PHYSICS (US)

Paper 0443/13
Multiple Choice

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

General comments

Questions 1, **8**, **9**, **11** and **32** were the best answered on this paper, and only **Question 35** caused widespread difficulty.

Comments on Specific Questions

Question 2

This question involved calculating distance travelled from the area under a speed/time graph. A significant number of candidates forgot to halve the product of final speed and time.

Question 5

The topic here was extension/load graphs. Many candidates did not realise the significance of the graph starting at the origin, meaning that the vertical axis represented extension rather than measured length.

Question 16

This question tested understanding of the process of evaporation, and it was generally well a However, the popularity of distractor C showed that, although there was awareness that the remaining would cool, the link between this and the lowering of the average energy of its molecules was less wid known.

Question 17

A significant number of candidates gave answers which implied that the pressure of the air in the pump could increase at constant temperature without its volume decreasing.

Question 18

Most responses were correct to this question on sound and hearing, but many candidates opted for C, frequency too high. Candidates should know that the amplitude of a sound wave must also be large enough for the sound to be heard.

Question 20

Most candidates knew the correct order for the electromagnetic spectrum, although a significant proportion chose D, which showed the electromagnetic radiations in order of *decreasing* frequency.

Question 22

A significant number of candidates chose option D, which showed a mirror facing towards scout Q. This would not be suitable as it would not reflect the ray in the required direction.

Question 31

Most responses were correct to this question on fuses. Some candidates realised that the fuse should be in series with the appliance, but did not know that it should be on the live side.

Question 33

Although the majority of candidates answered this question correctly, a significant minority seemed unaware of this standard method of demagnetisation.

Question 35

Although this question was simple recall, it was not well answered. Option C, the field around a straight wire, was the most popular answer.

PHYSICS (US)

Paper 0443/23
Paper 2 Core

Key Messages

Apart from the basic requirement to learn information from right across the Core syllabus, there were three further aspects in which candidates could have been more careful and so have improved their performance.

In calculations, candidates must set out and explain their working correctly. When a candidate gives a wrong final answer and no working is shown, or the working is very unclear, it is often impossible for the Examiner to give any credit.

Greater care and accuracy is needed by some candidates when drawing or completing diagrams.

In order to improve their performance, candidates should practise applying their knowledge to new situations, for example 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 most of the candidates, but a significant number struggled when required to rearrange the equations.

The questions on energy transfer and the sound and light topics were generally not well answered by candidates. There were a significant number of candidates who gave answers that were related to the topic being tested but did not answer the question, possibly because of not reading the question properly or recalling a learned response to a different question.

Often candidates had been well taught how to apply their knowledge and understanding to fairly standard situations. On occasions however, when asked to apply their knowledge to a new situation, they demonstrated some confusion and a lack of breadth of understanding. The more successful candidates were able to think through the possibilities and apply their knowledge when the question asked for suggestions to explain new situations.

The English language ability of the vast majority of the candidates was adequate for the demands of this paper. However, there was a small minority who struggled to express themselves adequately.

Comments on specific questions

Question 1

(a) The majority of candidates were able to sketch most of the speed/time graph for the motion of the motorcyclist. The most common mistake was the omission of the section where the motorcyclist slowed down. A few candidates had not read the question carefully and started their sketch graph at zero instead of 15 m / s.

(b)(i) Most candidates correctly calculated the time to travel between A and B. Weaker candidates inverted the formula or multiplied the distance by the speed.

(ii) A large number of candidates indicated that the actual time would be less than that calculated in **(b)(i)**.

(c) Only the more able candidates were able to calculate the distance travelled from the area under the speed/time graph. Weaker candidates simply multiplied 20 and 25.

Question 2

(a) This description seemed to cause considerable confusion amongst weaker candidates. More candidates gave clear, concise descriptions of how the value of the extension was determined.

(b) Many candidates gained credit for this straightforward question. Weaker candidates made the mistake of starting their line from the origin.

Question 3

(a) A large proportion of the candidates were able to identify the energy changes involved in this situation, with many scoring all of the available credit.

(b) Almost all of the candidates gained credit.

(c) Similarly, the majority of candidates were able to state what happened to the kinetic energy of the wheel when the weight hit the ground.

Question 4

(a) Most candidates scored full credit, the main source of error being inaccuracy in taking readings.

(b) (i) The majority of candidates answered correctly. The main problem came in not stating that the left hand column was lower than the right hand column.

(ii) Most candidates answered correctly, although many did choose to add the two readings instead of subtracting them.

(c) Many candidates scored full credit, but a significant number did not average correctly the two readings.

(d) A significant number of candidates suggested that the water would be too dense.

Question 5

(a) The majority of candidates selected one correct response, but only the more able ticked both correct answers.

(b) There were many creditworthy suggestions, but some candidates did not improve upon the arrangement outlined in the question.

Question 6

(a) This straightforward question gave rise to many rather confused answers, with responses ranging from “no effect” to “differences in pitch”.

(b) There were many correct responses, but the weaker candidates confused the two parts.

(c) The majority of candidates scored some credit, but only the better candidates were able to construct a short passage explaining the transmission of sound through air.

(d) Few candidates could quote two values within the required ranges of frequencies.

Question 7

(a) The more able candidates recognised that this arrangement would produce a spectrum on the screen.

(b) Very few candidates ticked only one box, which is a significant improvement on a similar question from last year. The most common mistake was to tick the box for diffraction.

(c) A large number of candidates did not use a ruler to continue the rays to the scre many gained some credit only the most able could more fully describe what would be s screen.

Question 8

(a) Most candidates gave the correct response.

(b) There were many good examples of ray diagrams, clearly showing refraction at the centre or at both surfaces of the lens. However, many candidates would benefit from further practise in drawing ray diagrams to improve their accuracy.

Question 9

(a) A number of candidates indicated that the usual purpose of a transformer was to turn AC into DC.

(b)(i) A significant number of candidates did not recall that the iron part of the transformer was called the core.

(ii) Most candidates answered the first part correctly. The calculation was often well done, but a significant number of candidates might have gained credit had they shown their working. In part **3**, the most common misconception was to state that the lamp would “burn out”.

Question 10

(a) (i) Many candidates gave a correct description for charging the rod.

(ii) The majority of candidates correctly described the ball moving towards the rod as the rod was brought near to the ball.

(iii) Most candidates knew that unlike charges attract each other.

(b) Most candidates gave a correct sketch showing the balls repelling each other, but a significant number thought that they would attract, or did not draw a diagram.

Question 11

(a) The majority of candidates correctly identified the voltmeter symbol.

(b) (i) Most candidates correctly indicated the use of an ammeter, but a significant number gave the answer “amp meter” which did not gain credit.

(ii) There were many correct responses, but some candidates connected the voltmeter in parallel with the resistor instead of the cell.

(c) (i) A significant number of candidates did not attempt the question, but those who did usually gained credit for two or three of the marking points. The most common issues were the use of an incorrect equation or not giving the correct unit for resistance.

(ii) The majority of candidates ticked the correct response.

Question 12

(a) A number of candidates omitted this question. Those who did answer it mostly gave the correct answer.

(b) The majority of candidates ticked the correct response.

(c) Significantly fewer candidates gained credit here compared to **(b)**, with many candidates indicating that the answer was again “half the number at the start”.

(d) The majority of candidates coped well with this question. However, there was so between proton number and nucleon number. A significant number of candidates were how to calculate the number of neutrons from the nucleon and proton numbers.

PHYSICS (US)

Paper 0443/33
Extended Theory

Key Messages

This paper is designed to test the entire syllabus, both Core and Supplement, although the majority of the parts deal more extensively with the Supplementary material than with the Core material.

In addition to being familiar with the entire syllabus, candidates must also be able to give answers in a variety of ways and to be able to relate one style of explanation to another. Candidates are required to be able to interpret information from graphs and to perform calculations accurately using formulae which are known. Although a high standard of art work is not necessary, candidates are sometimes required to draw diagrams which are clear and comprehensible. Where a verbal explanation is required, candidates need not be too concerned with the grammatical accuracy or elegance of the answer, but it must be clear and unambiguous and it must, of course, deal with the point being examined.

All numerical answers must be followed by the correct unit and, where the calculated answer runs to many decimal places, the answer given should be correctly rounded. There remain a few candidates who do not give units and who receive a reduced credit as a consequence.

When answering a question, it is important that a candidate restricts the answer to exactly what is being asked; otherwise, contradictions can be produced which invalidate a correct comment that has already been made.

General Comments

There are candidates who spend some of the allocated time writing out answers in pencil and who then trace over these answers in ink; this is at the very best a poor use of time but it may also ensure that the answer is significantly less clear than it otherwise would be, and in some cases credit may be lost when the Examiner cannot be sure what answer is intended. This practice should be vociferously discouraged.

The amount of answer space provided for written answers should be sufficient for an answer that obtains full credit, and candidates who write lengthy answers in small handwriting are prone to lose credit by including material that is contradictory. No answers should be written on the front cover and where an answer continues beyond the answer space, a simple reference to the location where the answer continues should be made. For questions involving calculations, the working needs to be clearly set out in order for the Examiner to give it credit.

Comments on Specific Questions

Question 1

(a) This part was answered correctly by the overwhelming majority of candidates. A very small number of candidates reversed the answers to part **(ii)** and part **(iii)** but very few other errors were made. It was especially encouraging that very few candidates indeed marked letter A where the car is stationary. Although the speed of the car is constant as asked, the car itself is not moving.

(b) (i) Very few candidates were able to obtain full credit here. Not all candidates realised that the acceleration could be obtained from the change in velocity of the car or that this could be obtained from the graph. Many of those who tried to apply the standard definition of acceleration to values obtained from the graph, used a value for the time taken of 6.5 s rather than a value for the change in time that was obtainable from the graph. Acceleration is not a straightforward topic and this common source of inaccuracy suggests that there are many candidates who can re... for acceleration but do not understand what it really means.

(ii) Some candidates had very little idea of what was required here. However, many candidates ... the formula needed and were able to obtain full credit either by giving the correct answer or, m... commonly, by correctly using their incorrect value from **(i)** which had already been penalised.

(c) There were many correct answers, with a majority of candidates realising that the absence of a resultant force ensured that the car was travelling with a constant speed.

Question 2

(a) This part was very well answered and very many candidates obtained full credit here. A few candidates used a beaker rather than a measuring cylinder and did not obtain full credit, whilst others did not mention one of the readings which were needed in their answer. A few candidates gave a full description of the determination of density rather than the determination of volume.

(b) (i) This was almost universally correct.

(ii) This was extremely commonly correct. A very few candidates supplied the ratio upside down whilst others used the term *weight* rather than *mass*. Full credit was obtained very frequently.

(c) This part of the question was also well answered with nearly all candidates describing a method based on using the lead weight to make the piece of wood sink. Although the correct answer could be obtained from just two readings, many candidates suggested the use of three readings. In some instances, this led to a lack of clarity as to which readings were being subtracted in order to obtain the volume of the piece of wood.

Question 3

(a) This was generally very well answered with a very large number of candidates obtaining full credit.

(b) (i) Many candidates obtained the correct answer by using the principle of moments correctly. The answers of some candidates did not suggest an understanding that the use of moments was needed here and an answer was obtained by using proportions; this usually gave a weight for the apple that was less than that of the weight used to balance it.

(b) (ii) This part was quite poorly answered. Only a minority of candidates gave a mass that was consistent with their answer for **(ii)**. Some candidates multiplied by g rather than dividing by it; others confused grams with kilograms and some candidates did not use the answer in **(i)** at all.

(c) (i) Few candidates made any mention of moments in this part and only rarely was full credit obtained. The suggestion that the weight of the apple plus the weight of the part of rule on that side of the pivot was equal to the weight of the part of the rule on the other side of the pivot was commonly made.

(c) (ii) Many candidates were successful with this part question.

Question 4

(a) (i)(ii) Although many candidates had some idea of what was needed here, full credit was only occasionally obtained. The points being assessed were primarily the separation of the molecules and the randomness of the arrangements. Some answers were not especially clear as the molecules drawn were of varying sizes and separations and included arrangements that were a mixture of randomly positioned molecules as well as clearly non-random arrangements.

(b) (i) The correct state of matter was very commonly underlined here.

(ii) Very few answers referred to the absence of the repulsive intermolecular force that opposes the compression of solids and liquids but many candidates made correct references to the large intermolecular spaces in gases.

Question 5

(a) Some candidates obtained full credit in this part but others did not get as far as the co answer. A common source of inaccuracy was to calculate an incorrect value for the e supplied; in many cases the time period of 180 s was ignored whilst in others the power w divided by it.

(b) (i) This was quite well answered and a significant number of candidates obtained full credit.

(ii) This question asks for two ways in which evaporation differs from boiling. Those candidates whose answers concentrated on boiling did not always make it clear how this related to evaporation, and full credit was commonly not obtained by such candidates.

Question 6

(a) (i) Only the correct letter was needed here and a large majority of the candidates gave the correct answer.

(ii) In addition to the correct letter, an explanation was needed, and a significantly smaller number of candidates scored credit. Candidates had difficulty explaining that thermometer E is the most sensitive because it has the smallest range and the greatest length.

(b) There were many answers here which incorrectly suggested that the sensitivity of a thermometer is determined by the thickness of the glass in the bulb. It is possible that candidates who gave this erroneous explanation mistakenly thought that sensitivity describes the speed at which a thermometer reaches its final reading. Full credit was only rarely obtained.

(c) This calculation proved challenging for many candidates. Many did obtain some credit for showing part of the working, but rather fewer obtained full credit. The fact that the range of this thermometer extends from –10 °C to 110 °C seemed to complicate the problem considerably for many candidates. The effect of the ten degree Celsius section at each end was only occasionally dealt with correctly.

Question 7

(a) This part was not well answered. Some candidates did not refer to vibrations or oscillations at all whilst others suggested that it was the wave itself that was vibrating. Many answers stated that a transverse wave moves in a direction at right angles to the wave direction, which is unclear or self-contradictory.

(b) (i) The relevant formula was widely known and the correct numerical substitution commonly gave the correct answer here. There were candidates who produced unclear formulae such as $w = \lambda s$. Many candidates, however, obtained full credit. Some others obtained the correct numerical answer but gave the wrong unit; a typical example was 813 m.

(ii) The answers here were not widely known and the answers given were very commonly inconsistent with each other.

Question 8

(a) (i) A significant number of candidates knew where the image was located but rather fewer candidates were able to show how to locate the position using the reflected rays. Very few candidates obtained full credit.

(ii) Although the answers given were mixed and occasionally contradictory, most candidates gave one or two correct characteristics of the image.

(b) This was generally sensibly answered and many candidates obtained full credit.

Question 9

(a) The answers given varied enormously in quality and accuracy. It was encouraging to see neatly drawn sets of equally spaced vertical field lines which obtained full credit. Some candidates, however, drew horizontal lines or the trajectory of what might have been a charged pa through the gap. It is possible that a candidate who did this has attempted to lea answers from significantly different questions in previous papers.

(b) (i) This was well answered and many candidates obtained full credit. A few candidates struggled w the powers of ten but were still able to obtain some credit. The erroneous equation $I = Qt$ was quoted surprisingly frequently.

(ii) Many candidates were aware that the conduction property is due to electrons but rather fewer stated explicitly that the electrons are free to move through the structure.

Question 10

(a) This was very commonly correctly answered; the correct formula was widely known and frequently used appropriately.

(b) This part was quite involved and, in order to obtain the correct answer, more than one stage in the calculation was required. Many candidates obtained some credit and a significant number were able to obtain full credit for the correct answer with the correct unit.

Question 11

(a) (i) Whilst many candidates obtained some or full credit here, there were also those candidates who did not know how to proceed and who left this part blank or who combined the numbers given in the question in an unsystematic manner.

(ii) Electromagnetic induction is frequently poorly understood and only a minority of candidates produced an answer that was clearly correct. Some credit was obtained by candidates who referred to the changing magnetic field but a common misunderstanding was to suggest wrongly that there is a current in the iron core transferring energy to the secondary coil.

(b) Many candidates knew the name of the appropriate component and the majority of candidates knew its significant property. This was well answered.

Question 12

(a) Although questions on this topic occur not infrequently, this question was rather poorly answered. A common misunderstanding suggests that the high voltage of transmission reduces the resistance of the cable. It does not and the suggestion that it does reduces the credit that a candidate would otherwise have obtained.

(b) (i) Most candidates stated that the resistance of the cable would be reduced when its diameter is doubled. Of those who attempted a quantitative response, the majority suggested that the resistance would be halved. Only a very small minority of candidates obtained full credit here by correctly stating that the resistance would, in fact, be reduced by a factor of four.

(ii) Many candidates produced a correct disadvantage here but others did not do so.

PHYSICS (US)

Paper 0443/04

Coursework

General comments

This year saw a significant increase in the number of Centres entering for coursework assessment. Regular Centres continued to produce work of the correct standard to justify the credit awarded and used tried and tested investigations which allow candidates to show their abilities to the best effect. This was also true of the majority of new Centres.

There were, however, a number of Centres where the credit awarded did not accord with the standards expected. In these cases it was due either to teachers at the Centre being too generous in their marking or, more commonly to Centres choosing assessment tasks which were not appropriate to the skills being assessed.

The majority of samples illustrated clear annotated marks and comments, which was helpful during the moderation process. The candidates at the majority of Centres were given many excellent opportunities to demonstrate their practical skills using a varied range of tasks from different areas of the specification; clearly a large amount of good work has been completed by teachers and candidates.

If more than one teacher has been involved in the assessment of practical skills, then it is very important that internal moderation is undertaken, to ensure that the standards applied for all candidates are comparable. This is made easier where all candidates do the same tasks, and the same mark schemes are used. It is acceptable to use different tasks, but this will require considerably more effort to be made to ensure that marks for one teaching group can be compared directly with those of another. It is best if just one teacher takes on the role of internal Moderator, as this is the only way to ensure that the same standards have been applied for the entire entry from one Centre. The external Moderators cannot change the rank order within a Centre; it is the Centre's responsibility to ensure that this is correct.

Skill C1 Using and Organising Techniques, Apparatus and Materials.

This skill involves following instructions and as such cannot be combined with skill C4 which involves writing instructions. The credit awarded depends on the complexity of the instructions followed, which may be simple one step instructions, more complex multi-step instructions, or instructions which are branched, that is where there are, at some point, two possible routes to take. The decision as to which route is taken depends on interpretation of an observation.

Skill C2 Observing, Measuring and Recording.

This skill involves making and recording observations. Tasks may be quantitative, involving measurements of qualitative observations. Care must be taken not to provide too much guidance on exactly what to observe and how to record it. The provision of tables and other formats, even in outline, limits the credit which can be awarded.

Trivial exercises involving one or two readings are not sufficient evidence for the higher credit.

Skill C3 Handling Experimental Observations and Data.

This skill involves processing results and finding patterns to arrive at a conclusion. It is much easier to demonstrate this skill if there is data to process. Most suitable of all are tasks from which a graph is produced as this makes it easier to find and explain patterns.

Again care must be taken to not give too much help in the way of leading questions or pre-drawn axes. In this skill also, such assistance lowers the credit available.

Skill C4 Planning and Evaluating Investigations.

Here a detailed plan must be written before the investigation is started. It is also essential that th then carried out as this enables an evaluation to be made and improvements suggested.

Very simple exercises are not really suitable as there must be opportunity to explain how variables are to be varied, measured or held constant.

Mark schemes should be related both to the task and to the criteria in the syllabus and should not be a slight rewording of the assessment criteria.

PHYSICS (US)

Paper 0443/53
Practical Test

Key Messages

To achieve well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves as possible. The practical work should include reflection and discussion on the significance of results, precautions taken to improve reliability and control of variables.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:
- handling practical apparatus and making accurate measurements
- tabulation of readings
- graph plotting and interpretation
- manipulation of data to obtain results
- drawing conclusions
- understanding of the concept of results being equal within the limits of experimental accuracy
- dealing with possible sources or inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

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 borne in mind when explanations or justifications are asked for. This was seen in some of the excellent, straightforward responses to **Questions 2(d)** and **3(e)**, which required references to results rather than theory, and in the clear practical details given by some candidates in **Question 3(f)**.

It is expected that numerical answers will be expressed to a number of significant figures which is appropriate to the data given in the question or a measurement carried out by the candidate. This was demonstrated in many good responses to **Questions 1, 3(e)** and **4(a)**. Candidates should be aware that the appropriate use of significant figures and the inclusion of units where appropriate, will be tested at some point in the Practical Test.

The relationship between the variables plotted in **Question 4** was most likely to indicate a clear curve. Many candidates recognised this possibility while others attempted to fit straight lines to plotted points which did not justify them. Candidates need to be aware that graphical questions may well have plots which indicate a smooth curve rather than a straight line.

Comments on specific questions

Question 1

Good responses to this question were seen from a number of candidates, although the later sections proved challenging for many.

(a) The majority of candidates recorded sensible values for the masses and for the vo
The resulting density was generally calculated accurately. As units for the mass and vo
given in the question, it was expected that the density would be expressed in g / cm^3.
generally the case, with Pa or omission of the unit being the most common errors.

Credit was given to candidates who converted correctly to kg/m^3 but this was rarely seen.

(b) Most candidates recorded an appropriate mass and volume and the difference in volume was usually calculated accurately. Density was often expressed to the expected 2 or 3 significant figures, as was appropriate for the volume and mass measurements from which it was calculated.

It was clear from a very small number of responses that the instruction in part **(a)** to leave the water in the measuring cylinder had been ignored, resulting in inaccurate values of water displaced following the necessary refilling of the measuring cylinder. This underlines the need to read and follow the instructions carefully.

(c) While an average value of density from the results obtained in parts **(a)** and **(b)** was calculated correctly by the majority, the use of ($\rho_1 + \rho_2$) or (ρ_1 / ρ_2) was seen.

(d) This question called for candidates to focus on the reading of the volume as carried out in part **(a)**. Many good answers, including diagrams, described the line of sight needing to be perpendicular to the reading, taken from the bottom of the meniscus. Either point was given credit. Answers involving the use of different measuring cylinders with more precise graduations were not acceptable.

(e) Many candidates found this question challenging. Although a number suggested a possible source of inaccuracy, few were able to correctly state and explain the effect on the value of density obtained. The most straightforward correct answers, both resulting in a larger value for density, identified that the balance may not be set to zero, producing a larger value of mass, or that friction between the test-tube, which did not float upright, and cylinder may result in a smaller displaced volume of water. While it is recognised that this would have a minimal effect, credit was given to those candidates who noticed that some of the mass of the cotton was supported by the edge of the cylinder rather than contributing to displacement of water.

Question 2

This question was done well by many candidates.

(a) Decreasing thermometer readings were recorded by the majority of candidates. Candidates should be advised to estimate to the nearest 0.5 °C if the thermometer provided allows this, rather than recording integer values. This helps to avoid a number of identical readings together and better show the trend in the case of temperatures which are decreasing slowly, as was often the case for beaker **A**.

It was usual to see the units and column *t* values inserted correctly, the latter usually including 0. Units are not required for each value of temperature recorded if the units are present in the column headings. The practice of attaching units to the data in the columns as well as the headings should be discouraged. On occasions, contradictions between the two were seen and could not be accepted.

(b) A measurably greater rate of temperature decrease in beaker **B** compared to beaker **A** was generally experienced. However, where candidates had not used fresh hot water but poured in water which had already cooled significantly, this difference was much less marked or sometimes reversed. While subsequent responses were judged on the results which candidates had obtained, it is obvious that some were confused by patterns which did not fit those that they might have expected. Centres must ensure that, in such experiments, fresh hot water is clearly available.

(c) The clearest pattern of temperature change likely to apply to both beaker **A** and beaker **B** was that the rate of temperature decrease at the start of the experiment was greater than at the end. A number of candidates were able to identify this but many described more complicated patterns, few of which applied to both beakers or were consistent throughout the experiment. Description of any genuine similarity was accepted.

(d) Some good simple answers were seen, in support of the suggestion, pointing temperature change in beaker **A**, with the larger volume of water, was smaller than tha **B** in the same time interval. Others calculated and compared the average rate of tem change over 180 s. A number of candidates omitted the reference to time interval and did n full credit.

It should be noted that a lower final temperature of beaker **B** was not acceptable as sufficient evidence if starting temperatures were not included in the justification.

(e) Good responses to this question were generally seen, with 'initial temperature of hot water' and 'room temperature' being common correct answers. Correct references to the dimensions of the beaker, the depth of the thermometer bulb and the volume of water were frequently seen.

Question 3

This was a question, involving some straightforward measurements, and many candidates were able to answer very successfully.

(a)(b)(c) Sensible values, recorded to at least 1 decimal place for potential difference and 2 decimal places for current, reflecting the precision of the meters provided, were seen in the work of most candidates. There were some large results for current that seemed to indicate the use of scales recording in mA, although the units were still given as A in these cases. If multimeters are supplied, Centres should ensure that this does not disadvantage their candidates.

(d) Correct units for V and I were usually given. Some candidates omitted the answers, possibly through not having read the question fully, and others gave the quantity, i.e. 'voltage', 'current', rather than the unit.

(e) The values of resistance were often determined accurately and included a correct unit. Although the data generally implied that resistance should be expressed to 2 significant figures, 3 significant figures were also acceptable. Candidates should not express calculated quantities such as resistance to a precision greater than is justified by the raw data used.

Responses to this question were judged against the results which had been obtained rather than the attempts by some candidates to use a theoretical argument. Many correct answers, matching the results and supporting the suggestion, were seen. Justifications were often that the difference between R_A and (R_B + R_C) was within the limits of experimental accuracy and a number of candidates reasonably quoted 10% as their expected limit. Where results clearly did not support the suggestion, candidates often did not give a justification declaring the difference to be outside the limits of experimental accuracy. Candidates often incorrectly disagreed with the suggestion because the two values were not exactly the same, even though they were extremely close.

(f) This question required candidates to consider precautions which could be taken in this type of experimental work. Straightforward techniques of using smaller potential differences and currents or, as most would have done in this practical, switching off between readings, were given credit, although only a minority of candidates gave such responses. Candidates should be aware that using wires with a larger cross-sectional area, a common incorrect answer, would have the effect of increasing the temperature rise rather than reducing it.

(g) A large number of candidates answered this question correctly, showing the symbol as a rectangle with a diagonal arrow through it and indicating a connection in the series part of the circuit. A common error was to draw a thermistor symbol or a plain diagonal line and the connection was sometimes incorrectly shown between the crocodile clips.

Question 4

This was the question that was least well done by many candidates with the explanations and the curved line of the graph being found particularly challenging.

(a) Many of the candidates were able to record a set of appropriate measurements in the table, with both variables increasing and expressed to at least 1 decimal place.

(b) Although most calculations were correct, some rounding errors in the s value were seen.

A number of candidates did not take into account that their measurements of *w* and always the same, despite recording them as different. However, some correctly pointed Others were given credit when they reported that the blurred edges of the shadow measurements difficult and that taking an average value would improve reliability.

(c) Some good graphical skills were seen, with clearly labelled axes, appropriate scales which allowed the plotted points to occupy at least half of the grid, and accurate plots shown with fine crosses. The advice is that plotted points should, preferably, be marked with small fine crosses. Small dots are acceptable but are often obscured when the line is drawn through them, making it more difficult to award credit for correctly plotted values. The large dots used by a significant number of candidates are not acceptable, as the intended value cannot be determined clearly. A sharp pencil should be used for the plots and for the line so that accurate drawing may be achieved and errors easily corrected.

Although it was usual that plotted points clearly indicated it, only a minority of candidates were able to produce a smooth well-judged curve. Many drew a straight line or used smaller straight lines to join the plots together. Many physical quantities have a relationship which will produce a curved line on a graph and candidates should be prepared for this.

(d) It was expected that candidates would take into account the increasingly large differences, which most experienced, between successive values of *s* and recognise the need for an intermediate point so that better line judgement could be achieved. Only a minority of candidates explained this adequately. The common response that 'more plots produce a more accurate line' did not sufficiently address the need for the intermediate point to be here rather than between other values on the *d* axis.

(e) Many candidates recognised that a shadow for distances of less than 15 cm between the lamp and the object would be too large to fit on the screen. Responses involving the increasing distortion or blurring of the shadow for smaller distances were quite acceptable. Although not suggested in the question, it would have been sensible for candidates to have tried the experiment at a smaller distance and it seemed probable from their answers that a number had done this.