult, although a significant number gave the correct order D C B E. Candidates who gave sentence D as the start and sentence E at the end of the process gained some credit.

Question 6

Most candidates showed a good knowledge of series and parallel circuits and of the formula for resistance in terms of voltage and current.

(a) This section was very well answered with the majority achieving success, although the rearrangement of the formula to find current caused problems for some candidates.

(b) It was encouraging that a large number of candidates successfully negotiated the subtraction of currents to obtain the correct answer. A number of candidates obtained the total resistance of the circuit, 9.2 Ω, rather than the resistance of lamp Q.

(c) (i) Candidates clearly knew their circuit symbols and this produced the highest-scoring section on the paper. However there was still room for improvement in that more care could have been taken over the drawing of the circuit in many cases, with fewer accidental gaps.

(ii) Over half of the candidates gave a sensible explanation to this part of the question about why the current is reduced when resistors are connected in a series circuit. Candidates who did not realise that the total resistance would be greater found this more challenging to answer. A commonly seen answer, which does not explain why the current is less, was the statement ‘current splits in a series circuit’.

Answers: **(a)** 0.4(0) A **(b)** 24 Ω

Question 7

This was a question on the motor effect requiring interpretation of a diagram with a current carrying conductor in a magnetic field.

(a) Many candidates gave the wrong direction for the current, indicating the direction of the movement of the electrons rather than the direction of the electric current in the wire. The convention for direction of current is to show the direction in which positively charged particles would move.

(b) Correct answers usually suggested that the current in the copper wire either produces its own magnetic field which interacts with the magnetic field of the magnet or that a magnetic field and current produce a force according to the left-hand rule. Many responses were too vague and a common error was to suggest that electromagnetic induction is involved.

(c) The question asks for the names of two different devices using the effect described in **(b)**. The motor or a device using a motor was the most common correct answer and loudspeakers or moving-coil meters were also sometimes correctly suggested. Many devices were not accepted, such as generators, transformers, relays and solenoids. Some suggestions were also vague, such as a ‘television’, which may contain a loudspeaker but also involves the use of other devices for its main purpose.

Question 8

This was a question on thermionic emission and electric fields.

(a) Many candidates correctly stated that the anode attracted electrons and many also correctly referred to thermionic emission or heating of the filament as the source of the electrons. However some candidates did not restrict themselves to answering the question but went on to refer to X- and Y-plates, fluorescence of the screen, etc.

(b) The structure of the cathode ray oscilloscope is not in the syllabus and does not need to be taught. It was unfortunate that many candidates merely discussed the purpose of the X- and Y-plates rather than the electric field set up between two oppositely charged plates. Those who did understand the concept of the question scored full marks easily for stating that one plate should be charged or connected to +ve and the other –ve, relating this to the electric field between the plates and the direction of movement of the electrons. This was sometimes better explained with a sketch diagram showing field direction and the direction of deflection of the electron in the field. Many weaker candidates seemed to think that this question was about electron flow in a magnetic field or suggested connecting both plates to positive.

Question 9

This was a question involving the motion of a car and included displacement as a vector, stopping distances, kinetic energy and acceleration.

(a) (i) Few candidates really understood how to measure displacement from the diagram. This could be done by drawing or by calculation involving, for example, Pythagoras' theorem. Most candidates were able to score some credit for using the scale of the diagram and to give an approximate direction such as North East but the bearing of a displacement or the use of points of the compass eluded many candidates, even though this is the most direct method to suggest a direction.

(ii) Good answers succinctly stated that distance is a scalar and displacement a vector. Although many candidates gave a correct answer, some responses were too vague and referred to the shortest and longest distances between two points and did not refer to the direction being involved in displacement and not in distance.

(iii) It was encouraging that many candidates were able to make the link that the car is changing direction and good answers included both a change of direction and a change in velocity or a reference to centripetal force or acceleration. Many candidates suggested that the car is accelerating due to a change in direction or 'turning' but failed to link this to a change in velocity. A common misconception was that the car accelerates because it is going downhill, even though the question says that the car has constant speed. Weaker answers confused resultant and gravitational forces, suggesting that going uphill needing acceleration in order to remain at constant speed.

(b) (i) This section was well answered by the majority of candidates; however a significant proportion stated that thinking distance was a 'time' rather than a 'distance'.

(ii) There were many good suggestions for factors that increase braking distance, usually factors that reduce friction either at the surface of the road or at the tyres, or increase the mass or speed of the car. Some candidates gave answers that were too vague e.g. just stating 'speed of car' rather than 'higher speed'. Weaker answers suggested factors that affect thinking distance rather than braking distance.

(c) (i) Almost all candidates gave the correct equation for kinetic energy but a small number of candidates failed to square the velocity when substituting numbers into the equation. Calculations involving powers of ten, in this case positive powers, were usually correct.

(ii) Although knowledge of the formula $F = ma$ was well known, this section produced the lowest average mark of the calculations in this question. This was often because the unit for acceleration was omitted or wrong, or that the mass was changed from kg into grams when used in the equation.

(iii) Most correct answers made a reference to friction, although some candidates merely referred to 'rubbing' or 'heat produced' and others referred to friction in the wrong place, e.g. between the driver's foot and the pedal.

Answers: **(a)(i)** 52 km 073°, N(73°)E **(c)(i)** 540 000 J **(ii)** 1.5 m/s^2

Question 10

This was a question about a soldering iron and a thermocouple used to measure its temperature.

(a) The answers to this question produced relatively few fully correct answers. The melting point of the metal used in the tip, 1000 °C, was correct more often than the melting point of solder, 200 °C. The metal used in the tip must still be a solid at 380 °C and so should melt above that temperature and the solder must be liquid at 380 °C and solid at room temperature, 20 °C. Choosing the melting point for solder as 380 °C is not appropriate as the solder would still be a solid at this temperature and not melt when placed on the soldering iron.

(b) (i) It was encouraging that most candidates used the correct formula and the temperature rise in the calculation. A few candidates confused thermal energy and specific heat capacity and the formula $E = mcT$ is recommended, using E for the energy.

(ii) The majority of candidates were successful in this section.

(c) (i) The best answers mentioned electron diffusion from the hot end to the cold end and suggested that electrons hit other particles to pass on their energy as they move throughout the metal. A number of answers failed to mention electrons at all or were answers where conduction was the passage of thermal energy from one vibrating particle to another, the process involved in non-metallic conduction.

(ii) Almost all candidates obtained some credit for realising that hot air rises. It was unclear in a number of answers that air, rather than particles of the metal tip were rising. The explanation was often attempted in terms of a change in density and the simple explanation that hot air expands and becomes less dense was the most succinct answer. Molecular explanations for the change in density were often not helpful and did not make clear that the air as a whole, when heated, was less dense.

(d) (i) The circuits drawn usually involved a hot junction and a meter. A cold junction was also often shown but was not required as the junction with the meter can act as the cold junction. The feature most often omitted was that there should be two different metals at the hot junction and it was encouraging to see specific metals named in good answers.

(ii) The most common reason why a thermocouple is suitable was most often quoted as being because 'it can measure high temperatures' or 'has a large range'. Other possibilities, such as its speed of response, its small size or the fact that it gives an electrical output were less often seen. The sensitivity, cost or ruggedness of a thermocouple were not accepted.

Answers **(b)(i)** 790 J 073°, N(73°)E **(ii)** 270 J

Question 11

This was a question about nuclear fusion, fission and the Geiger Marsden experiment.

(a) (i) This section, surprisingly, produced the poorest response in the question. The question asks for the cause of an initial collapse in a cloud of gas in space. Rarely was the simple answer of gravitational attraction mentioned and often the answer started off by describing the high temperature.

(ii) Although many candidates recognised that high temperature was necessary for nuclear fusion to occur, other conditions such as high pressure or high density were less commonly given. Some candidates mentioned specific temperatures which were sometimes the surface temperature of the Sun, 4000 °C, rather than a core temperature.

(b) (i) The majority of candidates correctly gave protons and neutrons as the particles found in the nucleus of uranium and gave the correct numbers of each. Some answers gave fission decay products such as krypton and barium or alpha and beta particles, rather than the particles actually found inside the nucleus itself

(ii) It was common knowledge that isotopes contain the same number of protons. Weaker answers mentioned just ‘protons’ without mentioning the ‘number of protons’. A few answers also added the same number of electrons, which was not penalised.

(iii) The description of nuclear fission required a neutron hitting or being absorbed by the uranium nucleus, splitting into two particles and the emission of more neutrons. A significant proportion of candidates failed to mention the role of the neutron at all or gave details about a nuclear power station, such as the moderator or control rods, which were not required.

(iv) The general difference between fission and fusion in terms of fission involving splitting and fusion the joining together of nuclei was used most commonly as the answer to this section. Even though the language used was sometimes vague, the general understanding of the difference was well known. Other differences such as the fact that the waste products in fusion are likely to be less radioactive for long were sometimes seen.

(v) The equation, when attempted, was almost always completely correct.

(c) (i) Over half of the answers correctly located P, the place where most flashes occur, in the middle of the screen on the right.

(ii) All that was required was a description that fewer flashes are seen moving away from P. Only a few candidates suggested that the flashes were less frequent and many answers, on the right lines, suggested that the flashes were dimmer, weaker or that there were no flashes at all.

(iii) Where candidates appeared to have met the experiment before there were some very sensible and well-written answers suggesting that the centre of the atom (the nucleus) is small, contains most of the mass and that the charge is concentrated there. Candidates who may not have met the experiment before often answered in terms of the absorption properties of the alpha particle.

Answer: **(b)(i)** proton number 92; neutron number 143

PHYSICS

Paper 5054/31
Practical Test

Key messages

- It is important that repeat measurements should always be taken and written down where appropriate.
- Working for calculations should always be shown, the units for quantities always stated and final answers should be given to an appropriate precision (usually 2 or 3 significant figures) and correctly rounded.
- Readings taken from an instrument such as an analogue ammeter or voltmeter should be written down to the precision shown by the instrument.
- For questions where the unit required is printed on the answer line, candidates should ensure their responses are given in the correct unit.
- Candidates should be encouraged to check their work and ensure their written responses are clear, particularly if they have changed or replaced their data with new values.

General comments

Stronger responses demonstrated that candidates were able to understand the questions and could perform the tasks requested, making careful observations, taking measurements with repeats and recording the information accurately. These candidates were able to construct well-organised tables of results, perform calculations by substitution into equations, plot line graphs and make valid comments, predictions or comparisons using their results and following the guidance provided in each part of a question. Some weaker responses gave comparisons that were too vague. For example, the terms 'change' or 'vary' were not precise enough and descriptors such as 'increases' 'decreases' or 'remains constant' should have been used as they are more specific.

A set of results for each set of apparatus used must be provided with the supervisor's report. It is important that the apparatus used complies as closely as possible to the equipment specified in the Confidential Instructions which are sent out to centres.

It is important that times are measured (or converted correctly if necessary) and recorded in the correct unit, the SI unit of seconds, s. Many candidates demonstrated poor skills in the correct use of a stopwatch and some were unable to convert the displayed time into a value in seconds written in correct decimal notation.

The plotting of graphs was generally good but some candidates found this challenging. A number of responses showed the use of impractical scales based on the difference between the first and the last values of their results divided by the number of squares on the grid. This often produced a scale that was impractical. Scales and the numbering on axes should be based on integers such as 2, 5 or 10 so that it is easy to find the coordinates of points on the line. Scales based on 3, 6, 7 should usually be avoided. The points should be plotted accurately and clearly, but finely marked. It is not expected that all points should lie on the line because candidates are using their own data. For example, in **Question 4** the best line should have been a smooth curve and not a straight line.

Comments on specific questions

Section A

Question 1

(a) The time, *T*, for 20 oscillations of the pendulum was measured with timing commencing at the point of release rather than the usual, more accurate, centre point. Values of 38.5 ± 2.0 s were accepted, with a precision of 1 or 2 decimal places with the correct unit. It is important that the time should be recorded as a decimal number in seconds, not minutes and not using colons or superscripts. A small number of candidates answered the question incorrectly by calculating their final answer as the time for only one oscillation. As the quantity *T* was a value for 20 oscillations it was not essential for repeat measurements to be recorded, but candidates who recorded repeat measurements and averaged them often wrote the best responses.

(b)(i) The distance between the two bosses was increased by lowering the second boss by 20 cm and the new time for 20 oscillations should have been 35.1 ± 2.0 s.

(ii) After a further lowering of the second boss by 20 cm the third value should have been 30.7 ± 2.0 s.

(c) Candidates were asked to describe the trend shown by the results. A statement was required describing how the time changed as the distance was changed. The strongest responses stated that as the distance, *D*, was increased, the time, *T*, decreased. This question assessed the overall quality of the results obtained by candidates, so credit was not awarded if the results did not fit the expected trend.

(d) An alternative method of timing an oscillation, commencing from the centre of the oscillation was described and candidates were asked to consider the speed of the mass used as the pendulum bob and to suggest why this method would be more accurate. There were a few good responses stating that the mass would be moving at its maximum speed when passing through the point corresponding to the centre of its oscillation.

Question 2

(a)(i) Most responses gave an acceptable value (in the range 4.5–5.1 Volts) and precision (1 or 2 decimal places) for the potential difference across the resistor.

(ii) At least two measurements should have been recorded, converted correctly into seconds and then averaged. Values between 2 s and 120 s should have been obtained

(b) When the process was repeated with the second resistor at least two measurements should have been recorded, converted into seconds if necessary and then averaged. The values in stronger responses were lower than those obtained with the first resistor, by a factor of about 7.

(c) Stronger candidates stated that the time taken was reduced and calculated the approximate factor by which it was reduced for their set of results.

Question 3

Only the strongest candidates answered **(a)** and **(b)** well.

(a)(i) Values of 12–18 degrees were accepted for the initial angle between the rule and the numbered arm of the beam.

(ii) Stronger responses showed the angle increasing each time by 6 to 8 degrees up to a final value in the range 40–45 degrees.

(b)(i) Many candidates recognised at least one difficulty, for example, keeping the apparatus sufficiently steady to obtain measurements, but very few provided adequate descriptions of a relevant improvement. Weaker candidates suggested holding the beam and rule together (this would disturb the system too much), fastening the protractor to the beam or using a larger protractor. Stronger candidates suggested fastening the protractor to the rule. Responses which suggested there was a parallax error were only accepted if there was sufficient detail explaining how that error arose when using the apparatus specific to this experiment.

(c) Stronger candidates gave one of the two accepted methods for checking the rule was horizontal, comparison with a known, distant horizontal reference line or the preferred method of measuring the distance between the lower edge of the rule and the bench surface at either end of the rule (or at two or more points along the rule at some distance apart). The use of a spirit level was not accepted because no spirit level was provided for the experiment.

Section B

Question 4

(a) Stronger candidates gave the lengths of one of the slits (27 ± 1 mm) and then the distance between the centres of the slits (17 ± 1 mm) was measured and recorded in units of cm or mm. These candidates recorded two or three values and the average for each quantity.

(b) The corresponding dimensions were measured and recorded for the image of the slits (55 ± 2 mm and 34 ± 2 mm respectively) and stronger candidates recorded two or three values correctly averaged.

(c) Measurements of the length of the image of the slit and the distance between the images of the slits were made for heights of the slit plate in the range 4.0 to 16.0 cm and a table of results constructed. In stronger responses, the headings were given by name or symbol with the correct quantity for each unit. There should have been at least six sets of results, including values close to the ends of, but within, the range requested. The values of length and distance should have risen by increasing amounts as the value of *h* was increased and in most cases this was confirmed. The ratio of $\frac{di}{li}$ should have been approximately constant. A few candidates replaced the heading $\frac{di}{li}$ with M or 'magnification'. This was not accepted as candidates were asked only about the ratio $\frac{di}{li}$.

A few weaker candidates calculated $\frac{li}{di}$.

(d) A graph was plotted of image length, *li*, (*y*-axis) against height, *h*, of the slit plate above the paper (*x*-axis). Stronger responses plotted a graph with a scale that was easy to work with and large enough to occupy at least half the grid in each direction, with fine points or crosses for plots and a neat, thin line of best fit curve drawn.

(e) (i) Some candidates did not understand the question, or misread it and constructed the tangent to the curve at a chosen *h* value.

(ii) The gradient of the drawn straight line was calculated in the usual way utilising a large gradient triangle.

(f) Many candidates gave no response to this part of the question and the responses that were given were usually not strong. However, stronger candidates recognised that whilst the values of $\frac{di}{li}$ were close to, but not exactly the same as, each other they were close enough to be considered the same within the margins of experimental error (about 10 per cent) and they stated that their results did indeed support the suggestion. Similarly, sets of $\frac{di}{li}$ which were very different (more than 20 per cent) could be regarded as not supporting the suggestion. Occasionally sets of $\frac{di}{li}$ gave no clear indication whether the suggestion was supported. Percentage errors were not required and statements such as "close enough" or "not close enough" to be regarded as equal were adequate.

PHYSICS

Paper 5054/32
Practical Test

Key messages

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General comments

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(d) An alternative method of timing an oscillation, commencing from the centre of the oscillation was described and candidates were asked to consider the speed of the mass used as the pendulum bob and to suggest why this method would be more accurate. There were a few good responses stating that the mass would be moving at its maximum speed when passing through the point corresponding to the centre of its oscillation.

Question 2

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(b) When the process was repeated with the second resistor at least two measurements should have been recorded, converted into seconds if necessary and then averaged. The values in stronger responses were lower than those obtained with the first resistor, by a factor of about 7.

(c) Stronger candidates stated that the time taken was reduced and calculated the approximate factor by which it was reduced for their set of results.

Question 3

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Section B

Question 4

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A few weaker candidates calculated $\frac{li}{di}$.

(d) A graph was plotted of image length, *li*, (*y*-axis) against height, *h*, of the slit plate above the paper (*x*-axis). Stronger responses plotted a graph with a scale that was easy to work with and large enough to occupy at least half the grid in each direction, with fine points or crosses for plots and a neat, thin line of best fit curve drawn.

(e) (i) Some candidates did not understand the question, or misread it and constructed the tangent to the curve at a chosen *h* value.

(ii) The gradient of the drawn straight line was calculated in the usual way utilising a large gradient triangle.

(f) Many candidates gave no response to this part of the question and the responses that were given were usually not strong. However, stronger candidates recognised that whilst the values of $\frac{di}{li}$ were close to, but not exactly the same as, each other they were close enough to be considered the same within the margins of experimental error (about 10 per cent) and they stated that their results did indeed support the suggestion. Similarly, sets of $\frac{di}{li}$ which were very different (more than 20 per cent) could be regarded as not supporting the suggestion. Occasionally sets of $\frac{di}{li}$ gave no clear indication whether the suggestion was supported. Percentage errors were not required and statements such as "close enough" or "not close enough" to be regarded as equal were adequate.

PHYSICS

Paper 5054/41
Alternative to Practical

Key Message

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

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

General Comments

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. Candidates need to think about what they would do in a practical situation rather than try to answer the question from the point of view of a theory paper.

The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly, although a few were unable to give an answer to the correct number of significant figures. Units were generally well known and usually included where needed.

Question 1

(a) In **(a)(i)**, the question required the candidates to measure two lengths accurately to the nearest millimetre. It is not possible to measure to 0.1 mm with a ruler and so some candidates lost a mark for giving the responses to 3sf. Answers should have been given to 2sf but 8 cm was accepted as this was an exact figure (although 8.0 cm would be better). Answers to **(a)(ii)** were mostly correct, some with error carried forward. In **(a)(iii)**, many candidates could make a sensible practical suggestion as to why it is difficult to measure the given length. Those who made general and non-specific remarks referencing parallax were not awarded credit..

(b) In **(b)(i)**, candidates were required to draw a circuit diagram from a picture of the arrangement of components. Most drew the arrangement correctly but many did not know the correct symbol for a light dependent resistor (LDR). In **(bii)(1)**, candidates were required to take the readings from a voltmeter and a milliammeter. Both answers needed to be fully correct for the mark and many lost this mark for either reading one of the scales incorrectly or for giving too many significant figures in their answer – they need to look at the scale and decide the appropriate number of significant figures in their response. The calculation in **(bii)(2)** was straightforward. Many candidates lost marks by not converting the miiliamps to amps or giving more significant figures than the 2sf instructed.

(c) The graph was drawn well by many candidates; a significant number lost two marks by using an unsuitable scale for the y axis. Scales rising by 3, 7, 9 or 15 provide problems with plotting and are not easily read. Many candidates in **(c)(ii)** correctly related the trend of decreased current in their graph to increased resistance (as the distance increased); others failed to notice that they were being asked about the change in <u>resistance</u> and not the change in <u>current</u>.

Question 2

(a) Candidates were expected to use the oscilloscope trace given to measure 5 divisions between the two waves and then to multiply this by the time base reading of 0.5 ms per division to get 2.5 ms. Many appeared unfamiliar with this and tried to use other theory methods, with 1.25 ms being a commonly seen incorrect response.

(b) Candidates were expected to notice that the metre rule in the diagram did not start exactly at 0.0 cm as the edges had been rubbed away. Many candidates made this observation; less successful answers were vague. It should be noted that the fact that a metre rule is old of itself does not necessarily mean that the rule is not suitable for use.

(c) This was a simple calculation using the candidate's values. Many lost the mark by not converting milliseconds to seconds.

(d) Candidates were asked to suggest a method to obtain a more accurate answer using the same apparatus. Consequently, the suggestion of using a different metre rule could not score a mark. Non-specific and general answers mentioning parallax did not gain credit. Some candidates suggested repeating the measurements without suggesting that the results be averaged. The best responses suggested moving the microphones further apart or repeating and averaging.

Question 3

(a) This was answered well.

(b) This was also answered well. Most candidates read these scales correctly and most candidates understood how to use the data to calculate the upward force on the cylinder.

(c) Part **(c)(i)** was answered well. In **(c)(ii)**, candidates were asked to describe how to find the diameter of a cylinder using a ruler. No other apparatus was mentioned and so no credit was given for the use of callipers etc. although credit was given for the use of set squares (or blocks of wood) if correctly explained. Candidates were expected to use 'repeat and average' at different positions or the maximum value of the reading across the circular cross-section. This type of question has been asked before but it was not well answered overall. Some candidates drew diagrams and said the ruler must go through the centre of the circle but did not to explain how the position of the centre was determined.

Part (c)(iii)(1) was answered well but **(c)(iii)(2)** was answered poorly. Candidates are expected to compare their value with the theoretical value and state whether or not the two values are the same within experimental accuracy e.g. within 10 per cent of the experimental value.

Question 4

(a) Just over half the cohort correctly named a stop-watch and a thermometer as the further pieces of apparatus needed to carry out the investigation. Other suggestions included rulers, forceps, retort stands, tables and ammeters.

(b) Good answers suggested a method suitable for the investigation and correctly explained how the readings taken could be used to decide which material was the better insulator.

(c) Those who gave a suitable method to use could usually correctly identify a variable that needed to be kept constant in order to make a fair comparison.

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

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.

General comments

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. Candidates need to think about what they would do in a practical situation rather than try to answer the question from the point of view of a theory paper.

The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly, although a few 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 plotting continues to improve.

Comments on specific questions

Question 1

(a) Most candidates drew the correct symbol for a voltmeter and placed it in parallel with the heater. Very few candidates drew the voltmeter connected in series in the circuit. Candidates should be reminded that correct symbols for electrical components are required. A voltmeter symbol with a line drawn through it was not accepted for credit.

(b) (i) The scale of thermometer was read correctly by the majority of candidates. Commonly seen incorrect answers were 41.0 °C and 48.5 °C.

(ii) 1 The best answers stated that when the heating coil was completely immersed, all the thermal energy produced by it would be transferred to the water and that none would be lost to the surroundings. A commonly seen incorrect answer given by candidates was ‘so that all the water could be heated’.

2 Most candidates realised that the water was stirred before taking each temperature reading to ensure that all the water was at the same temperature.

(c) (i) The graph question was done well, with many candidates scoring 3 or 4 marks. The axes were usually labelled, and sensible scales were chosen. Some candidates ignored the instruction to start the temperature axis at 20 °C and as a consequence, lost credit.

There were far fewer 'awkward' scales (multiples of 7, etc) seen this year. Such scales provide problems with plotting and are not easily read.

Most candidates plotted the points accurately and made good attempts at drawing a curve of best-fit, as requested.

Candidates should be reminded that they need to plot to the nearest half square. Plotting all the points on grid intersections can sometimes mean an error in the plot.

(ii) Candidates were asked to use their graphs to determine the temperature rise of the water in the first 200 s of heating. Almost half of the candidates determined the temperature of the water after 200 s correctly, but did not subtract the initial temperature of the water from this value.

(d) (i) Most candidates substituted correct values into the given equation to calculate the thermal energy supplied by the heater in the first 200s.

(ii) The determination of the specific heat capacity of the water was done well, with candidates making correct substitutions of their values into the given equation and rearranging the equation correctly. Occasionally the mass of the water was converted into kilograms before substitution, and the answer was out by a factor of 1000. Answers were usually quoted to a sensible number of significant figures, but there were many examples of incorrect rounding of the final answers. Candidates should be reminded to round their final calculation values correctly and not simply truncate the value obtained on their calculator.

(e) (i) Most candidates were able to examine the apparatus set-up in Fig. 1.1 and make a sensible suggestion as to why their calculated value of the specific heat capacity *c* was inaccurate.

(ii) Sensible improvements to the apparatus set-up to produce a more accurate value of *c* were made by most candidates. Most answers followed on from candidates' suggestions in **(e)(i)**.

(f) Very few candidates realised that the temperature of the water stopped rising when it reached 82 °C because the hot water was losing thermal energy at the same rate that the heater was supplying it. Most answers stated that the water had begun to boil at 82 °C, and as a consequence of this, the temperature remained constant.

Question 2

(a) The angle of incidence of the ray of light at point X was measured correctly by most candidates. A commonly seen incorrect answer was 60° instead of 30°

(b) (i) Most candidates used a ruler and protractor and drew neat diagrams. The refracted ray was usually drawn correctly; some answers showed it on the wrong side of the normal inside the prism.

(ii) The normal at the point of emergence of the ray from the prism was usually drawn correctly. The most frequent error was to draw the normal at the point of emergence as a vertical line, instead of at right angles to the prism surface.

(c) Only a minority of candidates were able to explain completely how the path of the emergent ray could be marked on the paper. Most candidates described a method of using pins or marking the emergent ray with crosses. Very few went on to complete the description by stating that a ruler and pencil should be used to join the pinholes or the crosses with a straight line back to the prism surface.

Question 3

(a) (i) Most candidates realised that the bottom of the ball needed to be level with the point of release, 55 cm.

(ii) The position of the eye, correctly placed to view the height of the ball was well understood. The majority of candidates drew an eye looking towards the ball and perpendicular to the ruler.

(b) (i) Despite the instruction in the stem of the question to use all of the results, the majority of candidates only used three results and discounted the first value of 55 cm. The averages were usually calculated correctly, but many candidates did not record the final answer to 2 significant figures.

(ii) Only a small minority of candidates gave a correct response to this question. Most candidates did not appreciate why it would be inappropriate to give the bounce heights to the nearest millimetre. Most candidates made reference to the fact that the ball would be moving too fast, when in fact, it is at rest when it reaches the highest part of the bounce. All that was required was a realisation that the bounce height would be very difficult to judge because the ball is only momentarily at rest and its direction changes quickly, so there would not be enough time to read the scale to that precision.

(c) Candidates met with much more success here, and most realised that for a drop height of 10 cm, there would not be enough time to read the scale or that it would be difficult to lower the head in time to take the reading.

Question 4

(a) (i) Most candidates realised that if the box contained a broken wire, then the lamp would not light. Very few candidates added to this statement to say that this would be true whichever way around the terminals P and Q were connected to the crocodile clips. This omission was not penalised in this part of the question.

(ii) Very few candidates produced a satisfactory answer to this straightforward part.

Most candidates realised that if the box contained a connecting lead, then the bulb would light when terminals P and Q were connected to the crocodile clips. Only a small minority of candidates stated that it would also light when the connections to P and Q are reversed. This extra reasoning is important because it is the only way to distinguish between the connecting lead and the diode.

(iii) This part was again poorly answered with most candidates describing the action of a diode, rather than what they would do to determine if the component in the box was a diode.

(b) Candidates met with much more success here, with most realising that if the circuit was connected to the box containing the resistor, the lamp would light less brightly, or the ammeter reading would be less.