PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

There was a wide range of candidate performances on this paper.

Question 21 on changes of state was very well answered. Likewise, **Question 9**, **Question 17** and **Question 32** were correctly answered by a large number of candidates.

Both **Question 17** and **Question 32** required candidates to read the question carefully. Candidates should not assume that a question that looks similar to questions asked in previous years is asking the same thing on the paper that they are currently sitting.

Comments on Specific Questions

Question 3

This question could have been answered in at least two ways. Either the initial kinetic energy of the car is equated to the work done against the sand as the car slows or the deceleration of the car, the time for which it is moving and the distance travelled could have been calculated. Both methods lead to the same answer which is option **C**. It was option **B**, however, that proved to be the most popular choice. This distance has the same numerical value as the time it takes for the car to stop and perhaps candidates chose it for this reason

Question 11

Most candidates obtained answers that related to the correct calculation of the resultant moment due to the two weights on the beam. These moments are in opposite directions and thus their resultant moment is obtained by subtracting one from the other. The candidates who scored well on the rest of the paper correctly divided this resultant moment by 50 cm to obtain the right answer.

Question 13

This question required the candidate to keep in mind the context of the question. The question reveals that there are four tyres in contact with the ground but even so, the most popular answer was **D** which is obtained by ignoring the factor of four.

Question 14

The relationship between the pressure and the volume of a fixed mass of gas at constant temperature is often expressed graphically but, in this question, the axes are labelled P and either V or $1 / V$. Since the two quantities P and V are inversely proportional, the graph of P against $1 / V$ is a straight line through the origin and so option **A** is correct. This is a question that requires candidates to be attentive to every detail.

A significant majority of the candidates who performed well on the rest of the paper choose the correct option here, whereas only a small minority of the candidates who performed less well on the other questions did so.

Question 24

A minority of candidates selected the correct option **C**. The angle between the reflected ray and the path that the light would have taken had it not been reflected is 100°.

Question 26

The needles of compasses placed at positions **A**, **B** and **D** are certain to point in directions that are horizontal and across the page and so the corresponding options cannot be correct. Although the direction of the needle of a compass placed at **C** depends on the exact shape of the field pattern, candidates are told that in one of the positions the needle points vertically downward and at **C**, this is a possibility.

Question 29

There are several ways of approaching this question, some of which are more mathematically exact than others. One approach is to determine the circuit in which the current in each cell is the greatest.

Question 31

The circuits shown both in option **A** and in option **C** show a diode connected in a direction which does not allow a current to be established (The diode is said to be reverse biased). In circuit **D**, the full e.m.f. of the cell is connected across each of the lamps and so this is the correct option. This was the option most commonly selected by the highest scoring candidates.

Question 34

The rate of rotation of an a.c. generator is affects the output in two ways: it affects the maximum voltage generated as well as the frequency of the voltage waveform. In this question, only option **B** shows an a.c. voltage of reduced magnitude and reduced frequency. This is the correct choice. The most widely selected option was option **C** which only shows a reduction in the magnitude of the voltage generated.

Question 35

Many candidates struggled with this question. The frequency is equal to the reciprocal of the time period. More candidates chose the erroneous options **A** and **C** than the correct option **B**.

Question 37

This question involves the application of a rule for the motor effect. It also requires the candidate to realise that the current caused by a beam of electrons is in the opposite direction to the motion of the electrons. The correct option **D** and its exact option **B** were each chosen by a very similar number of candidates

PHYSICS

Paper 5054/12
Multiple Choice

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

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

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

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

General comments

Many separate areas of the syllabus can be assessed in a multiple choice paper and candidates need to have developed a thorough and detailed knowledge of the contents of the syllabus.

Question 2, **Question 11** and **Question 31** were answered correctly by almost all candidates. Only one of these questions is a question that depends only on the direct recall of knowledge. Some application of that knowledge is required in the other two items.

There were some questions where candidates seemed to assume that a different question is being asked. Candidates need to read the stem of a question carefully. A question that looks like one that has been attempted during the course need not be asking the same point. This seemed to be happening in **Question 3** and **Question 17** and these are discussed below.

Comments on Specific Questions

Question 3

This is a case where the question needs to be read carefully and the candidates who chose option **B** had probably not noticed that the unit in all the options is the centimetre (cm) rather than the metre (m).

Question 4

This question could have been answered in at least two ways. Either the initial kinetic energy of the car is equated to the work done against the sand as the car slows or the deceleration of the car, the time for which it is moving and the distance travelled could have been calculated. Both methods lead to the same answer which is option **C**. It was option **B**, however, that proved to be the most popular choice. This distance has the same numerical value as the time it takes for the car to stop and perhaps candidates chose it for this reason.

Question 6

Many candidates supplied the correct answer here as they realised that the third statement is not an essential condition for the block to remain stationary.

Question 9

Only candidates who performed well on the rest of the paper revealed a preference for the correct answer **A**.

Question 12

Most candidates obtained answers that related to the correct calculation of the resultant moment due to the two weights on the beam. These moments are in opposite directions and thus their resultant moment is obtained by subtracting one from the other. The candidates who scored well on the rest of the paper correctly divided this resultant moment by 50 cm to obtain the right answer.

Question 17

Candidates who answered this incorrectly were more likely to select option **D,** which is the proportion of the input energy that is wasted rather than the efficiency of the motor.

Question 20

The correct option **C** was by far the most commonly chosen by candidates who scored well in the other questions. However, it was the least commonly chosen by candidates who scored less well elsewhere indicating that they do not fully understand what is meant by ‘sensitivity’ and ‘range’.

Question 21

The air in the cylinder cools but the piston is free to move. As the cylinder cools, therefore, the piston will move until the pressure of the air inside the cylinder is equal to the atmospheric pressure outside, as it was with the hotter air in the initial situation. Many candidates, while recognising that the mass of the air stays constant, assumed that the pressure would change. Option **B** was very commonly chosen.

Question 22

A minority of candidates selected the correct option **C**. The angle between the reflected ray and the path that the light would have taken had it not been reflected is 100°.

Question 25

This question concerns the behaviour of a diverging lens. The effect of such a lens on light that is not parallel, is to make it more diverging or less converging than it was before it entered the lens.

Thus, the correct option is **D** in which the light that emerges from the lens is less converging than the light that enters the lens. Option **A** was more commonly selected than the correct response.

Question 30

The needles of compasses placed at positions **A**, **B** and **D** are certain to point in directions that are horizontal and across the page and so the corresponding options cannot be correct. Although the direction of the needle of a compass placed at **C** depends on the exact shape of the field pattern, candidates are told that in one of the positions the needle points vertically downward and at **C**, this is a possibility.

Question 40

This question depends on the recall of a syllabus statement and the realisation that term such as ^{14}C has a meaning that differs from the meaning of, say, ^{12}C. The correct answer was the most frequently supplied but the more usual isotope of carbon was also popular.

PHYSICS

Paper 5054/21
Theory

Key messages

- Candidates should always give units when giving the final answer to numerical questions. They should also be encouraged to give answers to an appropriate number of significant figures (usually at least two). Fractions are not accepted as answers unless a ratio is specified.
- A carefully drawn diagram can show what the candidate intends to convey much more accurately than just words. If a diagram is asked for or suggested, it should be drawn carefully and neatly and then labelled so that the candidate's intent is clear.
- The number of marks shown, and the amount of space provided give a guide to the length of the answer required. Candidates who exceed the space provided may be wasting time by giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided.

General comments

The majority of questions were accessible to all candidates.

The standard of written English was high. There was no evidence that the intent of any question was misunderstood. The quality of expression even among the weaker candidates was good, even if the underlying physics was sometimes inaccurate.

Calculations were generally performed well.

Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it. Occasionally candidates who had performed a correct calculation lost a mark by either omitting to give a unit or by giving an incorrect unit.

A minority of candidates ignored the rubric for ***Section B*** and answered all three questions.

Comments on specific questions

Section A

Question 1

(a) The experimental procedure for obtaining results to plot an extension-load graph for a spring was not well known. Most accounts stated that the extension was measured without giving any details details of how this could be done. Many candidates did not state that the extension must be measured for a number of different loads so that a graph of extension against load could be plotted.

(b) (i) Candidates were required to sketch a load-extension graph for a spring stretched beyond its limit of proportionality. Most candidates drew an initial straight line of positive gradient from the origin on the axes provided. Few continued their sketch to show a curve of increasing gradient, which never becomes vertical, at the end of the linear portion. Most of the graphs which displayed a non-linear portion after the initial straight line, showed the gradient decreasing instead of increasing.

(ii) The concept of *limit of proportionality* was well known with most candidates marking with the letter P the point where the gradient of the graph started to change.

(c) The calculation of the extension of the spring for the given load was well done.

Question 2

(a) The change in gravitational potential energy of the car as it travelled from A to B was calculated correctly by the majority of candidates. Some answers were out by a factor of 10 as those candidates had omitted the value of *g* from the equation that they had used.

(b) Less than half of the candidates used their result from **part (a)** to deduce the speed of the car when it reached B. The most successful candidates used the law of conservation of energy, but many correct solutions were also seen with candidates using an appropriate equation of motion.

(c) (i) Only the most able candidates were able to use energy considerations to explain why the car did not go any higher than point D.

(ii) Candidates found this question very challenging. Most candidates stated correctly, that after reaching D and coming to rest, the car will travel back down the curved slope. Only a handful of candidates recognised that the car will then travel up the other side and returned to the level of A, the point from which it was released.

Question 3

(a) The pressure difference between the trapped air in the glass tube and the atmospheric pressure was calculated correctly by the majority of candidates by applying the equation $p = h\rho g$. Many candidates then subtracted the given value of atmospheric pressure from this answer instead of adding it to atmospheric pressure.

(b) (i) Candidates still have difficulty producing a molecular explanation of what happens to a gas when changes of temperature, pressure or volume occur. Many candidates stated correctly that the molecules of trapped air would move faster when they were heated. Fewer candidates said that the molecules would hit the surface of the tube harder or more often. Even fewer candidates completed the explanation by stating that the pressure of the air inside the tube increases as a result.

(ii) Correct answers to this final part were rare. Candidates were expected to explain that, as a consequence of heating, *h* would increase until the pressure of the trapped air in the tube became equal to the pressure due to the liquid on the other side of the tube plus the atmospheric pressure.

Question 4

(a) The fact that X-rays are part of the electromagnetic spectrum was known by most candidates.

(b) (i) Most candidates gave satisfactory definitions of the term *frequency*.

(ii) The fact that gamma rays have the greatest frequency of the waves in the electromagnetic spectrum was well known.

(c) (i) Good, complete explanations as to how X-rays are used in hospitals to produce an image of broken bones were rare. Few candidates explained that X-rays are directed towards the body part with the suspected broken bone. Even fewer candidates stated that X-rays can pass through flesh but not bone – many candidates believed that the X-rays were reflected back by the flesh/bone. Very few candidates referred to a detector of some sort, such as a photographic film.

(ii) About half of the candidates knew why X-rays are not used for pre-natal scanning. These candidates stated that X-rays can cause cancer/mutations etc. Vague answers such as X-rays are dangerous were not accepted.

Question 5

(a) (i) Only a minority of candidates were able to use the diagram in combination with the information about the charge on the ion, to deduce the number of protons in the nucleus of the ion.

(ii) Most candidates were unable to write down the symbol for the nucleus in nuclide notation, even allowing for an error in **(i)** being carried forward to this part.

(b) The term *isotope* was well understood, and some very good explanations were given by candidates.

(c) Few candidates knew that the force of attraction between negatively charged electrons and the positive nuclear charge was responsible for the electrons in an atom not escaping. Partial credit was given for a statement that opposite charges attract.

Question 6

(a) Around 70 per cent of candidates could name the metal from which the core of an electromagnet is made. Steel, aluminium and copper were commony-seen incorrect answers.

(b) (i) The calculation of the power transferred to the electromagnet was usually correct. Occasionally, the unit of power was missing or incorrect.

(ii) About half of the candidates were able to calculate the charge driven around the circuit in 4.5 hours correctly. The most common error was the failure to convert the time into seconds. Many candidates multiplied the time in hours by 60, instead of 60×60. The unit of charge was not well known.

(c) Candidates found this final part difficult. Only the most able candidates explained that, as the electromagnet coil becomes hotter, its resistance increases and, as a consequence of this, the current in the coil decreases.

Section B

Question 7

(a) Candidates had great trouble in explaining the variation of the speed of the sledge with time using the given speed-time graph for the journey of the sledge down the hill. Most candidates scored 0 or 1 of the 3 marks available for the explanation.

Although most candidates recognised that the speed of the sledge increases initially, few candidates explained why. Even fewer candidates mentioned that the air resistance on the sledge increases as the sledge speeds up. The fact that the sledge eventually reached a terminal/constant velocity was recognised by about half of the candidates.

(b) Most candidates knew that they had to find the area under the graph to calculate a distance. Many misread the graph and substituted incorrect values into the formula for area. The most able candidates went on to subtract their answers from 35 m to determine the distance between the front of the sledge and the wall when the sledge stopped.

(c) (i) The deceleration of the sledge was calculated correctly by the majority of candidates. The most common method was to find the gradient of the relevant portion of the graph. Others obtained the correct answer using an appropriate equation of motion.

(ii) The resultant force on the sledge was calculated correctly by most candidates. The most common error here was the failure to use the combined mass of the child and the sledge in the equation $F = ma$.

(iii) Less than half of the candidates could state the energy transfer taking place when the sledge decelerated. The expected answer was from kinetic energy to thermal energy, but most answers contained other forms of energy, usually potential energy and chemical energy.

(d) This difficult final part of the question was poorly answered. It was rare to see the term *inertia* mentioned, or any reference made to Newton's First Law of motion to explain why the child jerked forwards when the brake was first applied to the sledge.

Question 8

(a) (i) Approximately two-thirds of the candidates who attempted this question were able to draw the correct shape for the outline of a diverging lens and add it to the given diagram in the correct place.

(ii) The majority of candidates correctly drew the paths of the rays to show the effect of a diverging lens on a parallel beam of light.

(b) (i) Approximately half of the candidates completed the given diagram correctly to show the effect of a short-sighted eye on a parallel beam of light. The most common errors were to show the parallel beam of light converging to a point on the retina, or behind the eye, rather than within it.

.

(ii) Most candidates knew that the image of a distant object detected by a normal eye is sharp, whereas that in a short-sighted eye was blurred.

(iii) There were some good explanations of how a diverging lens corrects the sight of a short-sighted eye viewing a distant object. Many candidates added a sketch to reinforce their explanations.

(c) (i) The completion of the ray diagram to show the position of the image of the given object was poor. Only the more able candidates scored full marks here. There was much confusion between the action of converging and diverging lenses on a beam of light, The majority of completed diagrams incorrectly showed the rays of light from the object converging to produce a real image after passing through the diverging lens. The position of the image was rarely labelled with the letter **I**, despite the instruction to do so.

(ii) Correct answers to this part were extremely rare. Most candidates stated correctly if the image they had obtained in their ray diagrams was real or virtual but failed to give the <u>explanation</u> requested, as to how they deduced this.

(iii) Candidates were required to mark the ray diagram with the letter E to show a position from which the eye can see the image. The letter E was missing from most candidates' answers.

(iv) Most candidates were unable to calculate the linear magnification produced by the lens. Some candidates were able to recall the equation for the magnification but substituted incorrect measurements for the object and image distances into the equation.

Question 9

(a) Surprisingly, few candidates were able to state two ways in which the e.m.f. of a battery differs from that of an a.c. power supply. The term *direction* was rarely mentioned, although the fact that the magnitude of an a.c. supply was continually changing was often stated.

(b) (i) The current in YZ was determined correctly by the majority of candidates. The most common error was to include the 30 Ω resistor in the calculation of the total circuit resistance, although the switch in series with this resistor was open.

(ii) Approximately half of the candidates stated correctly that wire YZ experienced a force because it carried a current and was situated in a magnetic field.

(iii) Less than one-quarter of the candidates chose the correct box.

(iv) Fleming's Left Hand Rule is not well understood.

(c) (i) Most candidates scored at least two of the three marks available for the determination of the total resistance of the circuit when both switches are closed.

(ii) Only a few candidates stated that the total resistance of the circuit decreased when the second switch was closed. Even fewer then deduced that the current would therefore increase, and the force on YZ would increase.

(iii) This was intended to be a challenging question. A small minority were able to gain some credit. The required ratio of the two currents was the inverse of the ratio of the two resistances in the parallel branch.

A few very candidates realised this intuitively and wrote down the ratio without needing to do any calculation. These candidates received full credit as they were not asked to show their working.

PHYSICS

Paper 5054/22
Theory

Key messages

Candidates should be reminded that the values of almost all of the measurable quantities referred to in this syllabus are only properly expressed by a numerical value accompanied by an appropriate SI unit.

The numbers given in questions tend to be to two significant figures and candidates are expected to express answers to an appropriate number of significant figures. Answers given to one significant figure are rarely acceptable.

Candidates also need to ensure that when numbers are rounded to an appropriate number of significant figures, this is done correctly. Weaker answers will quote, for example, the first two figures of a number even though the second figures ought to have been rounded up rather than being left unchanged.

General comments

In general, answers are clear and legible but occasionally answers were poorly written and difficult to interpret. Candidates should ensure they write their answers in pen in the appropriate space on the question paper.

Comments on specific questions

Section A

Question 1

(a) The distance between P and Q corresponded to the area (in terms of the scales on the axes) under the line on the graph and this could be calculated in a few different ways. Candidates who tried to use $x = vt$ in some form, were rarely awarded full credit as the determining the distance travelled when the train was decelerating was more challenging. One set of figures from the graph led to a distance of 7007 m (when calculated exactly). This should have been expressed as 7.0 km rather than as 7 km.

(b) (i) Although there were some candidates who were unaware of how to proceed, many candidates calculated the acceleration correctly using points from the line.

(ii) This was often answered well. The acceleration was calculated either completely correctly or by using a previous inaccurate value for the acceleration correctly.

Question 2

(a) This was reasonably well answered but a significant number of candidates struggled to determine the volume of the block. Common errors were the use of 1.8 (m^2) as the volume or the use of the square of 2.0 (m).

(b) (i) This part was well answered with many candidates knowing exactly what needed to be done. Sometimes the unit used was the newton (N).

(ii) Candidates needed to realise that the final kinetic energy of the block just before it struck the pile, was equal to the original gravitational potential energy. Those who did realise this often continued and obtained a correct value for the speed of the block on impact.

Question 3

(a) Many candidates were aware that the unburnt gas contained chemical energy but thermal energy, heat and kinetic energy were also seen from time to time.

(b) (i) This was only occasionally answered well. Candidates needed to mention that the red-hot screen emits infrared radiation.

(ii) Candidates who answered this well realised that the shiny surface is a good reflector as it is a poor absorber. The reflective properties of the shiny surface were important in this context.

(iii) This was approached more successfully but there were candidates whose explanations were lacking in detail.

Question 4

(a) The answers given to this part varied widely. Some candidates gave clear and detailed descriptions of an experiment with which they were clearly familiar.

(b) This part was only answered well by stronger candidates. Many answers did not describe the vibration of the molecules.

(c) Appropriate answers were common with candidates referring to the molecular separation more often than the pressure or density. Answers such as “where the wavelength is greater” showed a common misunderstanding. There were a few candidates who described what was meant by refraction.

(d) Candidates needed to use the largest of the frequencies in the range given to calculate the smallest wavelength. The incorrect answer 20 m was quite common. Answers such as 1.1 mm or 0.011 cm were also seen.

Question 5

(a) Many answers here lacked precision. There were some answers that stated that an e.m.f. was current or a charge or a force.

(b) This was answered well by many candidates who were able to give one of the answers from the mark scheme.

(c) (i) There were many good answers here and a range of answers that contained some relevant information. Some candidates moved directly from the reduced resistance of the thermistor to an increased reading on the voltmeter without any intervening explanation and others stated that the reduced resistance led to a reduced reading on the voltmeter. An expression such as ‘the resistance decreases’ does not by itself make it clear that it is the resistance of the thermistor that is being referred to.

(ii) Although many candidates gained some credit, the correct final answer was only seen sometimes.. The value ‘1.0 V’ was seen more frequently than the correct value. Few candidates treated the circuit as a potential divider.

Question 6

(a) Few candidates were able to describe how a transformer works and the idea that the core conducts a current from the primary coil to the secondary coil was a common error. There were also candidates who offered clear and accurate explanations and who used the term 'induction' or similar correctly when referring to the e.m.f. in the secondary coil.

(b) (i)(ii) These two calculations were done well and full credit was often awarded. There were other candidates who made errors in arithmetic and some candidates who were uncertain of the correct approach; the equation $V = IR$ was used in **(ii)** by some candidates which did not lead to the correct answer.

Section B

Question 7

(a) Many candidates were able to give a partial explanation of how convection in the water takes place but fewer were able to give a completely correct explanation. Some candidates stated that the water is being heated from the bottom whereas in the example given, it is being cooled from above. Many candidates stated that the cooled water becomes less dense and sinks. The change in density was not always correctly related to the motion of the water.

(b) (i) This was very well answered with a very large proportion of candidates stating the correct transfer mechanism.

(ii) Many candidates were awarded full credit here.

(c) (i) This part was very well answered. A very significant majority of candidates obtained the correct final answer using the correct calculation.

(ii) This part was answered well, with a large number of candidates giving one difference between boiling and evaporation and many of these also giving a second point. That boiling occurs throughout the liquid and that it produces bubbles are essentially the same point. These answers were not credited separately.

(iii) Many candidates were able to refer to one of the two points given in the mark scheme A much smaller number mentioned both points. The need for there to be work done against the intermolecular forces was more frequently seen.

(iv) This part was reasonably well done and the correct final answer was commonly given. There were some candidates who tried to apply the equation $E = mc\text{D}T$ and other candidates used 2.3×10^6 (J/kg) as though it were an energy. Candidates also needed to convert the time of 10 minutes to seconds and some did not do this.

Question 8

(a) Many candidates made one of the two points required and some made both points. Candidates needed to refer to the motion of electrons and the direction of this motion for full credit. Some answers stated only that negative charge moved and did not say from which object or to which object. Sometimes, the final charge of the cloth was not addressed.

(b) This was generally answered well. A few candidates stated something similar to "because metals are good electrical conductors" which is restating the question in a rearranged form.

(c) (i) This was answered well but one source of inaccuracy was to draw too many charges or to draw different numbers of positive and negative charges.

(ii) Many candidates were aware of what was happening and gained credit. Candidates who limited their answers to a comment that charge moves in the wire did not give an answer that was sufficiently detailed.

(iii) This was not very well answered. Candidates needed to recognise the significance of the expression ‘distribution of charge’. Many candidates described the movement or the sign of the charge with no reference to its location.

(iv) Only a minority of candidates gave an accurate answer here. Answers involving the rod removing charge or the sphere becoming uncharged were common.

(d) (i) This was not answered well.

(ii) Although a correct and carefully drawn diagram was often seen, many answers included curved lines unevenly distributed around the sphere. The number of answers presenting circular field lines suggested a confusion with the magnetic field of a current-carrying wire.

Question 9

(a) This part was often well answered but some candidates were not able to draw the correct conclusion concerning gamma radiation.

(b) (i) This part was very often correctly answered.

(ii) This part was less well answered with incorrect or irrelevant comments on the electrons being seen sometimes. Some candidates contradicted what had already been stated in the previous part.

(c) (i) Some answers were completely correct whilst others varied in quality. Some answers described what is meant by background radiation in a sufficiently clear manner but answers such as “alpha-particles” could not be credited.

(ii) There were some good answers here and some answers that were not appropriate in the circumstances outlined.

(iii) Some candidates obtained partial credit for a reference to the randomness of radioactive emission. Only a few candidates were awarded full credit.

(iv) Only a small number of candidates were able to obtain a correct value for the half-life. Many candidates did not use the graph at all but halved a number from the question itself.

(v) This part was poorly answered.

PHYSICS

Paper 5054/31
Practical

Key messages

The working for calculations should be written down.

The units for quantities should always be given using the correct symbol. If the unit is not given on the answer line, then it must be written down by the candidate, using the correct symbol or name.

Final answers should be rounded to an appropriate number of significant figures, usually two or three. Readings from analogue instruments such as ammeters and voltmeters should be recorded to the precision of the instrument being used.

In many cases the required unit is already given on the answer line of the question paper. Candidates should ensure that their response is converted into that unit (if necessary), before writing it in the answer space.

Centres should ensure that the equipment provided conforms to the specifications given in the Confidential Instructions, as this gives candidates the best opportunity of obtaining good, complete sets of results.

General comments

This paper assesses candidates' practical skills in physics, such as: following a set of instructions safely and accurately, using simple laboratory equipment to make observations and take measurements, collecting sets of results and process them, performing calculations, drawing conclusions and making judgements and then writing comments about the results and making conclusions.

In order to achieve good results and to work safely, candidates should have previously acquired some basic practical experience of handling equipment and working carefully, methodically, and safely. They should also have developed the ability to make careful observations and take accurate measurements and record their results accurately. It is important to take repeat measurements and average them whenever it is appropriate to do so.

In stronger responses, candidates demonstrated that they were able to read and understand the questions and perform the required tasks by following the instructions, making accurate, careful observations and measurements and recording them accurately.

Measurements should be repeated whenever possible, and the average taken. When measurements are repeated it may become clear that one of the readings is incorrect. This gives candidates the opportunity to select the correct result(s), obtaining more data if necessary, and increases the mark that they are likely to be awarded. There are, however, some situations where it is not appropriate to take repeat measurements (for example in **Question 2** there would have been insufficient time to perform the exercise twice). Candidates need to exercise judgement about whether to repeat readings.

Raw readings recorded in tables should recorded to a consistent number of decimal places. Calculated quantities should be recorded to consistent numbers of significant figures.

Stronger candidates were able to construct tables of results with appropriate headings, with the name of the quantity and the unit given for each column. The results obtained could be used to perform calculations by substituting values into equations, plotting line graphs or making valid comparisons, judgements or comments about the results. Some of the weaker responses given when candidates were asked to make comparisons were too vague.

Many candidates need to improve their graph plotting. Candidates should remember that graphs are intended to facilitate the interpretation of their experimental results not only for themselves but also for other people.

A number of good responses to questions involving the plotting of graphs were spoiled by using impractical non-linear scales. A commonly seen error was to create a scale based on the difference between the first and last values in the results table and aligning these with the total number of divisions on the axis. This usually resulted in a graph which filled the grid but was based on a non-integral scale from which it was difficult to plot the points or use to derive further information (such as to calculate the gradient) and which also led to errors in plotting and reading. Graphs need to occupy only more than half the grid in the x and y directions and should be based on a scale of 2, 5, or 10 units, corresponding to 10 small grid lines.

Comments on specific questions

Question 1

(a) In order to obtain meaningful results when using a plotting compass, the needle of the compass must be able to rotate freely. Candidates were asked how they would check that the compass needle was free to move without lifting the compass off the bench. There were many good responses to this part of the question.

(b) In order to find the maximum distance at which the plotting compass's needle started to deflect it was necessary to move the bar magnet towards the compass and to start from a point sufficiently far from the compass for the magnet to have no influence on it (this was accepted as the compass and magnet being separated by a distance of about 50 cm or more). The bar magnet should then be moved slowly along the rule towards the compass.

There were few good responses to this part of the question. Most candidates described a method in which the bar magnet was initially placed next to the compass and then moved away to find the distance at which deflection ceased.

Question 2

(a) Temperatures of water in two boiling tubes were measured with a thermometer placed near to the mark indicating the water level in the first test tube and at the bottom of the tube in the other test-tube. The two temperatures should have been recorded, with the unit, to the nearest degree or half degree. They should have been almost identical but a difference of up to 5 °C was accepted and acceptable temperatures for room temperature covered a wide range in order to make allowance for different environmental conditions in various locations. The majority of responses gained full credit. A few candidates incorrectly recorded the temperature of the hot water instead of the room temperature.

(b) When the same amount of hot water was added to each boiling tube, the maximum temperature recorded by both thermometers should have been considerably higher than the temperatures recorded in the first part of the question. The tubes were then left to cool for 4 minutes and the temperatures recorded again, the temperature decreases calculated and the tube which showed the smaller temperature decrease identified. It was expected that tube A would show the smaller decrease, but credit was based upon the candidates' findings as there could be variations in equipment and environment which could have influenced the result.

(c) Candidates were required to suggest two reasons that would account for the temperature decreases they observed. Many responses were vague and some even contradicted the observed results. There were also some very good responses. Valid reasons could have been based on differences in the amounts of hot water added, the heat capacities or masses of the glass tubes, the depth of immersion, or temperature differences due to convection currents, or any other sensible suggestion that would account for the differences observed.

Question 3

(a) (i) The lens diameter and the diameter of the rod above it were measured and should have been recorded in millimetres, to the nearest millimetre. The diameter of the lens should have been approximately 50 mm and the rod about 7 mm. There were many good responses. A few candidates gave answers that were out by a factor of ten, indicating they had measured in centimetres rather than the millimetres indicated on the answer line.

(ii) The ratio of the diameter of the lens and the rod should have been calculated. When candidates are asked to calculate a ratio then the answer to the calculation must be given as a single decimal number, unless it happens to be an integer. Answers in the form of fractions or written in ratio format using a colon are not acceptable. There were many good responses.

(b) The height of the rod was adjusted and then the lens moved into place so that it was just below the rod and slightly to one side of it. The lens was moved down until the point was reached where the image of the rod in the lens was observed be magnified to an extent that it just filled the whole view within the diameter of the lens. The lens was then fixed in place and the distance between the rod and the lens should have been measured. A distance of between 10 and 20 cm was accepted. It is emphasised that it is important that centres provide equipment that conforms to the specification given in the Confidential Instructions. This is particularly important in optical experiments.

(c) (i) The magnification was calculated using the equation given and the candidates' values for y (the height of the rod above the mirror which was fixed at y = 40 cm) and their measured value of x. The answer should have had no unit.

(ii) Candidates were asked to state whether their values of r and m could have been considered to be equal. They should have looked at the values they obtained and made a decision whether the two values were close enough to be equal within the limits of experimental error (usually accepted to be about 10 per cent) or not. Calculations were not required in this part of the question but could have been helpful when trying to make a decision. Weaker responses such as "they are the same because they both round off to the same whole number" or vague responses such as "they are approximately the same" were not accepted.

Question 4

(a) Candidates were asked to identify the type of voltmeter they were using and to state its range and precision. In stronger responses, the range was given from lowest value to the highest, e.g., from 0V to 20.0 V and the precision described as to the nearest 0.01 Volt or whatever level of precision applied to their instrument. The words 'from' and 'to' are important when describing a range and should be used. Likewise, the phrase 'to the nearest' forms a part of the response required to describe the resolution of an instrument, but the precision could also be written in the form using a plus and minus sign, for example, +/–0.05 V. The unit was required. Many weaker candidates gave only a single figure for the range. A range must be described in terms of starting at one value and ending at a higher value. There were few good responses.

(b) The supply voltage and the potential difference across 100 cm of the resistance wire were measured. Both values should have been positive values and not zero, written down and V_L should have been smaller than V_S. There were many good responses.

(c) The strongest responses stated that the jockey was clipped to the wire to make a good, firm electrical contact with the wire in order to obtain a steady reading on the voltmeter and to get the true value at the exact distance required.

(d) Candidates were required to measure the potential difference at a range of different lengths along the resistance wire and to put their results in a table. Column headings with the appropriate units were required and ten sets of data were expected, with the values recorded to a sensible and consistent number of significant figures. Good results showed the value of V_L increasing as the length of wire increased.

(e) Stronger candidates showed plots of the length *L* (in cm) along the x-axis and the potential difference *V* (in Volts) along the y-axis. It should be remembered that if a quantity has a unit, then that unit must be shown on the appropriate axis. Stronger candidates also demonstrated a good choice of scale so that at least half the grid was occupied by the plotted points in each direction and a scale based on multiples of 2, 5, or 10 corresponding to 10 small grid lines. They plotted points accurately (to within the nearest half a 2 mm square) and all the data was plotted. These candidates also produced a neat best-fit line which had the plots distributed as evenly as possible either side of the drawn line.

(f) To calculate the gradient, candidates needed to select two points on the line, separated by at least half the length of the line. It is not necessary to select plotted points (and may actually be impossible as a best-fit line may not go through plotted points.

Candidates needed to show their working including the co-ordinates for the points that they had selected (which should also have been indicated clearly on the graph). Stronger responses showed the detail of a correct calculation, showed the working and gave an answer to a reasonable number of significant figures (not 1 sig fig). Weaker responses sometimes calculated the inverse of the gradient or used gradient triangles that were too small or incorrectly located.

(g) For the final part of the question, candidates were asked to use the given equation to calculate the resistance of the piece of resistance wire. Full working for the calculation should have been shown. Final answers should have been in the range of 8 to 12 Ohms. It was noticed that some centres must have used resistance wire of a different specification as their value was consistently significantly different. The use of wires different to that specified by the CI needs to be mentioned in the supervisor's report. However, candidates were still able to obtain useful sets of data and the results in the Supervisor's report was helpful in these cases.

PHYSICS

Paper 5054/32
Practical

Key messages

The working for calculations should be written down.

The units for quantities should always be given using the correct symbol. If the unit is not given on the answer line, then it must be written down by the candidate, using the correct symbol or name.

Final answers should be rounded to an appropriate number of significant figures, usually two or three. Readings from analogue instruments such as ammeters and voltmeters should be recorded to the precision of the instrument being used.

In many cases the required unit is already given on the answer line of the question paper. Candidates should ensure that their response is converted into that unit (if necessary), before writing it in the answer space.

Centres should ensure that the equipment provided conforms to the specifications given in the Confidential Instructions, as this gives candidates the best opportunity of obtaining good, complete sets of results.

General comments

This paper assesses candidates' practical skills in physics, such as: following a set of instructions safely and accurately, using simple laboratory equipment to make observations and take measurements, collecting sets of results and process them, performing calculations, drawing conclusions and making judgements and then writing comments about the results and making conclusions.

In order to achieve good results and to work safely, candidates should have previously acquired some basic practical experience of handling equipment and working carefully, methodically, and safely. They should also have developed the ability to make careful observations and take accurate measurements and record their results accurately. It is important to take repeat measurements and average them whenever it is appropriate to do so.

In stronger responses, candidates demonstrated that they were able to read and understand the questions and perform the required tasks by following the instructions, making accurate, careful observations and measurements and recording them accurately.

Measurements should be repeated whenever possible, and the average taken. When measurements are repeated it may become clear that one of the readings is incorrect. This gives candidates the opportunity to select the correct result(s), obtaining more data if necessary, and increases the mark that they are likely to be awarded. There are, however, some situations where it is not appropriate to take repeat measurements (for example in **Question 2** there would have been insufficient time to perform the exercise twice). Candidates need to exercise judgement about whether to repeat readings.

Raw readings recorded in tables should recorded to a consistent number of decimal places. Calculated quantities should be recorded to consistent numbers of significant figures.

Stronger candidates were able to construct tables of results with appropriate headings, with the name of the quantity and the unit given for each column. The results obtained could be used to perform calculations by substituting values into equations, plotting line graphs or making valid comparisons, judgements or comments about the results. Some of the weaker responses given when candidates were asked to make comparisons were too vague.

Many candidates need to improve their graph plotting. Candidates should remember that graphs are intended to facilitate the interpretation of their experimental results not only for themselves but also for other people.

A number of good responses to questions involving the plotting of graphs were spoiled by using impractical non-linear scales. A commonly seen error was to create a scale based on the difference between the first and last values in the results table and aligning these with the total number of divisions on the axis. This usually resulted in a graph which filled the grid but was based on a non-integral scale from which it was difficult to plot the points or use to derive further information (such as to calculate the gradient) and which also led to errors in plotting and reading. Graphs need to occupy only more than half the grid in the x and y directions and should be based on a scale of 2, 5, or 10 units, corresponding to 10 small grid lines.

Comments on specific questions

Section A

Question 1

(a) When the spring had been extended according to the instructions, the position on the scale of the two ends of the spring's coil, *x* and *y* should have been recorded in millimetres, to the nearest millimetre, with *x* less than *y*. There were many good responses, but a few weaker candidates gave unrealistic values, or gave values that were obviously in centimetres.

(b) Candidates were required to describe their plan for an experiment investigating whether *x* was proportional to *y*.

Many candidates had difficulty with this part of the question, and few gained full credit.

Candidates needed to describe an experiment using the block of wood on the bench to obtain further values of *x* and *y*.

Many candidates had difficulty in working out how to obtain further values of *x* and *y* as both *x* and *y* had to be obtained by changing some other quantity. The most obvious means of obtaining these values was to repeat the steps described earlier in the question but to use different masses on top of the block. An alternative method would be to use the same mass, the same block and vary the surface.

This part of the question also asked how it could be shown whether *x* was directly proportional to *y*. Many candidates gave weak or unclear responses.

In order to show that the two quantities were directly proportional then a graph of *y* against *x* would have to be a straight line which also passed through the origin. This latter condition was often omitted in weaker responses, but it is an important detail. An alternative non-graphical means of showing direct proportionality in a response is to determine that that the ratio of *x* to*y* is a constant (or, in other words, *x* divided by *y* gives the same value each time) for each paired *x* and *y*.

Question 2

(a) The time taken for a given volume of hot water to cool by 10 °C was measured in seconds. There were many good responses but there were some unrealistically low values and a few candidates recorded times that were not in seconds, the required unit.

(b) The cooling rate should have been calculated by dividing the temperature change (10 °C) by the time in seconds. The answer should have been given as a decimal number, to more than one significant figure.

(c) The mass of the beaker, *m*, mass of water, *M*, used for the experiment and the specific heat capacities of water and glass were given along with the formula to use in order to calculate *P*, the rate of loss of thermal energy from the beaker of water. Many candidates performed the correct substitutions and calculation but few gave the correct unit (Watts or Joules per second) to their answer. Some weaker candidates used an incorrect mass or used the wrong pairing of specific heat capacity for the masses.

(d) There were very few good responses to this part of the question. Answers for this type of question should assume that the experiment was carried out correctly and competently so responses stating, for example, that the student did not put in enough water could not be given credit. Correct responses had to explain why the real rate of loss of thermal energy could be lower (not higher) than the calculated value.

The accepted reasons which could account for the actual value of *P* being lower than the real value of P were that: the water is not in contact with the whole of the beaker; the hot water was less dense than cold water (so the volume of hot water added overestimated the mass of the water); or that, as the water was very hot, there was a gradual reduction in mass of the water due to evaporation.

Question 3

It is emphasised that it is important that centres provide equipment that conforms to the specification given in the Confidential Instructions. This is particularly important in optical experiments.

(a) The height of the lens above the bench (set by Supervisors) should have been 31.0 cm written to the nearest millimetre. A few candidates appeared to have used the wrong scale on the rule and obtained approximately (100 – 31.0). This should have been noticed by candidates when checking their answers as being a large overestimate of the height. It is possible that a few candidates adjusted the height of the lens prematurely. The first adjustment asked for occurs in **(c)**.

(b) Candidates were asked to describe their observations when a piece of graph paper was moved from a position just under the lens to the surface of the bench. The squares of the graph paper would have become larger and also blurrier. There were few good responses that mentioned both features. Some candidates noticed that as the image became blurrier or larger there was also more coloured fringing to the image, and this should have been regarded as blurring.

(c) (i) Many candidates had difficulty with this section. There were many incorrect responses, but credit was awarded either for correctly counting the number of complete (whole) squares horizontally across the view through the lens (or on **Fig. 3.3**) or the number of whole squares (or almost whole squares) seen within the area of the lens (or on **Fig. 3.3**). This meant that values of 4, 5, 12 or 16 were accepted. There were few good responses.

(ii) The diameter of the lens should have been divided by twice the number of complete squares observed across the diameter of the lens, i.e., D/2N, to obtain an estimate of the magnification. This could have been described in words or a formula given. There were very few correct responses.

(d) The most obvious means of improving the method would be to consider the partial squares. For example, two approximately half squares could be considered as equivalent to another full square. There were few good responses. Credit was awarded to candidates who explained how to obtain a more accurate diameter of the lens using additional sensible equipment, such as a pair of set squares or a pair of calipers.

Section B

Question 4

(a) (i) The potential difference across the terminals of the supply should have been 4.5 ± 0.5 V, written to 2 or 3 significant figures. Supervisor values were taken into account. It should be noted that V_s should have been a positive value. A negative value was not penalised here but it indicated that the voltmeter's terminals had been connected the wrong way around. Candidates are advised to gain experience and knowledge of the correct way to connect a voltmeter.

(ii) The potential difference across the 150 Ohm resistor was measured and *V* should have been 0.5 ± 0.2 Volts.

(iii) The current in the LED was calculated by dividing *V* by 150.

(iv) The potential difference across the LED was calculated using the given formula and taking the value of n as 5 (the number of 150 Ohm resistors in series with the LED). It should have been noticed that the potential difference across the LED could not be higher than the supply voltage.

(v) The resistance of the LED was then calculated. Correct values would have been in the region of a few hundred Ohms.

(b) (i) The correct headers and their units for each column should have been written in. Stronger candidates showed columns for V/Volts, V_{LED}/Volts, I_{LED}/A and R_{LED}/Ω.

(ii) Stronger candidates listed five sets of data with correct calculations, with consistent numbers of significant figures (or decimal places) down each column. The currents should have shown the trend of increasing by larger amounts as *V* increased. There were many good responses.

(c) The axes of graphs should always be labelled with both the quantity and the unit. The orientation of the axes (which quantity is plotted along the x-axis and which is plotted along the y-axis) should have agreed with the instruction given. If the data suggests it to be more convenient or that it will produce a better scale, it is perfectly acceptable to plot the graph in landscape format instead of portrait format. The graph should have occupied at least half the grid in each direction and the points plotted to within half a small square of their true position, using fine plots and the best line drawn. A smooth, fine line of a decreasing curve with a decreasing gradient should have been produced. It should be noted that it cannot be assumed that the relationship was indirect proportionality just because a decreasing curve with a decreasing gradient was obtained. Some good graphs were seen, but many could have been improved.

(d) The choice of the supply voltage and the resistors used was made so that there was no damage to the LED when current was flowing, that the voltage, the total resistance in the circuit (and the current) was not too high or too low so that the LED would be seen to glow when current was flowing. There were few good responses.

PHYSICS

Paper 5054/41
Alternative to Practical

Key messages

- Candidates should be advised to avoid using set phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. Answers suggesting how an experiment can be improved need to be linked to the practical situation being considered and candidates need to state how their suggestions improve accuracy has improved or avoid parallax.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule or ruler with a millimetre scale should be given to the nearest millimetre. If a measured length is, say, exactly 2 cm, the value should be quoted as 2.0 cm.
- Candidates need to take care and pay attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams is improved by using a sharp pencil and a ruler.
- 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.

General comments

The number of candidates taking the paper this year was small. The level of competence shown by the candidates was generally 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.

Most candidates attempted all the questions and there was no evidence of candidates suffering from lack of time. The more able candidates were able to follow instructions, record observations clearly and perform calculations accurately. However, some candidates did not round their numerical answers correctly or round to a reasonable number of significant figures. Units were generally well known and usually included where needed. The standard of graph drawing was disappointing in only a small number of cases.

Due to the low candidate entry, a few general comments on the questions are given below.

Candidates generally showed that they are adept at using data and the following questions were answered well:

1(b)(iv) Candidates then went on to find the refractive index of the block using the equation given. They were asked to give their answer to an appropriate number of significant figures and the majority did give this value to 2 or 3 significant figures both of which were acceptable.

2(b)(i) Finding the average of three different times presented very little difficulty.

3(b)(i) This was a straightforward measurement of a length and was done well although some candidates come to the examination without a ruler.

3(b)(ii) and (iii) Candidates used their value in **(b)(i)** to find the volume and then the density of the modelling clay in the question. This was done well but weaker candidates had difficulty in giving a correct unit for the density.

4(a) Nearly all candidates knew that an ammeter is used to measure current.

The following questions caused difficulty, where candidates struggled to explain methods and give conclusions:

1(a) The question described a ray of light passing through oil in a transparent plastic container. Candidates were asked to give a property of the oil that would be needed for the experiment to work. They were expected to realise that the oil would need to be transparent or explain that it needed to let light pass through. Only the most able candidates gained this mark.

1(c) The question asked why the practical method described might not give an accurate value for the refractive index. This question was answered poorly and only a handful of candidates gave creditworthy responses. The fact that the oil was held in a plastic container would have meant that the plastic would also have refracted the ray of light to a small degree.

2(b)(ii) Two sets of data were provided, and candidates were asked to explain why cooling the water by 10 °C was not double the time taken for it to cool by 5 °C. Candidates did not understand that hotter water will cool faster since there is a larger difference between its temperature and room temperature.

4(b)(i) and (ii) A list of apparatus was given, and candidates were told that a candidate measures the current for a range of potential differences. They were asked to draw a circuit diagram using some or all of the apparatus listed.

Many candidates did not know the correct symbol for a resistor or a variable resistor. Many candidates thought they had to use everything in the list and did not select the correct apparatus. A simple series circuit containing a battery, an ammeter, a fixed resistor and a variable resistor was expected but very rarely seen.

In **(b)(ii)**, candidates were asked how to obtain different values of potential difference across the fixed resistor and only a few suggested adjusting the variable resistor.

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

- Candidates should be advised to avoid using set phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. Answers suggesting how an experiment can be improved need to be linked to the practical situation being considered and candidates need to state how their suggestions improve accuracy has improved or avoid parallax.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule or ruler with a millimetre scale should be given to the nearest millimetre. If a measured length is, say, exactly 2 cm, the value should be quoted as 2.0 cm.
- Candidates need to take care and pay attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams is improved by using a sharp pencil and a ruler.
- 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.

General comments

The level of competence shown by the candidates was good. Some candidates approached this paper as they would a theory paper and not from a practical perspective. Only a very small number of candidates did not attempt all sections of each of the questions and there was no evidence of candidates being short of time. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included where needed. Writing was legible and ideas were expressed logically.

Comments on specific questions

Question 1

(a) The reading on each meter was almost always given correctly. The ammeter reading was sometimes given as 0.9 A instead of 0.09 A.

(b) (i) The calculation of the resistance of the lamp when the length of resistance wire in series with it was 10.0 cm. This presented no problems for the majority of candidates.

(ii) The missing value of current in the table was usually calculated correctly from the information presented. Most candidates gave their answers to 2 significant figures, as expected.

(c) Only stronger candidates understood the meaning of the term 'directly proportional'. Most candidates assumed that, because the resistance of the lamp increased as the length of resistance wire in series with it increased, the two quantities were directly proportional.

Candidates were asked to justify their answers by using values from **Table 1.1**. A minority of candidates did use values from **Table 1.1**, attempting to find the ratio of resistance to length for at least two pairs of values of resistance and length, showing that this ratio was not constant.

(d) (i) Many candidates gained full credit for the graph-plotting exercise. The axes were usually labelled, and sensible scales were chosen. There was little evidence this year of scales on the axes that were multiples of 3, 7 etc. The use of such scales makes it difficult for candidates to plot their points accurately.

Most candidates plotted the points accurately. Candidates should be reminded that if dots are used, they must have a diameter less than one-half the size of a small grid square. Candidates should also be reminded that they need to plot to the nearest half-square, so plotting all the points on grid intersections will sometimes mean an error in the plot.

Attempts at drawing a curve of best fit were very good. Most candidates attempted to draw a line which passed through the middle of the data, with any plotted points that did not lie on the line equally scattered about the best-fit curve. Candidates should be reminded, that if they suspect a plotted point to be anomalous, they can indicate this by circling and labelling it and then ignoring it when the best-fit curve is drawn.

Occasionally the question was misread, and candidates plotted the wrong variables. When this occurred, partial credit for plotting the graph could still be gained.

(ii) Candidates should be reminded to look at the mark allocation for each part of the question. There were two marks available here for describing the trend displayed by the curve that they had just drawn. Many candidates only made a single comment such as "as the potential difference V increases, the resistance R of the lamp increases". Only stronger candidates went on to state that the resistance increased non-linearly as V increased, or that the rate of increase of R decreased as V increased.

(e) The completion of the simple series circuit diagram, part of which was given in **Fig. 1.4** was not done well. Many candidates were unable to supply the correct symbol for a variable resistor. However, most candidates connected the symbol that they had drawn in series with the power supply, and were able to gain partial credit.

Question 2

(a) The length of the pendulum, 3.5 cm, was measured correctly to the nearest millimetre by the majority of candidates. Occasionally the length was given incorrectly as 3.50 cm, indicating a precision inappropriate for a 30 cm ruler.

(b) The majority of candidates were able to use the given scale to calculate the actual length of the pendulum. Occasionally candidates divided their measured length in **(a)** by 8, instead of multiplying.

(c) (i) Most candidates were familiar with reading a stopwatch and wrote down the time as 21.21 (s). Some candidates rounded this to 21 (s), but they were asked to record the reading shown on the stop-watch.

(ii) The method of calculation for the average time for one oscillation of the pendulum was well known. However, many candidates did not include the value that they had recorded in **(i)** in the calculation.

(d) The calculation of the period of the pendulum was usually done correctly. Occasionally candidates divided the time for 20 oscillations by numbers other than 20.

(e) Candidates were required to substitute their value for the period of the pendulum obtained in **(d)** into the given equation to calculate a value for the acceleration due to gravity. Although the calculation was usually carried out correctly, the answer was often not rounded to 3 significant figures as requested in the question.

(f) (i) Stronger candidates realised that if only two oscillations of a pendulum were timed, then reaction time errors would be a significant proportion of the recorded time.

(ii) Although there were some correct answers here, others were too vague to credit. Only stronger candidates realised that if 200 swings of the pendulum were timed, the oscillations might have stopped before 200 were recorded or that it was possible to lose count of the number of swings during the timing process. A vey common incorrect answer was that it would take too long to time 200 swings.

Question 3

(a) A number of candidates measured the wrong angle – the angle between the incident ray and the glass block. Candidates need to be able to identify the angle of incidence from familiar ray diagrams. The degree symbol was occasionally omitted from the value of the angle measured.

(b) (i) The instruction to draw the refracted ray inside the glass block was usually carried out correctly. Many rays drawn were very thick. Although not penalised here, the consequence of this was to lose the accuracy mark awarded for the measurement of the angle of refraction.

(ii) The point of emergence of the refracted ray from the glass block was usually labelled correctly with the letter N.

(c) (i) Despite being told that the emergent ray from the glass block was not deviated further, a number of candidates showed the light bending again as it left the glass block.

(ii) The description of how optics pins could be used to mark the path of the emergent ray accurately was only done well by stronger candidates. Other answers lacked precise detail. Only a minority of candidates stated that pins must be placed on the emergent ray, and even fewer candidates went on to say that the positions of the pins must then be joined by a straight line.

Question 4

(a) Most candidates gave clear explanations as to why the thermometer bulb must not touch the sides or the base of the beaker when measuring the temperature of the hot water in the beaker.

(b) The reason for stirring the water before taking a temperature reading was also well understood by the majority of candidates.

(c) Again, the reason for viewing the scale of the thermometer at right angles, perpendicular to the scale was well known. Most candidates stated that it was to avoid a parallax or a line-of-sight error.