PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

The results show that all the candidates had covered all parts of the syllabus, and had been well prepared.

The candidates found **Questions 9**, **10**, **11** and **38** to be relatively easy, while no questions were unusually difficult.

Comments on Specific Questions

Question 15

A surprisingly large number (40%) did not know that heat transfer through a vacuum is by radiation only. Candidates should be reminded that conduction and convection both require a medium in order to transfer heat.

Question 16

A large number incorrectly chose **C**. These candidates had appreciated that the liquid does not have a fixed shape because the molecules move. However, the forces between the molecules in a liquid have to be large to keep the molecules together (giving a fixed volume), and to prevent the molecules moving apart (as in a gas).

Question 29

Many candidates were not sure of the effect of using cells in parallel. The advantage of connecting cells in parallel is that they take longer to run down. The e.m.f. is not changed.

Question 30

A large number of candidates thought that a lamp works only on a d.c. supply. Candidates should be reminded that filament lamps light when connected to both d.c. and a.c. supplies.

Question 36

Almost as many chose **C** as chose **A**, perhaps confusing the commutator with the core.

Question 39

There was an equal split of candidates between **A** and **C** here. It is the number of atoms of the radioactive isotope that halves.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

The results showed that the candidates had been well prepared across all parts of the syllabus.

Questions 8 and **40** were found to be relatively easy. None of the questions were found to be unusually difficult.

Comments on Specific Questions

Question 15

A large number of candidates incorrectly chose **C**. These candidates had appreciated that the liquid does not have a fixed shape because the molecules move. However, the forces between the molecules in a liquid have to be large to keep the molecules together (giving a fixed volume), and to prevent the molecules moving apart (as in a gas).

Question 22

Almost half of the candidates chose **A** or **B**. Candidates should be reminded that the speed of all electromagnetic waves in air is constant.

Question 35

Almost as many chose **C** as chose the correct answer **A,** perhaps confusing the commutator with the core.

Question 38

Almost a third of the candidates (including many of the more able candidates) incorrectly chose **C**. It is the number of atoms of the radioactive isotope that halves.

PHYSICS

Paper 5054/21

Theory

Key Messages

- To gain full credit, candidates should always give units when answering numerical questions. If a unit is complex (for example J/(g °C) for specific heat capacity), they can use the relevant formula together with basic units that they do know, in order to work out the unit.

- Candidates should be encouraged to write down any formula that is used in a calculation. This ensures that credit is gained, even if substitution of the data is wrong or the calculation is incorrect.

- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. Sometimes, the need arises to cross out an answer to part of a question and replace it with a new answer elsewhere. If this is done, candidates should make a simple reference to the location of the new answer.

General Comments

The questions were accessible to all candidates and there was no section of any of the questions where a correct response was not seen, although **Question 3** almost invariably produced very low scores, indicating the unfamiliarity of candidates with the thermocouple thermometer. **Question 11(b)(ii)** also produced only a small number of correct responses.

The standard of written English was high and there was no evidence of a language problem, even for the weaker candidates. The quality of expression, even among the weaker candidates was very good, even if the underlying physics was sometimes inaccurate.

Where a question calls for extended prose, candidates should take time to plan their answer, and not list everything that they know about a topic. For example in **Question 9(a)**, most candidates produced an unconnected list of energy forms/changes without explaining in which part of the motion of the rocket they occurred. Also, in **Question 11(d)**, where candidates were asked to explain in molecular terms why heating a gas at constant volume causes its pressure to increase, many candidates did not approach this in a systematic way, but instead listed as many facts as they knew about gas molecules, without focusing on the reason behind the pressure increase. The more able candidates expressed themselves eloquently and succinctly, confining their answers to the question asked, and scored full credit effortlessly.

Calculations were generally performed well and 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 omitted to give a unit or gave an incorrect unit.

In ***Section B***, **Question 10** was the most popular choice. **Questions 9** and **11** were less popular. A minority of candidates ignored the rubric for ***Section B*** and answered all three questions.

Comments on Specific Questions

Section A

Question 1

(a)

(i) Although most candidates knew how to solve the problem and chose the correct method of solution, many had difficulty recalling the formula for the volume of a cube.

(ii) The weight of the cube was usually deduced correctly from the mass quoted in **(i)**.

(b) The calculation of the thermal energy absorbed by the ice cube was competently done. Powers of 10 sometimes caused problems.

Question 2

(a) Candidates found this part very difficult and correct explanations were rare. All that was required was the idea that the work done by the falling block raised the elevator or was converted to potential energy of the elevator. Many candidates incorrectly stated that little work was done because the elevator was empty.

(b) The power calculation was well done, with most candidates calculating the total work done and then finding the work done per second. Occasionally, the time taken and the distance moved were interchanged in the quoted formulae.

Question 3

(a)

(i) Most candidates could not start to draw the required diagram. Where correct diagrams were drawn, careless drawing often resulted in the award of only partial credit. The most common error was not to place the junction of the metals into the flame.

(ii) The use of fixed points and the voltmeter reading to determine the value of the temperature in the flame was found to be difficult by nearly every candidate. This section of the syllabus was not familiar to candidates, and candidates would benefit from further time being devoted to teaching it.

(b) Sensible advantages of using a thermocouple thermometer to measure the temperature of a flame were given by few candidates. It was expected that candidates would recall that a thermocouple has a small heat capacity, can measure rapidly varying temperatures, or enables remote measurement to be made.

Question 4

(a) This ray diagram completion was drawn correctly by very few candidates. Instead of drawing the emergent rays as a parallel beam, nearly all candidates made the rays converge to F_2.

(b) Most candidates were able to state the correct change to the speed of light as it passed into the lens, and then back out into air again.

(c)

(i) The frequency of the light was usually calculated correctly. Some candidates had difficulty coping with the powers of 10 that appeared in this question.

(ii) The constancy of the frequency as light enters glass from air was known by about half the candidates.

Question 5

(a)

(i) Many candidates correctly stated that the rod had gained electrons. Weaker candidates had the electron flow reversed, with the rod losing electrons.

(ii) Most candidates stated that the cloth would become positively charged.

(b)

(i) Candidates who had drawn the correct orientation of charges often drew charge distributions that were not symmetrical, and often had many more negative charges on one side of the sphere compared with positive charges on the other.

(ii) Usually, only partial credit was scored here. Most candidates stated that there would be attraction between the negative charge on the rod and the positive charge on the sphere. Very few candidates went on to say that the attractive force was stronger that the repulsive force, or that the positive charges were closer to the negatively charged rod.

Question 6

(a)

(i) Most candidates were able to draw a recognisable sine/cosine curve in order to gain credit. Some candidates ignored the rubric instruction that there were **two** rotations of the coil, and only drew in one cycle of the wave.

(ii) The fact that the output voltage would increase was deduced by most candidates. The more subtle fact, that the frequency of the output voltage would increase as well, was only deduced by the more able candidates.

(b) This resistance calculation was carried out correctly by most candidates. The correct formula was chosen and the arithmetic carried out correctly.

Question 7

(a) The action of the potential divider in the given circuit was not understood by the majority of candidates. Many candidates incorrectly thought that when the sliding contact was moved from S towards C, that the resistance of the circuit would decrease, making the current in the loudspeaker greater. They went on to deduce wrongly that the sound produced by the loudspeaker would get louder. Candidates would benefit from further practice with problems involving potential dividers.

(b) The relationship between the loudness and amplitude of a sound was well known and most candidates gained partial credit. A common misconception was that the frequency of the sound would also increase as the sound got louder.

Question 8

(a) The mass numbers and the atomic numbers usually balanced on both sides of candidates' equations, but many responses received no credit because the correct numbers for the beta particle were not known.

(b) Most candidates were able to draw the path of the gamma ray through the magnetic field correctly. Far fewer candidates were able to deduce the path taken by the beta particle. Many candidates, who knew that the beta particle would be deflected downwards in a circular arc, did not show the particle start deflecting in this direction until it had either left the field, or was part way through the field.

(c) The randomness of radioactive emission was not well understood, and only the more able candidates realised what was expected here. Few were able to state that the process is random over time/direction, or that the particular nucleus that does decay is unpredictable.

Section B

Question 9

(a) Most candidates realised that the initial energy was stored as chemical energy in the rocket fuel and that this was being changed to potential energy. The intermediate energy change sequence was not well explained, with many candidates merely listing as many energy forms as they could remember – often quite unrelated to the question asked.

(b)

(i) The size of the initial acceleration of the rocket was deduced correctly by the majority of candidates.

(ii) The fact that the acceleration then began to increase was appreciated by many candidates, but fewer went on to state that it eventually became constant.

(iii) Although a majority of candidates realised that the gradient of the graph was required, far fewer found the gradient of the linear region of the graph. A very common error was to take the end-point coordinates of the graph to calculate the gradient, despite the fact that the initial acceleration was non-uniform.

(iv) The resultant force on the rocket was calculated correctly by a majority of candidates. A common error was to use the gravitational acceleration at the Earth's surface instead of the actual acceleration of the rocket at t = 80 s.

(v) This more demanding part was answered correctly by a small minority of the most able candidates. Most candidates subtracted the weight of the rocket from their calculated value of the resultant force on the rocket, instead of adding the forces together.

(c)

(i) The statement of Newton's third law of motion was usually quoted correctly.

(ii) Only the most able candidates could explain unambiguously how Newton's third law applied to the motion of the rocket, despite the help given in the stem of the question. In most answers, it was not clear on which body the stated forces were acting.

Question 10

(a)

(i) The table was almost always filled in correctly

(ii) Many candidates gained partial credit here. Answers to this question did not address the question being asked, and often gave an irrelevant account of what would happen if different combinations of switches were open or closed. Candidates would benefit from careful reading of the question before beginning to write an answer.

(iii) The fact that the fan needed to be on so that the heater would not overheat was suggested correctly by most candidates.

(b)

(i) About half the candidates realised that the total power of the appliances was needed to calculate the current supplied to the oven. Many candidates ignored the power of the fan, but were still able to obtain partial credit.

(ii) The selection of a suitable fuse rating was usually done well, but candidates should choose integral values when asked to suggest a rating. Often the suggestion of a suitable fuse rating was given to be lower than the current being supplied to the oven and this choice would be unsuitable. Most candidates knew that the fuse should be placed in the live wire.

(iii) This section of physics theory was not fully understood by the majority of candidates. Most candidates stated correctly that earthing the metal case would avoid electric shock, but could proceed no further. Very few candidates mentioned the fact that the casing had to become live before there was a danger of electric shock, and even fewer stated that the fuse would then blow and disconnect the supply. Candidates should be encouraged to think carefully about the purpose of earthing, and may benefit from further support in this area.

(c) The calculation of the cost of using the fan proved to be difficult. Many candidates did not use the power rating of the fan and merely multiplied the given numbers together. The conversion of watts to kilowatts was not often seen.

Question 11

(a)

(i) Most candidates knew that the moment of a force was measured by taking the product of force and distance and received credit for this. Fewer stated that the distance needed was the <u>perpendicular</u> distance to the fulcrum.

(ii) The moment of the force was usually calculated correctly.

(iii) Only the more able candidates could deduce that the moment of the force would decrease as the crankshaft rotates, because the distance from the axis to the force decreased.

(b)

(i) Candidates were able to calculate a value of pressure from the given values of force and area and receive partial credit. Very few candidates made the final step and realised that this was the excess pressure of the gas in the cylinder above atmospheric pressure. Only a very small minority of candidates added their calculated value to the atmospheric pressure to calculate the minimum value of the pressure of the gas in the cylinder.

(ii) This proved to be the most difficult question on the paper and only a very small number of candidates were able to suggest a valid reason as to why, in practice, the pressure of the gas was greater than the candidates' calculated value. All that was required was a reference to friction and what the consequence of friction would be in this situation.

(c) This part also proved to be difficult. Few candidates were able to deduce that if the gas in the cylinder expands then the pressure in the cylinder would decrease, and so the force *F* would decrease.

(d) Although many candidates understood the idea that the pressure in a gas was a result of the molecules of the gas colliding with its container walls, few could organise their thoughts clearly to explain the increase of pressure when heating a gas at constant volume. Candidates should be encouraged to organise their thoughts before putting pen to paper. The idea of molecular collisions with the walls of the container, and <u>not</u> with each other needs to be emphasised when explaining how gas pressure in a container occurs. It is also important for candidates to understand that, as the temperature of the gas increases, the rate or the frequency of the collisions with the walls increases.

PHYSICS

Paper 5054/22

Theory

Key Messages

- To gain full credit, candidates should always give units when answering numerical questions. If a unit is complex (for example J/(g °C) for specific heat capacity), they can use the relevant formula together with basic units that they do know, in order to work out the unit.

- Candidates should be encouraged to write down any formula that is used in a calculation. This ensures that credit is gained, even if substitution of the data is wrong or the calculation is incorrect.

- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. Sometimes, the need arises to cross out an answer to part of a question and replace it with a new answer elsewhere. If this is done, candidates should make a simple reference to the location of the new answer.

General Comments

The most able candidates performed very well on this paper and such candidates tended only occasionally to make careless errors or find difficulties on the most challenging sections of the paper. Some candidates had left a significant number of the questions unanswered and this was one reason for lost credit. The standard of written English was, in the vast majority of cases, either very good or at least acceptable and comprehensible. Very few candidates misunderstood questions for reason of language fluency and, although the standard of physics varied, it was clear that it was the subject itself that was being tested rather than any linguistic skills.

The examination skills of the candidates are good; numerical answers tend to be rounded to an appropriate number of significant figures and many candidates do this accurately and carefully. There remain a very few candidates who give answers as fractions or who leave out units which numerical answers almost always require.

In **Section B** candidates were given a choice of two questions from three. **Question 9** – a question on mechanics – was the most commonly chosen; most candidates chose **Question 9** and either **Question 10** or **Question 11**. Consequently few candidates chose to answer both **Question 10** and **Question 11**. Of these last two questions, slightly more candidates chose to answer **Question 10** than **Question 11**. Those candidates choosing **Question 11** tended to be the stronger candidates who performed better on the paper as a whole and they tended to score well in this question also. All of the optional questions contained both straightforward parts and more challenging parts and, provided that a candidate was sufficiently familiar with the physics being tested, no advantage was gained by choosing a particular pair of questions in **Section B**. Even though each of these three optional questions appeared on adjacent double pages, some candidates answered parts from all three questions and did not submit any complete answers in **Section B**. This was unfortunate as only two **Section B** questions can be credited. Some candidates answered all three questions in **Section B**, but this does not offer any advantage; candidates should be advised to choose two questions and spend their time carefully answering two questions rather than rushing to answer three.

Comments on Specific Questions

Section A

Question 1

(a) Many candidates realised that this part of the question was about moments and gained credit by applying the principle in some way. Not all candidates correctly obtained the distances 40 cm and 25 cm; others used the values on the ruler and did not perform the necessary subtraction.

(b) The majority of candidates quoted the correct formula for density and substituted in their mass value from **(a)**. Dividing by 1.6×10^{-4} proved a source of confusion for some candidates. Candidates would benefit from further practice using negative indices, especially in calculations involving division.

Question 2

(a)

(i) This part was almost invariably answered correctly, although some candidates incorrectly gave kilogram as the unit here.

(ii) Very many candidates realised that the loss in potential energy was equal to the gain in kinetic energy and obtained the correct answer for the height lost by the skier. Some, however, tried to use $\frac{1}{2}mv^2$ in some way.

(b) Although many candidates realised that the work done by the skier was equal to his kinetic energy, this part proved quite challenging for others. Several candidates tried to apply $F = ma$ in some way but were unable to do so.

Question 3

(a)

(i) The correct formula – in one way or another – was very commonly quoted in this part. Errors were made where candidates wrote a formula implying that it is the ratio p/V that is constant.

(ii) Most candidates with the correct formula in **(i)** obtained the correct answer here. There were some candidates who made errors in rearranging this formula.

(b) Many candidates realised that a fully inflated balloon would burst when higher up in the atmosphere, but only a few offered an explanation of why this would happen. A number of candidates stated that the atmospheric pressure was greater higher up.

Question 4

(a) Although many candidates realised what was required here and gave the correct answer, others were unable to quote the value itself. Other candidates did not realise that the speed of microwaves is the same as the speed of all other electromagnetic waves and tried to obtain the value from the diagram or the formula $v = f\lambda$.

(b) Many candidates obtained the correct answer here but some were confused; some of those who realised that the diagram represented 2.5 wavelengths did not go on to obtain 16 cm. Others simply quoted 40 cm.

(c) Many candidates made some of the points expected but rather fewer were able to gain full credit. Candidates tended to quote one or two valid points and to explain them in greater detail than expected rather than giving a more general outline of what was going on.

(d) Many candidates stated two common properties and received full credit.

Question 5

(a)

(i) Almost all candidates labelled the induced N and S pole of the iron bar correctly.

(ii) Many candidates realised and stated that the iron bar would be attracted to the U-shaped iron core but only a small number of candidates offered any explanation for this behaviour. Many of those who did stated correctly that unlike poles attract, but a few referred to charges rather than to poles.

(b) Many candidates knew exactly what was happening here and gained credit. Just a few stated that the poles would reverse.

Question 6

(a)

(i) Whilst many candidates knew what was needed here, some candidates appear to be unfamiliar with such circuits. The voltmeter was sometimes put in parallel with the power supply or in series with the rest of the circuit and a few diagrams omitted the power supply. The question asked for a labelled circuit diagram and those candidates who drew a circuit without any labels at all could not be awarded full credit. Many candidates omitted the variable resistor from the diagram and then referred to changing the current in **(ii)**. Candidates would benefit from practice drawing circuit diagrams and further experience of such experiments in the laboratory.

(ii) This part was commonly well done and most candidates gained at least partial credit.

(iii) The correct formula was almost invariably given by the candidates.

(b) Candidates found this part extremely challenging. Many drew a straight line through the origin rather than the expected horizontal line above the horizontal axis.

Question 7

(a) The formula was widely known and very commonly applied to obtain the correct answer. The size of the numbers in this part seemed to cause candidates few difficulties and there were very few arithmetical errors here. There were a few candidates, however, who gave the correct numerical answer but with the unit J rather than W.

(b)

(i) A very large number of candidates were able to state the correct formula and obtain the correct answer with the correct unit here.

(ii) This calculation was completed correctly by most candidates.

(c)

(i) Most candidates stated that one advantage of increasing the transmission voltage is the reduction in the rate at which energy is wasted by being converted to heat. There were a few candidates who merely stated that the current loss would be reduced and this was not enough to gain the mark.

(ii) Many candidates scored this mark either through mentioning the presence of a step-down transformer between the transmission lines and the domestic supply or by explaining one danger of having such a high domestic voltage. Some answers were not sufficiently focused; these included those which suggested that such a high voltage would result in an explosion but gave no other details of how this might happen.

Question 8

(a)

(i) Most candidates were able to gain at least partial credit here. In a few cases the rays met behind the retina or below the central axis, but most produced an accurate answer. Some candidates did not continue the rays beyond the image to the retina.

(ii) Many realised that the image was not formed on the retina.

(b) This question proved problematic for the majority of candidates. Only a minority drew a diverging lens of any sort and not all of those drew diverging rays emerging from it. Some answers were confused by the inclusion of the eye lens and subsequent converging rays. It was most helpful when the candidates who drew two lenses made it clear which was the answer to the question.

Section B

Question 9

(a) Many candidates read the graph accurately and gained credit. A few candidates gave answers read incorrectly from the graph such as 70.2 m / s.

(b)

(i) Most candidates calculated the area under the graph and obtained the correct answer. Those who used $x = vt$ usually obtained the answer 648 m which is double the correct value.

(ii) The calculation was very commonly correct and the correct answer was usually given. The correct unit for acceleration – m/s^2 – was almost always included.

(iii) Although this part was correct slightly less frequently than **(i)** and **(ii)**, it was still very often correct. Some candidates, however, used $F = mg$ and obtained 6500 N.

(c) This part proved to be something of a challenge. Candidates should be advised that air resistance and friction are both likely to increase as speed increases.

(d)

(i) Some candidates realised that the centripetal acceleration was due to the change in direction of the car's velocity but some common misunderstandings were highlighted here.

(ii) Many candidates gave answers such as *towards the centre* but only some of these stated that it was the centre of the circular path and some gave vague answers such as *towards the corner*.

(iii) Few candidates obtained the correct answer here. It was not always realised what was being asked for and some candidates repeated their answer to **(i)**. If there is an acceleration towards the centre of the circle, there must be a force on the car in that direction, and candidates needed to think about the origin of this force.

Question 10

(a) Although there were many correct answers given, some candidates did not state that the melting point is a temperature. 'The point where a solid becomes a liquid' was not sufficient because it is not clear that temperature is involved.

(b)

(i) This numerical answer was frequently calculated accurately, although some answers were incorrect by a factor of 10^3.

(ii) This calculation was also very commonly correct and it was very encouraging to see how often the square root was correctly obtained.

(iii) This part was a challenge to many candidates. Very few candidates realised that some energy would be needed to raise the temperature of lead to its melting point and other energy loss mechanisms were rarely explained in sufficient detail.

(c) Most candidates were able to describe some differences between the molecular structure of a solid and that of a liquid. Some candidates only described one or two differences and some only discussed the solid state and did not compare it to the liquid state. Candidates should be advised that a question about a change between states requires some discussion of both the initial and final state.

(d) The candidates who tackled this question as a calculation tended to gain credit. Other candidates were more likely to give imprecise answers such as *it takes more energy to melt the heavier bullet*. To determine whether the bullet melts or not, it is necessary to know that it requires twice as much energy.

Question 11

(a) The correct answer was very commonly given here with only a few candidates giving *fusion* or *radioactive decay* instead.

(b)

(i) Three numerical answers were required here and most candidates obtained the first two answers. The third answer proved more challenging, however, and 140 and 143 were common incorrect answers.

(ii) Many candidates did well here and gained full credit. The common error of quoting $E = mc^2$ but then substituting 3.0×10^8 rather than its square was made by only a small number of candidates. A few candidates used $E = ½mv^2$ and did not obtain credit.

(c) This part of the question proved to be challenging and few candidates were awarded full credit here. Although many candidates included a block diagram, these rarely received credit. Candidates proved rather better at answering the question in a more conventional manner. Those who described how the steam was used to rotate a turbine and hence induce an electric current in a generator went beyond what was asked for and could not be credited for this part of their answer.

(d)

(i) Many candidates realised that the definition of a half-life involves the time taken for something to halve and many gained full credit here. A common misunderstanding is that the half-life is the time for the number of protons or neutrons to halve. Candidates who made no reference to time taken did not receive any credit.

(ii) Many candidates were able to state one appropriate safety precaution that should be taken when handling radioactive materials.

PHYSICS

Paper 5054/31
Practical Test

Key Messages

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.

- Candidates should be aware that it is important to record measurements to the correct precision. In particular, measurements from a metre rule should be given to the nearest millimetre to gain full credit. Measurements of time from a digital stopwatch should be given to 0.01 s.

- Always read the question carefully to ensure the correct procedure is carried out.

- Candidates should be encouraged to repeat their measurements when answering questions in **Section A** in order to obtain full credit.

- It is important to choose a sensible scale for the graph in **Section B**. Scales based on intervals of, for example, 3 cm, are difficult to use and will lose credit both for the scale and for the plotting of points.

General Comments

In **Question 3**, the distance between the board and the screen was to be kept at 100.0 cm but it was clear, from the results obtained by some candidates, that the distance had been changed. Candidates should read the question carefully and ensure that the experiment they carry out is the one described by the instructions in the question.

Candidates should practise using the instruments that are likely to be used in the practical paper. For example, in **Question 2** a number of candidates misread the reading on the stopwatch obtaining, for example, a reading of 0.135 s for t_1 when the actual value should have been 13.5 s.

Comments on Specific Questions

Section A

Question 1

(b) Candidates have clearly learned the technique of checking that a string is horizontal by measuring the height above the bench at 2 places and checking that the 2 values obtained are the same.

(c) It was clear that most candidates had made the correct measurements in this section. Errors included:

- units not given for any of the 3 quantities,

- $h_1 - h_2$ greater than l, which is not possible if the measurements had been taken correctly,
- some lengths recorded to the nearest cm rather than the nearest mm, e.g. l = 25 cm rather than 25.0 cm.

(d) A relatively generous range was allowed for θ and this ensured that able candidates gained credit in this section.

Question 2

(a) Since the question stated "determine an accurate value for t_1", it was expected that candidates would repeat their measurement of t_1. A number of candidates misread the stopwatch so that, for example 13.5 s was recorded as 0.135 s. T_1 was often calculated correctly but the answer was sometimes not given to the correct number of significant figures because t_1 was given to the nearest second, e.g. 12 s for t_1 gives 0.6 s for T_1, which is then only to 1 significant figure rather than 2.

(b) Many candidates did not repeat their measurements, and so were unable to gain full credit.

(c) The majority of candidates obtained a value for the ratio that was in the required range and therefore gained full credit. Such candidates had obviously mastered the technique of measuring the periods of the oscillating masses. Occasionally a unit was incorrectly given for the ratio and some candidates calculated the ratio of the frequencies rather than the ratio of the periods.

Question 3

(b) Able candidates obtained correct values for u and v. In other cases it was clear that candidates had not followed the instructions in the question paper so that $u + v$ was not equal to 100.0 cm. These candidates could still obtain correct values for d and s provided a focused image had been formed on the screen. Since the focal length of the lens supplied was 15 cm, the value of u should have been greater than 15 cm. In a number of other cases it was clear that the candidate had not set up the apparatus correctly because the value of u was considerably less than 15 cm. In these cases the values obtained for d and s were not correct.

(c) Many candidates could not be awarded credit here because they took a single measurement of d. The phrasing of the question indicates that some special technique should be used to determine d. Examiners expected candidates to measure d across several bright spots, but only a small number of candidates did this. Repeat measurements were also allowed, provided the measurements were shown. A number of candidates said that they took repeat measurements but there was no evidence of any repeat readings.

(d) Only the more able candidates obtained a value for s that was in the correct range.

Section B

Question 4

(a) The majority of candidates drew a correct circuit diagram. A very small number of candidates drew the voltmeter in series with the heater. Some candidates did not show the 15 Ω resistor connected between A and B but, as long as the points A and B were shown, this was allowed.

(b) In the majority of cases, correct values were obtained for the current and potential difference. Common errors here were:

- omission of units,
- values that were incorrect by a factor of 10 or 2, e.g. 0.71 A instead of 71 mA or 142 mA instead of 71 mA.

(c) The results section was probably the part of this question that caused most difficulty. The main source of error was lack of results. Some candidates did not use any series combinations of resistors and so obtained only 3 results. Provided the results showed the correct trend (V increases as R increases; I decreases as R increases), then credit was given for this. Very able candidates actually obtained 8 data points by taking a reading when R = 0.0, i.e. with just a length of connecting wire connected between A and B.

(d) Graph plotting was generally good. It was not necessary to start the graph at the origin because the initial voltage was often in the region of 1.0 V. Often if the graph was started at the origin, the data on the *y*-axis may have occupied less than half the page, resulting in credit not being awarded.

(e) More able candidates used a large triangle to determine the gradient of the graph and obtained a correct value to an appropriate number of significant figures. Errors made by some candidates included:

- using a small triangle,
- using data points that were not on the best fit line,
- quoting the gradient to either 1 significant figure or too many significant figures.

PHYSICS

Paper 5054/32
Practical Test

Key Messages

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.

- Candidates should be aware that it is important to record measurements to the correct precision. In particular, measurements from a metre rule should be given to the nearest millimetre to gain full credit. Measurements of time from a digital stopwatch should be given to 0.01 s.

- Always read the question carefully to ensure the correct procedure is carried out.

- Candidates should be encouraged to repeat their measurements when answering questions in **Section A** in order to obtain full credit.

- It is important to choose a sensible scale for the graph in **Section B**. Scales based on intervals of, for example, 3 cm, are difficult to use and will lose credit both for the scale and for the plotting of points.

General Comments

The paper produced the required differentiation between candidates. Generally, **Section A** proved more difficult than **Section B**. The calculation of the energies in **Question 2** caused difficulty to some candidates because not all of the measured quantities were converted to SI units. In **Question 3**, many candidates did not know that the angle of incidence was the angle between the incident ray and the normal; many used the angle between the top surface of the block and the line L. Results in **Question 4** were generally good. Most candidates drew a correct circuit diagram, had correct values for the current and potential difference and obtained a correct value for the power. In many cases more values of temperature and time could have been recorded by taking measurements every half-minute. Examiners expected candidates to interpolate between the divisions of the thermometer to obtain a more accurate graph, but this was only done by a small number of candidates. The graph plotting and gradient calculation were good.

Comments on Specific Questions

Section A

Question 1

(a) The majority of candidates recorded l and w to the nearest mm or better and gave the appropriate unit. The main sources of error were:

- omission of the unit,

- a reading taken to the nearest cm, particularly the measurement of w, which many candidates gave as 21 cm rather than 21.0 cm.

More able candidates either repeated their measurements or used the set square to ensure that the measurement was taken perpendicular to the side of the paper.

(b) Very few candidates repeated their measurement of t_S, despite the fact that this was likely to be the most inaccurate measurement in this question, but generally the value of *t* was correct.

(c) The calculation of the density was generally correct and most candidates obtained a sensible value. In some cases, candidates did not know the unit of density. The assumption in **(ii)** was found to be difficult. Examiners were looking for the idea that all the sheets of paper were the same but this was rarely discussed. The most common answers were of the form "I have assumed that the density is less than 1 g cm^{-3} because the paper floats on water", which suggests that the candidates were not aware of the meaning of the word 'assumption'.

Question 2

(a) Most candidates obtained a correct value for *h*. The main sources of error were:

- omission of the unit,
- a reading taken to the nearest cm, e.g. 7 cm,
- a factor of 10 error, e.g. 72 cm; this was possibly a unit error—the candidate may have meant 72 mm.

(b) The main difficulty here was the calculation of E_P. Errors included:

- omission of, or wrong unit,
- leaving *h* in cm rather than converting it to metres so that the energy was 100 times greater than the expected value.

(c) When a question states "determine the average time", it is expected that candidates will repeat their measurements of *t* to obtain a mean value. Credit is available for repeating measurements, so candidates should be encouraged to do this.

In **(ii)** the wrong value of *s* was sometimes used. The value should have been 0.700 m as stated in the question, but some candidates used their value of *h* and others used a value of 1.00 m.

In **(iii)** incorrect values of kinetic energy were sometimes obtained because either *v* was used in cm / s or the value of *v* was not squared.

(d) More able candidates had values of E_P that were greater than E_K but did not state that some of the initial potential energy was converted to thermal energy (or was used doing work against friction).

Question 3

(a) Many candidates had the angle of 50° between XY and the line L, rather than between the normal and line L.

(b) The block was usually placed in the correct position and the outline was marked.

(c) In order to determine the most accurate position of the ray that leaves the block, candidates should mark 2 points that are as far apart as possible. Ideally one of these marks should be at the point where the ray leaves the block and the other point should be close to the "For Examiner's Use" margin. Very few candidates were awarded credit for this construction.

(d) The angle of refraction should have been measured between the line MN and the normal. A number of candidates measured either the angle between MN and XY or the angle of emergence from the block, leading to an incorrect value for the refractive index.

Section B

Question 4

(a) The majority of candidates drew a correct circuit diagram. A very small number of candidates incorrectly drew the voltmeter in series with the heater.

(b) In the majority of cases, correct values were obtained for the current and potential difference. Errors seen were:

- omission of units,
- values that were incorrect by a factor of 10 or 2, e.g. 0.32 A instead of 3.2 A or 6.4 A instead of 3.2 A.

(c) Nearly all candidates obtained a correct value for the power. The only problems were either the omission of units or the use of J rather than W.

(d) The results section was probably the part of this question that caused most difficulty. The main sources of error were as follows:

- many candidates only took 5 readings, taking a reading every minute; candidates should have no difficulty taking readings every half-minute in this question.
- in some cases the times in the table were clearly in minutes (1, 2, 3, etc.) but the heading at the top of the table was given in seconds e.g. *t* / s.
- very few candidates attempted to interpolate between the divisions of the thermometer. It was expected that at least one of the measurements of temperature would be to better than 1 °C.

(e) Graph plotting was generally good. It was not necessary to start the graph at the origin because the initial temperature was often between 20 °C and 30 °C. If the graph was started at the origin, the data on the *y*-axis may have occupied less than half the page, thus meaning credit could not be awarded.

(f) More able candidates used a large triangle to determine the gradient of the graph and obtained a correct value to an appropriate number of significant figures. Weaker candidates often:

- used a small triangle,
- used data points that were not on the best fit line,
- quoted the gradient to either 1 significant figure or used too many significant figures.

PHYSICS

Paper 5054/41
Alternative to Practical

Key Messages

- Units are important in practical work. Candidates should be encouraged to ensure that all answers are written with units, except where quantities are dimensionless and this has been carefully considered. It may be useful for candidates to do a final check of the paper to ensure that units are all included where they are needed.

- Candidates should be encouraged to give sufficient significant figures in numerical answers. This may at times require an answer of 1.0 in preference to simply 1 as this shows the precision of the final answer.

- When drawing lines of best fit, candidates should be encouraged to consider the position of all points. Simply joining the first and last points on the line does not usually give the line of best fit.

- Candidates can increase the accuracy of their straight lines on diagrams by using a sharp pencil and a ruler.

General comments

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

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

The level of competence shown by the candidates was sound, although, as in previous years, some candidates continue to approach this paper as they would a theory paper, and not from a practical perspective. Only a very small number of candidates did not attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with the range of practical skills being tested. The more able candidates followed instructions, recorded observations clearly and performed 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)

(i) The majority of candidates were able to mark the required vertical distance *h* in the correct position on the diagram. A sizeable minority of candidates did not read the question carefully enough, and marked the distance from the ceiling to the bob. Candidates should be made aware of the need for accuracy in marking distances on given diagrams. Often the end of the candidates' marked lines strayed too far away from the bottom of the pendulum bob to be awarded credit.

(ii) Most candidates drew the eye in a correct position, looking towards the bottom of the bob. Occasionally, candidates had the eye in the correct position, but looking away from the bob.

(b)

(i) Any sensible disadvantage of timing 50 swings was given credit. The most common acceptable answers were that the time would be too large, the candidate may lose count, or the amplitude of the oscillations would decay/the pendulum would stop swinging.

(ii) Almost all candidates were able to fill in the values of T and T^2 in the table. Candidates should be encouraged to think carefully about rounding and remember to quote to an appropriate and consistent number of significant figures.

(iii) The standard of graph plotting continues to improve and most graphs produced by candidates were neat and made maximum use of the grid supplied on the question paper. Sensible scales were usually chosen, points plotted accurately and neat best fit lines drawn.

(iv) An accurate description of the shape of the graph proved to be difficult for the majority of candidates. Most candidates only stated that the graph is a straight line. To obtain credit here, candidates needed to go further and comment that the graph also had a negative gradient or that as one quantity increased, the other decreased.

Question 2

(a) Many candidates found difficulty using their ideas on balancing/moments to deduce that the flattened end of the straw would move downwards when the screw is moved into the straw. This question caused difficulty even to the more able candidates – much guesswork seemed evident.

(b) Correct answers to this more demanding part of the question were rare. Only the very able candidates realised that a known mass would be needed in order to calibrate the scale in grams. Even when this was realised, there was often no link made between the deflection produced by the known mass and the markings which would need to be added to the scale.

(c) **(i)**,**(ii)** The correct scale readings of 1.5 cm and 3.8 cm were deduced by the majority of candidates. Where the scales were read incorrectly, the usual answers given were 2.5 cm and 4.2 cm.

(iii) The calculation of the mass of the hair was done well by most candidates. Occasionally, arithmetic errors spoiled what were otherwise valid methods. Candidates who had been lost marks for incorrect scale readings were able to obtain full credit here because the Examiners used the candidates' readings to calculate the mass of the hair.

(d) Most candidates were able to suggest a sensible advantage of the straw balance compared to an electronic digital balance. The most commonly stated correct advantages were that the straw balance was cheaper to build and did not need electricity to work. The most commonly stated incorrect response was that the straw balance would be more accurate.

Question 3

(a) Most candidates correctly identified the X- and Y-shifts as the controls needed to move the dot to the centre of the c.r.o. screen.

(b) Although many candidates did draw connections from either side of the cell/resistor to the Y input, there was often careless and untidy drawing of the connecting lines for which credit could not always be awarded. Candidates should be encouraged to use a sharp pencil and ruler and pay attention to accuracy. Many attempts were spoiled by joining the connecting lines from across the cell to the X and Y-shift terminals.

(c)

(i) Most candidates found difficulty relating the given grid back to the initial diagram of the c.r.o. Only the more able candidates spotted that the Y-gain setting of the c.r.o. was 2 V/cm, and hence 1 cm on the vertical axis of the given c.r.o. grid represented 2 V.

(ii) Only a minority of candidates were able to deduce the voltage of the cell from the information supplied. It was evident from the answers given that many candidates had very little practice of either using a c.r.o. or observing these simple measurements being demonstrated; candidates would benefit greatly from laboratory experience in this area.

(d)

(i) A majority of candidates thought incorrectly that the spot/dot would return to the centre of the screen. All that was required of candidates was to state that the dot would move down. The more able candidates stated that the dot would move down as far below the centre as it was initially above.

(ii) Again, only the more able candidates realised that the dot would move horizontally across the screen, or that a straight line would be observed. Many candidates stated incorrectly that a wave would be displayed on the c.r.o. screen.

Question 4

(a) Almost all candidates were able to make a good attempt at this question. The normal and the angle of incidence were usually marked correctly. The correct angle was usually chosen for the angle of incidence, and its value was usually measured correctly to within ±1°.

(b) Candidates answered this part well and usually followed the instructions given to obtain a reasonable diagram indicating the correct refraction of a ray of light through a parallel sided glass block.

(c) The angle of refraction was usually correctly selected, and its value measured correctly within the allowed tolerance.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- Units are important in practical work. Candidates should be encouraged to ensure that all answers are written with units, except where quantities are dimensionless and this has been carefully considered. It may be useful for candidates to do a final check of the paper to ensure that units are all included where they are needed.

- Candidates should be encouraged to give sufficient significant figures in numerical answers. This may at times require an answer of 1.0 in preference to simply 1 as this shows the precision of the final answer.

- When drawing lines of best fit, candidates should be encouraged to consider the position of all points. Simply joining the first and last points on the line does not usually give the line of best fit.

- Candidates can increase the accuracy of their straight lines on diagrams by using a sharp pencil and a ruler.

General Comments

The majority of candidates were able to show a good understanding of the practical situations used in this paper and had seen or performed the experiments.

The numerical work was generally well done, with only a few candidates missing units and giving incorrect significant figures.

The graph work is generally very good with candidates producing neat and accurate graphs. Care and attention to detail is still required by some.

Expressing ideas clearly is still a challenge for many candidates, especially when describing experimental detail or sources of error in experiments. Practice at previous questions will give candidates experience of the type and style of questions in a variety of experimental scenarios.

In **Question 1**, units were expected in **(b)(i), (b)(ii)** and **(c)(iii)**. A surprising number omitted the unit in just one of these. Candidates should be encouraged to go back and check all numerical answers and units after completing each question.

In graph work, care and attention to detail is important. In **Question 2**, many candidates did not use the values given on the graph for the start of their scales.

Some candidates gave a list of possible answers to some questions. This often results in credit not being awarded; Examiners do not award a correct answer amongst a set of contradictory incorrect responses. Candidates should be encouraged to give only one detailed response in a one mark answer. This was particularly noticeable in **Question 2**, parts **(a)(ii)** to **(iv)** and **(b)**.

Overall the standard of candidate responses is high and candidates are showing more ability to answer the questions in the context of the practical situation given, rather than a reliance on stock answers which are not relevant to that situation.

Comments on Specific Questions

Question 1

(a)

(i) The majority of candidates gained credit, although the wording was often ambiguous. Stronger candidates clearly described moving the lens towards or away from the screen or object. Credit was awarded for simply stating 'move the lens', but moving the object or screen did not gain credit as this would alter *D.* Weaker candidates gave a variety of unacceptable responses, including 'use a different thickness lens', 'turn lens round' and 'use a brighter object'

(ii) Although the majority of candidates understood the question, many did not gain credit as they moved the apparatus in the wrong direction, i.e. lens up or object down. Some candidates gave contradicting alternatives here, and could not be awarded credit. Candidates should be encouraged to only give one response.

Weak candidates often gave responses such as moving the lens towards the screen, showing a lack of understanding of the apparatus.

(iii) This question was poorly understood and few candidates gained credit here. Most candidates did not relate the question to the experiment and apparatus and gave answers concerning the geometrical centre of the lens using tangents or the centre of mass of the block. In the context of the question, the required answer was about locating the position of the centre of the lens on the ruler.

(b)

(i) The calculation of the distance *d* was correctly evaluated from $u_2 - u_1$ by most candidates. The most common error was to omit the unit.

(ii) The calculation of *f* was correctly evaluated by most candidates. Weaker candidates forgot to square the values after substituting correctly into the equation. Other errors included giving the answer to one significant figure and incorrect rounding.

(c)

(i) The graph was generally well completed with candidates showing good graph skills. Very few did not label the axes correctly, although some omitted the unit m^2 on the *y*-axis.

The scales caused some problems with many being confused by starting the vertical axis from $D = 0.9$ m. A common mistake was to label the major grid lines 1.8, 2.8, 3.8 etc. which does not give a linear scale from 0.9. These candidates then often plotted the points correctly on their scale.

A few candidates drew large blobs for the points. Neat crosses are the preferred method of marking points.

The main error occurred in drawing a best fit line. A significant number of candidates joined the first and last points. This is not a best-fit line in this graph as all the intermediate points then lie above the line.

(ii) Candidates were required to show their working to gain full credit here. This entailed using at least half the graph line either drawn as a triangle on the graph or clearly in a calculation. Many candidates incorrectly used two consecutive points from the table to calculate the gradient. However, many gained partial credit for obtaining an answer within the limits given in the mark scheme. In this instance, credit was awarded for the response '1', although it should be noted that one significant figure does not show the correct precision for the answer and 1.0 is preferred.

(iii) Most candidates were able to divide their answer to **(ii)** by 4 correctly. Some candidates left their answer as a fraction and others did not give a unit. Neither of these answers received credit.

(d) This part question was often poorly answered with only the most able candidates appreciating the reason for plotting a graph rather than using a single value to calculate the answer. The majority of responses simply stated 'more accurate' rather than explain why this is the case. Some excellent answers were seen where candidates explained that the gradient gives an average of the results.

Question 2

(a)

(i) Although candidates were expected to use the wire given in the diagram as part of their circuit, credit was given to those candidates who drew a correct complete circuit which did not include this wire. The quality of the circuit diagrams drawn varied considerably. Candidates should be encouraged to use a sharp pencil and ruler and pay attention to accuracy in drawing components. Many gained full credit here, but there was often an incorrect symbol for a variable resistor. Other errors seen included a line through components and additional components which would compromise the circuit such as a voltmeter in series.

(ii) Most candidates realised that increasing the voltage of the supply or decreasing the resistance of the circuit would increase the current. Credit was not awarded for 'changing the resistance'. Many candidates gave answers concerning the magnets' positions or strength which is irrelevant here.

(iii) Many able candidates gave clear and accurate responses about reversing the power supply. Some had difficulty explaining this clearly, with answers such as 'change the position of the cell'. The use of labelling on the diagram should be encouraged. This was well used by some candidates who labelled the + and – terminals of the cell and used this in their explanation. There were a considerable number of candidates who incorrectly suggested using a diode in the circuit or reversing the magnets.

(iv) Most candidates gained credit here. The simple statement of reversing the magnets was acceptable. Many described in detail placing the N-pole in the position of the S-pole and vice versa. Changing the position/direction of the magnets was insufficient for credit. The response 'change the direction of the current' was seen in weaker candidates' responses.

(b) Many candidates appreciated that a large current would cause the wire to become hot. An alternative acceptable response was that it may damage the ammeter. The response 'damage the circuit' was insufficient and not awarded credit. Many candidates added to a correct answer that 'it would cause a short circuit' which is incorrect.

Question 3

(a)

(i) Most candidates appreciated here that the movement of the water would be more visible to the class in a large beaker. Answers simply stating 'more water' or more space' were insufficient. Some candidates confused the experiment with diffusion and any comment about diffusion was not accepted here.

(ii) Many candidates did not read the question carefully enough and stated 'so the crystal has more time to dissolve'. The required answer was so that the water becomes still. This was expressed in a variety of ways by candidates e.g. 'gives the water time to settle' or 'the water stops moving'. The temperature of the water here is irrelevant, so any comments about water temperature were ignored.

(iii) The important word in the question here was 'gently'. Some candidates concentrated on the word 'heated', but without this the experiment will not happen. The key idea required in the answer was that the convection happens 'slowly'. The reverse argument was also accepted. Some candidates thought that this would make it happen more quickly.

(b) The candidates needed to show water moving up from above the crystal and water moving in to replace it. This was not well answered by many candidates with a confusion of arrows both inside and outside the water seen. A common error was to draw the arrows upwards from above the centre of the beaker rather than above the crystal. Some candidates drew bubbles in the water or lines with no direction arrow.

(c) Many candidates appreciated and explained clearly that the water was now purple or that the water was warm.

Question 4

(a) The majority of candidates correctly stated Geiger-Müller Tube. Acceptable alternatives were Geiger counter, GM tube and phonetic spelling was accepted. Some candidates simply used the words on the diagram 'counter detector'. A large range of incorrect answers were given. This was the part question most often left blank.

(b)

(i) Most candidates attempted the average calculation correctly. The most common error here was to give the average count per 2 minutes rather than convert it to counts per second.

(ii) The required response here was that radioactivity is random. Alternative wording was just repeating the stem of the question which tells the candidate that the counts are different. Some candidates thought it was due to experimental error, i.e. teacher reaction time or poor equipment.

(c) Most candidates were able to identify a reason why there was no need for safety precautions in this experiment. The most common correct responses were that there was no specific source present and that the level of radiation was low. Answers such as 'the experiment is not dangerous' were not acceptable.