PHYSICS

Paper 0972/11
Multiple Choice (Core)

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

Key messages

Candidates should be reminded to pay close attention to the units given in questions.

General comments

Many candidates found this paper very challenging. Although **Questions 11**, **17** and **19** were answered well they found **Questions 5**, **15**, **16**, **23**, **25**, **26**, **29**, **34**, **35**, **38** and **40** more difficult. In several questions candidates appeared to be unsure of the subject material.

Comments on specific questions

Question 5

The most common answer given was option **A**, 0.044 kg, showing that the majority of candidates failed to recognise that the question asked for the weight of water, not the mass. This emphasised that careful reading of the question is required.

Question 11

Candidates answered this question well and recognised which forms of fuel are renewable / non-renewable.

Question 15

Very few candidates were aware that evaporation causes cooling. There are some dramatic experiments which can be done which emphasise this, for example the freezing of water by the forced evaporation of ethanol.

Question 16

Nearly half of the candidates thought that reducing the volume of a gas, at constant temperature, caused the average speed of the molecules to increase. Stronger candidates understood that a change in average speed of the molecules of the gas causes its temperature is to change.

Question 17

Candidates showed an understanding of the idea that as the temperature of the ring increases the diameter of the iron ring increases, as does the diameter of the hole.

Question 19

Although there was a lot of information for this question, most candidates answered correctly.

Question 23

Stronger candidates understood that refraction, which is caused by the change of speed of radiation as it moves from one medium to another, leads to a change in wavelength of the radiation.

Question 25

Only the strongest candidates answered this question correctly. There was some evidence of guessing, with each response being chosen in almost equal numbers. For some candidates it is possible that the layout of the spectrum caused some difficulty.

Question 26

Candidates were expected to know that the range of audible frequencies for humans is 20 Hz to 20 kHz. It seemed that difficulties arose in this question in combining this knowledge with the information given regarding the audible frequencies of dolphins.

Question 29

Most candidates thought that the ammeter read the current in the resistor R_1 when it was connected at points 1 and 2 only (option **B**) failing to understand that it also gives it at point 4, where the current has recombined after passing through the two arms of the parallel circuit.

Question 34

Stronger candidates understood the basic working of a potential divider and recognised that as the resistance across a voltmeter decreases so the reading on the voltmeter also decreases.

Question 35

The strongest candidates understood that it is the relative movement between a magnet and a conductor which leads to an e.m.f. being induced. Thus no relative movement, whether it be a strong or weak magnet means that there is no induced e.m.f. and, also that an e.m.f. will be induced if the relative movement is either away or towards each other.

Question 38

This question was problematic for many candidates as many did not read the question carefully enough. These candidates did not recognise that the question asked for a comparison of the numbers of protons and electrons.

Question 40

Only the strongest candidates showed an understanding of half-life. There was some evidence of guessing, with all four options chosen in fairly equal numbers.

PHYSICS

Paper 0972/21
Multiple Choice (Extended)

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

Key messages

Candidates should be reminded to pay close attention to the units given in questions.

General Comments

There were some very strong performances and generally the standard was high. Candidates answered **Questions 1**, **3**, **5**, **9**, **17**, **20**, **25**, **30**, **25**, **31** and **37** really well. They found **Questions 22**, **23**, **27**, **32**, **34** and **40** more challenging.

Comments on specific questions

Question 1

Almost all candidates answered this question correctly.

Question 3

Candidates were able to spot the units on the graph axes and relate the diagonal straight line to the nature of the motion.

Question 5

Candidates showed a full understanding of the relationship between mass and weight, with virtually all candidates answering correctly.

Question 9

Candidates were familiar with the equation defining momentum.

Question 17

Candidates had a clear understanding of the differences between boiling and evaporation.

Question 20

A large majority of candidates were able to identify the amplitude of the wave. However, a small but significant number gave the double amplitude.

Question 22

This question was challenging for many candidates. There was some evidence of guessing. Candidates needed to be aware that the diagram showed light incident on the glass-air boundary at the critical angle and then had to use the formula $n = 1 / \sin c$.

Question 23

Whilst a large majority of candidates were aware that infrared radiation has a longer wavelength than visible light, there was a significant minority who failed to recognise that all forms of electromagnetic radiation travel at the same speed through a vacuum.

Question 25

The vast majority of candidates showed they understood the principles of magnetic induction.

Question 27

Although nearly half the candidates were able to identify the correct response, there were many who showed little understanding of the electromotive force of a rechargeable battery and were under the impression that it referred directly to the energy stored in the battery.

Question 30

Almost all candidates answered this question correctly.

Question 31

Most candidates were able to answer this question correctly.

Question 32

Although this was a challenging question, almost half of the candidates were able to work through the physics and identified the correct response.

Question 34

This question was challenging for many candidates. However, stronger candidates understood that it is the relative movement between a magnet and a conductor which leads to an e.m.f. being induced. Thus no relative movement, whether it be a strong or weak magnet means that there is no induced e.m.f. A common error was to think that an e.m.f. will only be induced if the relative movement is towards each other and no e.m.f. is induced if the movement is away from each other.

Question 40

Only the strongest candidates answered this question correctly. A significant minority of candidates showed a lack of understanding of half-life. Amongst those who did show an understanding, over half failed to reduce the raw count (shown on the graph) to take account of background radiation.

PHYSICS

Paper 0972/31
Core Theory

Key messages

- It is important that candidates read the questions carefully in order to understand exactly what is being asked.
- In calculations, candidates must set out and explain their working correctly. If poor or no working is shown, when an incorrect final answer is given, it is often impossible for credit to be given for those parts that are correct.
- Greater clarity and precision was needed when answering questions requiring a description or explanation.
- In order to improve their performance candidates should practise applying their knowledge to new situations by attempting questions in support materials or exam papers from previous sessions.

General comments

A high proportion of candidates were well prepared for this paper. Equations were generally well known by many candidates, but a significant number struggled to even recall the equations.

Often candidates were able to apply their knowledge and understanding to fairly standard situations. On occasions, when asked to apply their knowledge to a new situation, they became confused and displayed a lack of breadth of understanding. More successful candidates were able to think through the possibilities and apply their knowledge when the question asked for suggestions to explain new situations. Less successful candidates found difficulty in applying their knowledge to new situations, did not show the stages in their working and did not think through their answers before writing.

The questions on electrical quantities, force on a current-carrying conductor in a magnetic field and radioactivity were generally not well answered by candidates. There were a significant number of candidates who either did not read the questions carefully enough, or gave answers that were related to the topic being tested, but did not answer the question as it had been set.

The English language ability of the majority of the candidates was adequate for the demands of this paper. There were a very small number of candidates, who struggled to express themselves adequately.

Comments on specific questions

Question 1

(a) The vast majority of candidates answered this question correctly. Weaker candidates gave responses such as 1.12. A few simply gave the reading as it appeared on the stopwatch.

(b) This was answered well with most candidates gaining full credit. Those who did not, usually gained partial credit for working. A small number of weaker candidates divided 54 by 120.

(c) Many candidates gained full credit for calculating the distance as 35 (m). A much smaller number gave the distance as 28 m and more gave answers of 49, 7 or 21 to gain partial credit. Most of the others knew that distance travelled = average speed × time or that distance is the area under the graph. Not all, however, knew how to work out the area under this line.

Question 2

(a) (i) This item was answered well by the majority of candidates. The experiment is clearly one that is familiar to many candidates. Almost all gained credit for measuring the mass and the volume and stating how these are used to calculate the density. The majority also gave details of how to measure the mass of the liquid.

Weaker candidates struggled with the science. Common errors were using the measuring cylinder to measure mass, not measuring the volume, not making it clear that it was the mass of the liquid that was required and confusing mass, volume and density. Some candidates thought the balance measured density directly. Many used the terms "measure" and "calculate" as if they had the same meaning.

(ii) The majority of candidates knew an acceptable unit of density, with most giving g/cm^3 as their answer. A small minority gave the unit as cm^3 or cm^3 / g.

(b) (i) The majority of candidates gave sensible answers relating to the density of the polythene block and the water. Weaker candidates suggested that polythene was lighter than the water. It was very rare to see considerations of upthrust being equal to weight.

(ii) This item was challenging for many candidates with almost as many candidates multiplying the mass by 10 as dividing it by 10. Candidates knew that g had to be in answers somewhere but mass = weight × g was seen almost as often as weight = mass × g. A number of candidates also divided g by the mass.

Question 3

(a) The majority of candidates calculated the correct answer of 28.8 N and almost always stated that the force was upward. However, many were unsure of how to calculate the resultant of three co-axial forces. Candidates performed various arithmetical functions on a selection of the numbers on the diagram and seemed to be quite random in their choice of direction. Relatively few clearly stated 45.4 as part of their working and many showed little or no working.

(b) The concept tested in this item was not well understood by the vast majority of candidates with very few answering correctly.

Question 4

(a) This was very well answered by almost all candidates. The experiment was well known and most candidates knew all the salient details and scored full credit. Generally candidates answered in concise language – a clear sign that they were well prepared for this topic.

(b) This question was answered well. Almost all candidates knew that the process was evaporation and most candidates went on to give a convincing explanation.

Question 5

(a) The vast majority of candidates were able to correctly complete the flow diagram for the geothermal power station.

(b) Many candidates gained partial credit, but many did not seem to be familiar with a geothermal power station and gave vague references to ideas in their answers such as: clean, expensive, cheap, easy to build, eco-friendly (or not).

Question 6

(a) Almost all candidates gave the correct answer. Responses from weaker candidates were usually 0.3 or 26, but these were given by very few candidates.

(b) The majority of candidates gained at least partial credit. Weaker candidates gave responses such as "insulating the tanks" or "use warm water" and some that lacked practicality e.g. "move it closer to the sun" or "cover the pipe with an insulator".

(c) Many candidates gained partial credit but only the most able scored full credit. The most common response was radiation and some referred to infra-red radiation. Conduction was commonly seen but few specified that it referred to transfer through the pipe. Centres should remind candidates that when talking about transfer of thermal energy, it is a good idea to state where the transfer is occurring.

Question 7

(a) (i) This was well answered by the majority of candidates. A few candidates gave the correct colours but in the wrong order and a small minority mentioned purple or brown.

(ii) This question proved challenging for many candidates, with almost as many arrows pointed to the left as pointed to the right.

(b) (i) Most candidates drew a ray that was correctly refracted at the first face. A small minority showed the ray passing into the prism undeviated or showed refraction beyond the normal.

The refraction at the second face proved to be much more challenging with a majority showing refraction in the wrong direction.

A number of candidates drew rays being dispersed – sometimes with little regard to the appropriate refraction.

(ii) The vast majority of candidates gained credit here but weaker candidates gave answers such as reflection, dispersion or diffraction.

Question 8

(a)(i) Most candidates gave a sensible measuring instrument with "metre rule" the most common. Weaker candidates gave answers such as "meter" or "meter tape". Trundle wheels were rarely mentioned and were more often described than named.

(ii) Most candidates had the idea of echoes formed by reflection of sound but often expressed this in very vague terms such as "hits the wall and comes back". A small number of weaker candidates thought that echoes occur in large open spaces.

(b) The majority of candidates scored full credit with answers of 340 m / s. However many others gave answers of 170 m / s and 85 m / s often without any working shown.

Question 9

(a) (i) The majority of candidates gained full credit but common mistakes were to write "alpha" and "beta" or to shorten microwaves to "micro" which was insufficient for credit. It is important that candidates do not use abbreviations when adding labels.

(ii) Only the strongest candidates answered this correctly with almost as many candidates circling "gamma ray" as those circling "radio".

(b) Many candidates gave reasonable precautions. However a large number indicted that goggles, gloves and a lab coat were all the protection needed.

Question 10

(a) Most candidates answered correctly. A common error was to label the variable resistor.

(b) A number of candidates found this question challenging, with almost as many candidates giving A as the unit for electrical current as those who gave I and Ω. Similar mistakes were made for V and the electrical quantities, with "ammeter" and "voltmeter" amongst the most common errors.

(c) The dependence of resistance on length was well known, although “shorter wires have bigger resistance” was a common incorrect response.

The dependence of resistance on cross-sectional area was less well known. A large number of candidates thought that thicker wires have greater resistance.

Question 11

(a) (i) Many candidates produced a well-drawn series circuit containing a recognisable cell and switch. Often, the cell had a line through the centre. The most common mistake was to try to incorporate the edges of the paper into a circuit that had no connection with the wire, or a cell symbol and switch drawn on to the line representing the wire without any attempt at a circuit.

(ii) and (iii) Only stronger candidates gained full credit for this question. The shape of the magnetic field was not well known. “From north to south” was a very common response but most efforts involved an attempt to describe the field around a bar magnet. Many candidates recognised that reversing the current would have no effect on the shape of the magnetic field.

(b) The majority of candidates found this item challenging. Only a small minority showed a wire between the poles of a magnet. These generally went on to answer the rest of the question well, but some confused the force on the conductor with electromagnetic induction. The majority gave a variety of circuits (most often the diagram given in the question).

Question 12

(a) (i) and (ii) The majority of candidates wrote “alpha” as one of their answers but rarely gave it for both.

(b) (i) Many candidates found this item challenging with “alpha”, “beta” and “gamma” suggested in roughly equal numbers, but “heat” and “infrared” were also given by weaker candidates. Many who gave beta then found it difficult to explain that the reading would change depending on the thickness of the foil.

(ii) Many candidates failed to read the question carefully enough and gave responses about the thickness of the aluminium rather than the reading on the meter.

(iii) Candidates who considered what happens to the rollers answered well and gave creditworthy responses. Many gave answers such as “the foil needs to be thicker” without considering how this may come about.

(iv) The vast majority of candidates answered correctly by giving 38 as the number of protons. Weaker candidates thought that the answer was 52.

PHYSICS

Paper 0972/41
Extended Theory

Key messages

In numerical work involving the use of a formula, candidates should write down the formula rather than beginning by writing down numbers. Credit can usually be awarded for the statement of a correct formula, but if any of the numbers that are written down are wrong, and with no formula, no credit is awarded.

Candidates should note the command words used in the questions and should ensure they follow these instructions. For example in **Question 5(b)(iv)** candidates were asked to "state and explain". Many candidates, in answering this question, only made a statement and did not include an explanation.

General comments

The paper allowed candidates of all abilities to apply their knowledge and demonstrate their capabilities over questions of variable difficulty. There were few examples of wrong or missing units in numerical answers in this session.

Comments on specific questions

Question 1

(a) An application of the syllabus item 'Calculate acceleration from the gradient of a speed-time graph' was required. Very few candidates recognised that this involved drawing a tangent to the graph at time = 30 s and calculating its gradient. Most candidates merely divided the speed at 30 s by 30 and failed to gain any credit.

(b) Many candidates could not interpret the lower gradient of the graph at time 100 s as showing that the acceleration had become less than the acceleration at time 10 s. Suggestions that this was caused by less driving force or greater resistive force, and thus a lower resultant force, were often not clearly stated.

(c) A clear statement or implication that the area under a graph is distance travelled gained credit. Many candidates went on to correctly calculate the area of the trapezium or the sum of the areas of a rectangle and a triangle.

Question 2

(a) Rather than stating the correct energy form as "chemical", a number of answers quoted "electrical" or "kinetic".

(b) (i) Writing down "mgh" gained partial credit. Correct substitution and calculation with the correct unit for the energy meant full credit was frequently awarded. Some candidates failed to state the formula and of these a few substituted the time as one of the numbers.

(ii) Many candidates gained credit for writing down an acceptable version of the formula for efficiency and for calculating the output power. Few candidates also calculated the efficiency, often through confusing power and energy.

(c) Some of the advantages and disadvantages quoted for an oil-fired power-station, those to do with cost and efficiency, were regarded as invalid due to their dependence on particular design features and the comparative ages of the two systems. Acceptable advantages of oil-fired systems usually referred to their non-dependence on weather conditions. Acceptable disadvantages included the pollution caused, the need for transportation of fuel or the fact that oil supplies will eventually run out.

Question 3

(a) (i) A number of candidates incorrectly calculated the numerical value of the weight, usually through the wrong use of g. Some candidates gave the incorrect unit.

(ii) Most candidates used pressure = force / area or weight / area and calculated the pressure correctly. Some candidates used mass instead of force or weight, not realising that the weight calculated in **(i)** was the force in **(ii)**.

(b) Only stronger candidates answered this question correctly. Common incorrect answers involved the weight of the container.

(c) Many candidates answered this question correctly and gained full credit.

Question 4

(a) (i) Most candidates answered this question correctly.

(ii) Most candidates gained at least partial credit for this question with many gaining full credit.

(b) Almost all candidates gained partial credit for stating that molecules collide with the walls of the box, but few candidates moved beyond this. However, some correctly added that these molecules changed their momentum in doing so. Incorrect ideas such as the suggestion that momentum is lost in the form of energy were seen. Very few candidates made the link between rate of change of momentum and force or stated that the pressure on the walls of the box is the force divided by the area of the walls.

Question 5

(a) (i) Confusion of the terms refraction and reflection led to some candidates quoting rarefaction, diffraction or total internal reflection.

(ii) If refraction had been the answer to **(i)**, the explanation needed to refer to change of speed, change of refractive index or change of optical density in passing from air to glass. Candidates often mentioned only change of medium or change of density however.

If reflection was given in **(i)**, a reference to the surface of the glass or the boundary was required.

(b) (i) A high number of wrong placements of one or both the principal foci were seen.

(ii) Many candidates drew a ray passing through the centre of the lens without deviation, and another that passed through one of the positions of F, including a wrongly placed one. For some of these candidates, it was sometimes not clearly shown that the image was inverted.

(iii) The height of the image was correctly stated by many candidates.

(iv) Many answers suggested the image was real, but failed to give an explanation.

Question 6

(a) (i) Most answers were drawn correctly. However, some candidates drew arcs which were clearly not centred on the centre of the gap and others had inaccurate spacing of the arcs. Candidates who used compasses tended to gain full credit.

(ii) Only the strongest candidates answered this question correctly. Although most knew that the wavefronts had straight sections, they often showed them longer than the width of the gap, or increasing in length as their distance from the gap increased. The sections of the wavefronts adjoining the straight sections were sometimes not curved, showing too much curvature or extending as far as the barrier.

(b) Many answers failed to describe an experiment and just showed the final wave diagram. Some diagrams showed rays rather than wavefronts or showed refraction rather than reflection. Stronger answers described a container for the water, a description of a barrier or how wavefronts were produced.

Question 7

(a) Most candidates correctly identified the presence of free electrons as the relevant feature. Occasional incorrect answers referred to a single electron or ions instead. Others described a solid's particle structure without accounting for what makes metals good conductors.

(b) (i) Much of the working was unclear and many candidates clearly struggled with the idea of involving two proportionalities. Some candidates confused cross-sectional area with diameter or radius, and squared one of the factors of 2. Nevertheless, a number of stronger candidates answered correctly.

(ii) Often with the benefit of an error in **(i)** carried forward, a majority of answers gained full credit. Some candidates having calculated 1/R, failed to invert their answer. A few candidates incorrectly added the resistor values.

(c) (i) Correct answers of 3E were given by stronger candidates. Many answers quoted numerical values.

(ii) Based upon their answer to **(b)(ii)**, even if this was wrong, many candidates ticked the correct box.

Question 8

(a) Many candidates gained full credit by using the correct formula and numbers allowed. Partial credit was awarded if 60 or 260 was used rather than 200, the correct value.

(b) Often with the benefit of the wrong energy in **(a)** carried forward, credit for the correct numerical answer could be given. Wrong statements of the unit of the specific latent heat of fusion often occurred.

(c) Many candidates did not consider the situation carefully enough and suggested heat loss from the water. Stronger candidates correctly referred to heat transfer into the water.

Question 9

(a) Some candidates suggested the given procedure would work and gained no credit. However, many stated the steps would not work, and then went on to explain should be done instead, gaining full credit.

(b) (i) Partial credit could usually be given for suggestions that the coil would turn or rotate. Statements that the rotation would be clockwise were less common. For full credit, candidates could explain that a force acts upon a current carrier in a magnetic field or explain the function of the split ring. The latter was the more frequently chosen option.

(ii) Many candidates answered this question correctly and gained full credit. .

Question 10

(a) This question proved challenging for many candidates. The strongest candidates suggested that an alternating current produces a changing magnetic field for credit. References to voltage or current being induced in the secondary coil were more common.

(b) (i) A large majority of candidates wrote down the correct formula and used it correctly.

(ii) Rather fewer candidates than in **(i)** were familiar with the formula relating to equal power in the coils of a transformer operating with notional 100 per cent efficiency. Even with the correct formula quoted, wrong manipulation of the numbers sometimes produced the wrong current.

(iii) With the correct current, or the wrong current in **(ii)** carried forward, many correct maximum numbers of lamps could be credited. However, particularly for those who had calculated the wrong current, many candidates divided that current by the fuse rating and gave an incorrect answer.

Question 11

(a) A large majority of candidates stated the correct particle numbers.

(b) Many candidates gained full credit, but some wrote down the product nucleus as Rn instead of Po, and less frequently, a wrong alpha symbol.

(c) Most candidates correctly recognised that 7.6 days equalled 2 half-lives, requiring 2 successive halving of the initial number of Rn nuclei. The more challenging calculation of the number of alpha particles emitted was achieved by quite a small number of candidates.

PHYSICS

Paper 0972/51
Practical Test

Key messages

Candidates need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability and control of variables.
Candidates should be aware that, as this paper tests an understanding of experimental work, explanations and justifications will need to be based on practical rather than theoretical considerations.
Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
Candidates should be ready to apply their practical knowledge to different situations. Questions should be read carefully to ensure that they are answered appropriately.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:

plotting graphs
tabulating readings
manipulating data to obtain results
drawing conclusions
dealing with possible sources of error
controlling variables
handling practical apparatus and making accurate measurements
choosing the most suitable apparatus.

It is assumed that, as far as possible, the IGCSE course will be taught so that candidates undertake regular practical work as an integral part of their study of physics. Questions on experimental techniques were answered much more effectively by candidates who clearly had regular experience of similar practical work and much less successfully by those who, apparently, had not.

The practical nature of the examination should be kept in mind when explanations, justifications or suggested changes are required as, for example, in **Questions 1(c)**, **1(d)**, **2(d)**, **2(e)** and **3(d)**.

Comments on specific questions

Question 1

(a) The majority of candidates successfully recorded the time in s, within the range expected. Most calculated the period correctly although some multiplied by 10 instead of dividing by 10. Many candidates calculated T^2 correctly but a significant number doubled the value of T. Relatively few candidates correctly gave the unit s^2. The value of g was usually correctly calculated.

(b) Most candidates recorded suitable values here and obtained a value of g between 8 and 12 (m / s^2), the accepted range. Candidates who had carried out the work with great care were credited for having both g values within the range 9–11 (m / s^2).

(c) Some candidates wrote precautions here rather than responding to the question about changes to improve accuracy. Using additional d values and counting more oscillations were the expected answers. Repeats of the original measurements could not be credited as this did not answer the question as it had been set.

(d) One of a number of suitable precautions could be used here. Most candidates chose to describe perpendicular viewing of the scale. This needed to be clearly expressed to gain credit. Vague references to vertical, horizontal, parallel or eye-level were not precise enough. Other good answers such as how to use a set square as an aid to measure *d* were seen less often.

Question 2

(a) Most candidates recorded the potential difference to at least 1 decimal place, and the current to at least 2 decimal places. Most also calculated the resistance correctly.

(b) Candidates were credited here for connecting the voltmeter correctly and so obtaining a new resistance value within 10 per cent of the first value.

(c) In this section candidates were credited for using the correct units for potential difference, current and resistance. The answer for the combined resistance was expected to be given correctly and to 2 or 3 significant figures.

(d) Here candidates were required to make a judgement based on their own results. The statement needed to be clear, saying that either the results support the suggestion or they did not. The justification then needed to match the statement with wording that showed a clear understanding of the concept of results being within, or beyond, the limits of experimental accuracy.

(e) Candidates were expected to complete the diagram showing three resistors in parallel with the variable resistor in series with the resistor combination. One voltmeter should then be shown in parallel with the resistor combination. Common errors here included drawing a thermistor in place of the variable resistor, drawing three voltmeters and, less commonly, three resistors in series. Candidates needed to plan their circuit diagrams carefully as a component drawn over an existing line could not be credited. For example, a resistor with a line through it changes the symbol to that of a fuse.

Question 3

(a) Many candidates completed the table correctly with values within the permitted ranges. Some calculated $u + v$ instead of the product uv.

(b) Most candidates labelled the graph axes correctly and drew them the right way round, choosing a suitable scale. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting is clear. Many candidates drew a well-judged straight line but some candidates drew a 'dot-to-dot' line whilst others drew a straight line that did not match the plots.

(c) Here candidates needed to clearly show the triangle method on the graph, with a large triangle using at least half the distance between the extreme plots. Many candidates achieved this.

(d) Successful candidates made a relevant suggestion from their experience. Some candidates appeared to be relying on answers they had learned from other questions that were not appropriate for this question. For example, using a darkened room is not a difficulty in this experiment. A difficulty could be that the room is too bright.

Question 4

Many candidates answered this planning question well. Those who followed the guidance in the question were able to write concisely and addressed all the necessary points. Most candidates explained a relevant experiment. However few wrote about any kind of measurement of the air gap which is a key part of the experiment. Construction of a table of readings helped some candidates to organise their thoughts and to write clearly about how to carry out the investigation. The table needed to include columns relevant to the description. Typically columns for size of air gap, temperature and time, all with appropriate units were included.

Credit was available for sensible suggestions of possible variables that should be kept constant. For example, the starting temperature of the water and volume of water used. Credit was also given for other useful suggestions such as use of a lid.

Candidates were expected to explain how to reach a conclusion from their suggested readings. Candidates needed to be aware that this is not the equivalent to making a prediction about the expected results.

PHYSICS

Paper 0972/61
Alternative to Practical

Key messages

- Candidates need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability and control of variables.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations will need to be based on data from the question and practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to unusual situations. Questions should be read carefully to ensure that they are answered appropriately.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:

- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- making accurate measurements
- choosing the most suitable apparatus.

It is assumed that, as far as possible, the IGCSE course will be taught so that candidates undertake regular practical work as an integral part of their study of physics. This examination should not be seen as suggesting that the course can be fully and effectively taught without practical work. Some of the skills involved in experimental work, including graph plotting and tabulation of readings, can be practised without doing experiments. However, there are parts of this examination in which the candidates are asked to answer from their own practical experience. Questions on experimental techniques were answered much more effectively by candidates who clearly had experience of similar practical work and much less successfully by those who, apparently, had not.

The practical nature of the examination should be kept in mind when explanations, justifications or further developments are asked for as, for example, in **Questions 1(d)**, **1(e)**, **2(b)**, **2(e)** and **3(e)**.

Comments on specific questions

Question 1

(a) Most candidates measured the distance correctly in cm.

(b) Some candidates divided by 10 instead of multiplying by 10 to obtain *D*. The majority of candidates successfully recorded the time in s. Most calculated the period correctly although some multiplied by 10 instead of dividing by 10. Many calculated T^2 correctly but a significant number doubled the value of *T*. The value of *g* was usually correctly calculated.

(c) Only a few candidates correctly gave the unit s^2. Candidates were expected to give their value for *g* to 2 or 3 significant figures.

(d) Some candidates wrote precautions here rather than responding to the question about changes to improve accuracy. Using additional *d* values and counting more oscillations were the expected answers. Repeats of the original measurements could not be credited as this did not answer the question as it had been set.

(e) One of a number of suitable precautions could be used here. Most candidates chose to describe perpendicular viewing of the scale. This needed to be clearly expressed to gain credit. Vague references to vertical, horizontal, parallel or eye-level were not precise enough. Other good answers such as how to use a set square as an aid to measure *d* were seen less often.

Question 2

(a) Many candidates recorded the potential difference correctly and most also calculated the resistance correctly. A significant number of candidates did not record the units of potential difference and current.

(b) Here candidates were required to make a judgement based on their own value for R_1 and the stated values for R_2 and R_3. The statement needed to be clear, saying that either the results support the suggestion or they do not. The justification then needed to match the statement with wording that showed a clear understanding of the concept of results being within, or beyond, the limits of experimental accuracy.

(c) Candidates were expected to give the correct total to 2 or 3 significant figures and to include the unit.

(d) Many candidates correctly ticked the third box but some chose one of the other two possibilities.

(e) Candidates were expected to complete the diagram showing three resistors in parallel with the variable resistor in series with the resistor combination. One voltmeter should then be shown in parallel with the resistor combination. Common errors here included drawing a thermistor in place of the variable resistor, drawing three voltmeters and, less commonly, three resistors in series. Candidates needed to plan their circuit diagrams carefully as a component drawn over an existing line could not be credited. For example, a resistor with a line through it changes the symbol to that of a fuse.

Question 3

(a) Many candidates completed the table correctly. Some calculated $u + v$ instead of the product uv.

(b) Most candidates labelled the graph axes correctly and drew them the right way round, choosing a suitable scale. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting is clear. Many candidates drew a well-judged straight line but some candidates drew a 'dot-to-dot' line whilst others drew a straight line that did not match the plots.

(c) Here candidates needed to clearly show the triangle method on the graph, with a large triangle using at least half the distance between the extreme plots. Many candidates achieved this.

(d) Many candidates gained credit for obtaining a value for *G* within the tolerance allowed. Stronger candidates gained further credit for *f* equal to *G*, expressed to 2 or 3 significant figures.

(e) Successful candidates made relevant suggestions from their experience. Some candidates appeared to be relying on answers they had learned from other questions that were not appropriate for this question. For example, using a darkened room is not a difficulty in this experiment. A difficulty could be that the room is too bright.

Question 4

Many candidates answered this planning question well. Those who followed the guidance in the question were able to write concisely and addressed all the necessary points. Most candidates explained a relevant experiment. However few wrote about any kind of measurement of the air gap which is a key part of the experiment. Construction of a table of readings helped some candidates to organise their thoughts and to write clearly about how to carry out the investigation. The table needed to include columns relevant to the description. Typically columns for size of air gap, temperature and time, all with appropriate units were included.

Credit was available for sensible suggestions of possible variables that should be kept constant. For example, the starting temperature of the water and volume of water used. Credit was also given for other useful suggestions such as use of a lid.

Candidates were expected to explain how to reach a conclusion from their suggested readings. Candidates needed to be aware that this is not the equivalent to making a prediction about the expected results.