PHYSICS

Paper 0972/11
Multiple Choice (Core)

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

General comments

Many candidates performed well across the paper and showed a good understanding of the syllabus.

Comments on specific questions

Question 1

Option **D** was the most common incorrect answer. These candidates possibly felt that the reference to something being digital made it more accurate. The fact is that calculators perform calculations accurately, but they cannot correct for poor data being entered into them. The correct technique is to measure many times and divide by the number being measured, as specified in Syllabus Section 1.1.3.

Question 2

Most candidates selected the correct response for this question and showed a secure understanding of the idea of deceleration.

Question 4

A majority of candidates answered correctly. The most popular incorrect option was **B**. This was possibly due to these candidates believing that a weighing device measures mass, whereas, in fact, a spring balance (properly called a newton-meter) measures force, even though it may have a scale expressed in kilograms.

Question 5

Many candidates had a good understanding on the transfer of energy between the kinetic and gravitational potential stores.

Question 9

Many candidates incorrectly thought that geothermal isn't renewable. In the very long term, all sources will vanish (or become irrelevant) when the Earth is swallowed up during the Red Giant phase of the Sun's life cycle. However, in the medium-term geothermal energy comes from the decay of radioisotopes that will outlive the earth and, therefore, will keep providing for as long as we like. On the other hand, fossil fuels (including natural gas, the correct answer) were formed during a finite epoch and will run out quite soon.

Question 10

Many candidates forgot to convert the time into seconds, but all coped with 'k' as a multiplier. Few candidates knew that they needed to both divide energy by time and convert the units.

Question 15

Most candidates were able to answer this question successfully.

Question 25

This question was challenging for many candidates. In the second diagram, the downward force on the balance is reduced, which means that object 2 is attracting object 1 and is, therefore positively charged. To decrease the balance reading yet further we need a bigger difference of charge on the two objects. So we would like object 1 to acquire extra electrons and /or object 2 to lose more electrons, and **D** obviously fulfils this requirement, while **C** (by far the most popular option) has the opposite effect. Options **A** and **B** are not so easy to deal with without some mathematics, but it is reasonably easy to see that if sufficient electrons are added or removed, one or other of the objects will have its charge reduced to zero, and there will then be no reduction of the balance reading at all.

Question 29

Many candidates found this question on electricity quite challenging. Many treated the resistors as if they were in series, and just summed the values. Stronger candidates usually answered correctly.

Question 31

The most popular option here was **B**, indicating that candidates thought of electromagnetic induction exclusively in terms of conductors and fields being in relative motion, and ignored the approach that focuses on a change in the magnetic flux linkage, as specified in section 4.5.1.1 of the syllabus, that is exemplified in diagram Q.

Question 38

Some weaker candidates did not know the order of the planets.

PHYSICS

Paper 0972/21
Multiple Choice (Extended)

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

General comments

Many candidates performed well across the paper and showed a good understanding of the syllabus.

Comments on specific questions

Question 2

Almost all candidates knew what deceleration is and were able to identify option **D** as the correct response.

Question 5

More candidates selected option **D** than the correct answer here. The parachutist is descending at terminal, that is, constant speed. Thus, the acceleration is zero, which means that the resultant force must be zero as well. On the other hand the velocity of the aircraft in option **B** is continually changing (because its direction is changing even though its magnitude remains the same), and so the aircraft is accelerating. This means that it must have a resultant force on it, known as a centripetal force.

Question 6

Some candidates answered this correctly. Hardly any candidates chose option **D**, indicating that candidates had a good understanding of the graphical representation of the magnitude of a vector.

Question 10

Many stronger candidates chose the correct answer.

Question 13

Most candidates chose option **B**. In this question, the gas gets hotter, so its molecules move more quickly. Each molecule therefore has more momentum when it strikes the piston, so the change of momentum at each collision is increased. But the pressure at the piston has not changed, and the area of the piston has not changed, so the overall force exerted on the piston has not changed either, which means that the total momentum change per unit time has not changed. If the momentum change delivered by each collision has increased, there must be fewer of them each second, so the frequency decreases (Option **A**).

Question 19

Syllabus Section 3.2.3.6 specifies that candidates should be able to complete such ray diagrams, so a good strategy would have been to sketch the other rays onto the question paper and notice that since both of the rays added point down and to the right, option **A** is the only possible option.

Question 23

Stronger candidates answered this correctly while weaker candidates often chose choose **A**.

Question 25

This question related to Syllabus Section 4.2.1.9 but only the strongest candidates answered this correctly.

Question 26

Nearly all candidates got this question right.

Question 28

Only stronger candidates knew which way the electrons move.

Question 36

In this question, candidates needed to recognise that while they may be used to determining half-lives from a decay curve, here they had to realise that the atoms present are all either of nuclide X or of nuclide Y and the total number of atoms remains constant. Therefore, the graph for the mass of X against time is an upside-down version of the graph given. The result then follows.

Question 37

Only stronger candidates were aware that the absorption of a neutron triggers fission.

PHYSICS

Paper 0972/31
Theory (Core)

Key messages

Some candidates were unclear about what does or does not count as a significant figure. Centres should encourage candidates not to round to 1 significant figure and should set practice exercises on this.

Some of the candidates' handwriting made it difficult to distinguish what they were writing. There were clear issues differentiating between 1's and 7's, 4's and 7's, 6's and 0's, 9's and 0's, 9's and 4's, 7's and 9's. Centres should encourage candidates to ensure that working and answers to numerical questions are as clear as possible.

General comments

The majority of candidates were well prepared for this exam. The majority were able to apply their knowledge and physics understanding to the questions set and produced many correct responses.

Candidates should ensure that they make it clear in their answers what they are referring to. On some occasions it was unclear what the pronouns 'it' or 'they' were referencing. Similarly, candidates frequently stated a property had changed but failed to state how it had changed i.e. increased/decreased. Candidates should be encouraged to use more precise language.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly determined the distance travelled in the first 100 seconds.

(ii) Most candidates correctly determined the speed during the first 100 seconds on the speed-time graph. The most common error was to substitute incorrect values from the graph.

(iii) Candidates found this item challenging and only the strongest candidates gained full credit. The most common error was to confuse this distance-time graph with a speed-time graph.

(b) The majority of candidates answered this correctly. The most common error was to give an incorrect or insufficient direction, e.g. forward.

Question 2

(a) The vast majority of candidates gained full credit for an answer of 7.7 g / cm^3. The most common error was to give an incorrect or no unit. Another common error was to recall an incorrect rearrangement of the equation for density.

(b) Candidates found this item challenging. Many candidates did not identify the correct name i.e. air resistance or drag, for the upward force. The most common errors were to call the force upward force or even gravity. Some candidates did not realise that at constant speed the upward force was equal in magnitude to the downward force or weight.

(c) Weaker candidates struggled to recall and apply the principle of moments to the balanced beam. The most common error was to try to use some form of W = mg to find the weight of the block. Stronger candidates correctly evaluated the moments equation to give an answer of 2.3 (N).

Question 3

(a) The simple kinetic particle model of matter was well understood by most candidates, and they usually scored full credit.

(b) Candidates were usually able to apply their knowledge of the simple kinetic particle model of matter to the particles in a solid.

(c) (i) Candidates found this item challenging. Many candidates did not identify the correct name for the process of thermal energy transfer through the metal pan as conduction. Common errors included simply stating heat energy, heating or radiation.

(ii) Many candidates did not give a clear description of convection in the water in the pan.

(iii) The majority of candidates answered this correctly. The most common error was to give an incorrect value in kelvin.

Question 4

(a) (i) Not all candidates read the height of the wave as 15 (cm) from the displacement-time graph. The most common error was 30 cm but many candidates gave 5 as their answer, possibly the number of peaks and troughs on the diagram.

(ii) Only stronger candidates could use their understanding of frequency to determine the number of complete waves sent out in one second as 0.5 from the displacement-time graph.

(b) Only stronger candidates gained credit here by identifying diffraction.

(c) (i) Only stronger candidates gained credit here by identifying refraction.

(ii) Despite the wording of the question, many candidates gave an answer of ‘direction changes’.

Question 5

(a) The majority of candidates gained full credit for correctly identifying microwaves and X-rays as the missing regions of the electromagnetic spectrum. Weaker candidates could either not recall the names of the regions or simply repeated some of the regions already on the chart,

(b) The majority of candidates gained at least partial credit here. A common error was to confuse the uses of infrared and ultraviolet radiation. Weaker candidates gave uses such as ‘medicine’ that were too vague for credit.

(c) The majority of candidates scored at least partial credit. A common error was to confuse the harmful effects of infrared and ultraviolet radiation.

Question 6

(a) The majority of candidates stated that the wind turned the turbine, the turbine turned the generator and this generated electricity to score partial credit. Only stronger candidates identified the KE of the wind as the source of energy for the turbine. Weaker candidates believed that the generation of electricity always involves the heating of water to form steam which drives a turbine and consequently, a generator.

(b) The majority of candidates were able to correctly recall the equation power = V   I and then to rearrange and evaluate the output voltage as 1200 (V). The most common error was to either multiply power and current or to divide the current by the power to give an answer of 0.83.

(c) Only stronger candidates were able to give two advantages of transmitting electrical power at high voltages.

Question 7

(a) Many candidates were unable to identify the distance from the centre of a lens to one of its principal foci as being the focal length of the lens.

(b) A number of candidates were unable to identify the distance from the principal axis to the point where rays from an object converge to as being the image of the object formed by the lens.

(c) Only stronger candidates gave three correct characteristics of the image formed by the converging lens. Generally, ray diagrams for thin lenses were not well understood by candidates.

Question 8

(a) Only stronger candidates answered this correctly. Many other candidates thought the question was about electromagnetic induction and so gained no credit. Stronger candidates gave a clear description of a sensible method for plotting the shape and direction of the magnetic field, giving sufficient detail for someone to be able to follow.

(b) Many candidates showed little understanding of electromagnetic induction and gained no credit here. Some gained partial credit for ‘magnetic field produced by coil P’ but did not link this to an induced current in coil Q.

Question 9

(a) (i) Only stronger candidates were able to describe the use of the variable resistor to change/control the current in the circuit/heater or to change/control p.d. across the heater. The most common error was to simply paraphrase the question and state that a variable resistor is used to change resistance.

(ii) The majority of candidates gained credit here by determining the number of cells required as 4. The most common error was to multiply the battery voltage and cell e.m.f. to give an answer of 9.

(iii) Only stronger candidates answered this correctly and many candidates did not give an answer.

(b) Many candidates did not recall that the energy, E, transferred by an electric current is calculated using E = I t V. The most common errors were to find the product of I and t or V and t or to have (I V) / t.

Question 10

(a) (i) Very few candidates answered this correctly. The most common error was to give the nucleon number as 136.

(ii) Many candidates answered correctly but others thought that the number of electrons was the difference between the nucleon number and the proton number.

(b) The most common error was in calculating the mass remaining after two half-lives. Many candidates thought that after 2 half-lives the mass remaining should be zero.

Question 11

(a) Many candidates gained partial credit but others could not identify the Moon and inner planets of our solar system.

(b) Many candidates gained partial credit for this question but others showed that they did not have a secure understanding of this section of the syllabus.

(c) Very few candidates could recall that the diameter of the Milky Way galaxy was of the order of 100 000 light-years.

PHYSICS

Paper 0972/41
Theory (Extended)

Key messages

Candidates should ensure they read questions carefully and that they answer the question being asked exactly. The number of marks allocated to a question gives an indication of the detail required in an answer.

Stating any formulae used before performing a calculation helps ensure that partial credit is available if, due to some arithmetic error, the final answer is incorrect. Final answer marks for calculations are only awarded for correct numerical answers with the correct unit. Where either the numerical value is incorrect or the unit is missing or incorrect, marks will only be awarded for working shown by candidates.

When asked to 'show that' a quantity has a particular value, candidates must demonstrate that they know the formula they are applying. They should be advised to write down the formula in words or symbols. Manipulation of numbers given in the question to achieve the correct numerical answer is insufficient to demonstrate understanding of the physics in the situation. This applied in **Question 1(b)(ii)** and **Question 3(b)(i)**.

General comments

Many candidates had prepared well for this examination demonstrating a good understanding across a range of topics within the physics syllabus. The one exception to this was **Question 10** where a number of candidates made no attempt at multiple parts of this question suggesting a lack of familiarity with this new area of the syllabus.

Candidates generally demonstrated a good understanding of quantitative skills with questions involving calculations. However, some weakness in working with numbers in standard form was apparent in **Question 10(c)(i)** and **Question 10(c)(ii)**.

Candidates are expected to give numerical answers to two significant figures unless instructed otherwise and almost all candidates did this throughout the paper. Candidates must also include the correct unit with any numerical final answer. In **Question 1(a)** and **Question 1(b)(i)** the unit was sometimes missing and in **Question 8(a)** and **Question 10(c)(i)** the unit was often missing.

When writing down formulae candidates are expected to use the symbols for physical quantities given in the syllabus. Any alternative symbol will only gain credit if it is clearly (and correctly) defined. This applied particularly in **Question 1(b)(ii)** and **Question 3(b)(i)** where candidates were asked to show that a quantity had a given value.

When candidates wish to alter their answer, they should cross out the response they do not wish to be considered and write their new answer down clearly (if necessary, using spare blank space in the answer booklet or a continuation sheet and identifying the question number they are answering).

Comments on specific questions

Question 1

(a) Stronger candidate correctly recalled the formula for gravitational potential energy, substituted numerical values and gave the answer with the correct unit. Some weaker candidates omitted g (acceleration of free fall) from their equation while others gave an incorrect unit or omitted the unit from their answer**.**

(b) (i) Most candidates remembered the formula for kinetic energy correctly. When substituting values into the equation, a significant number of candidates did not square the velocity and others calculated the difference in the velocities before substituting. Weaker candidates either omitted the unit, gave an incorrect unit or were unable to recall the correct formula.

(ii) Candidates who understood that velocity, and therefore change in momentum, is a vector quantity gained full credit. They needed to write down the equation they were using and to show the correct change of momentum by identifying one of the velocities as negative with respect to the other (positive) velocity. Some candidates took short cuts and did not show that the velocities were in different directions. Most candidates obtained partial credit for correctly calculating the modulus of the momentum before and after the ball bounced. Some weaker candidates realised that the required answer was the sum of the modulus of the momentum values and rewrote the formula for change in momentum to fit. A few weaker candidates subtracted their KE in **(i)** from their GPE in **(a)**.

(iii) The strongest candidates recognised that change in momentum = force × time, used the value for change in momentum given in **(ii)** and so calculated the correct answer. Most candidates attempted to answer this question by using F =ma and a = $\Delta v / \Delta t$. A common error with this method was to recalculate the change in velocity without accounting for the change in direction and so to give an answer of 1.6 N. Partial credit was awarded with both formulae in this method, but no credit was given for just the equation F = ma.

Question 2

(a) Most candidates understood that copper contains delocalised electrons, but only stronger candidates were able to describe their role in conduction. Stronger answer to this question included a reference to the electrons gaining energy from particles, moving through the metal and transferring the energy to distant particles. Some candidates wrote about transfer of energy via particle vibrations suggesting that either they had not read the question carefully or that they misunderstood what lattice vibrations are. A few weaker candidates attempted descriptions of radiation or convection rather than another way that thermal energy is conducted.

(b) In this question, candidates were asked to select the particular property of shiny surfaces relevant when using a pan to heat food. They needed to recognise that avoiding the loss of thermal energy was the desired advantage and the relevant property of a shiny metal was that they are poor emitters of radiation. A reference to shiny surfaces being poor emitters, without mentioning radiation (or equivalent) did not gain credit. Many candidates mentioned shiny surfaces being poor absorbers of radiation or good reflectors of radiation, which was not relevant to this question.

(c) Many candidates correctly identified convection as the main method of thermal energy transfer through water.

Question 3

(a) Most candidates were able to state that the particles in liquids are close together or the equivalent. A completely correct answer required the additional statement that repulsive forces between particles in liquids are large. Some candidates wrote down general statements about the properties of particles in a liquid, such as that particles slide over each other, without applying the statement to the question asked.

(b) (i) Showing that the pressure due to the water at the base of the block is approximately 850 Pa required more than manipulating the numbers given in the question to calculate 852. Most candidates were able to recall the formula for calculating the pressure in a liquid before substituting the values correctly to gain full credit. Candidates using symbols other than those given in the syllabus should define them clearly. A few candidates worked from first principles, using the equations p = F / A and **ρ** = m / V with varying degrees of success.

(ii) This was answered well with most candidates able to recall the equation p = F / A, and many able to rearrange it correctly and give the correct unit.

(iii) There were many good answers here with candidates correctly applying the equation m = W / g. Weaker candidates recalled the equation incorrectly or were confused about whether they were finding the mass or weight. Some candidates calculated the value correctly but then gave the unit as g instead of kg.

Question 4

(a) (i) Few candidates gave a precise enough answer to this question. Many referred to gravity rather than weight or the force of gravity. Weaker candidates referred to the centre of gravity as being the point where most of the weight acts or the point at which the object balances. Although correct statements about the centre of mass were credited, it should be noted that the syllabus now requires understanding of the centre of gravity as distinct from centre of mass.

(ii) Only stronger candidates gave the expected answer relating the idea that a small tilt or rotation makes G no longer vertically above the base or that a small tilt or rotation produces a moment. Some candidates gained credit by stating that both the centre of gravity was high and the base area was small. Weaker answers only referred to either the position of the centre of gravity or the area of the base. The weakest candidates were unable to answer the question and just tried to explain the role of the wires in holding up the transmitter or described some detrimental effect on the transmission of radio waves.

(b) (i) Few candidates correctly identified T as pointing in the direction of the wire and towards the ground. Many candidates showed T pointing towards the point of contact between the supporting wire and the transmitter and at right angles to the transmitter or along the wire and away from the ground.

(ii) Many candidates correctly stated that moment = force × perpendicular distance from pivot. Some omitted the word perpendicular, and others said it was the distance to the centre of gravity or another location other than the pivot. Very few managed to draw the correct perpendicular distance, either not attempting to draw it or expecting the force to be perpendicular to the transmitter.

(c) There were many correct answers with the most common being the use of (mobile) phones, Some candidates gave answers that were too vague, e.g. “communication” and others confused radio waves with sound waves and referred to sonar. Weaker candidates often just repeated the example given in the question.

Question 5

(a) Candidates were able to gain full credit here for a description of hydroelectric, tidal or wave energy being used to generate electricity. Most candidates recognised that the energy in water is used to turn a turbine. Some candidates confused tidal and wave energy giving an answer that was a mixture of the two methods of electricity generation. Weaker candidates sometimes described electricity generation from energy stored in fuels which heat water rather than energy stored in the water being the source.

(b) Candidates needed to be specific in answering this question. Low running costs are an advantage of hydroelectric power and high building costs are a disadvantage. A vague reference to cost did not gain credit as either an advantage or disadvantage. The most common advantage given was that it is renewable. Common disadvantages related to the availability of water or suitable locations for a power plant or the high cost of building dams.

(c) Many candidates gained full credit here. Others recalled one method for which the main source of energy is not the Sun.

Question 6

(a) (i) Most candidates were able to locate the image. Most often a ray was drawn from the top of the object, through the centre of the lens and then a second ray from the top of the object, parallel to the principal axis to the lens and then refracted through F. These rays were then extrapolated back to locate the top of the image at their intersection. Some candidates refracted rays at the lens to some random point along the principal axis (instead of F), while others bent their extrapolated rays (sometimes to force the image to be at F). The weakest candidates were not able to construct two correct rays and either formed a real image or did not manage to form an image at all.

(ii) Candidates scored partial credit for an accurate image with careful drawing of rays using a ruler, sharp pencil and refracting rays at the centre of the lens. To gain full credit, candidates needed to convert the scaled distance from **Fig. 6.1** to the actual distance from the lens. Few candidates managed to do this. Often rays were drawn with insufficient care to get an accurately positioned image. Weaker candidates were confused by the scale diagram and often scaled up the actual distance from the lens.

(b) Most candidates who identified a virtual image also provided a suitable explanation. The most common explanation was that it cannot be projected on a screen. Weaker candidates were unable to explain why it was virtual or they thought it was a real image.

(c) Stronger candidates stated that a converging lens would reduce the (overall) focal length of the eye and cause rays to intersect (or a focussed image) on the retina, rather than behind it. A significant number of candidates referred to magnification of the object rather than a focussed image. Some referred to rays reaching the retina rather than meeting there. Weaker candidates did not correctly interpret long-sightedness as meaning that distant objects are in focus but closer ones are not.

Question 7

(a) Most candidates stated that electrons (or negative charges) moved from the cloth to the rod, gaining full credit. Some candidates incorrectly suggested that the cloth had a net negative charge at the start. Weaker candidates incorrectly stated that positive charges move.

(b) (i) Only the strongest candidates clearly expressed that an electric field is a region where a charged particle experiences a force. A common insufficient answer was to describe it as an area around a charged particle where a force is felt, without stating that it is a charged particle that experiences the force.

(ii) Stronger answers had straight, radial lines, drawn with a ruler, evenly spaced around the sphere, touching the sphere (but not extending inside) and with arrows pointing inwards. Common errors included very unevenly spaced lines or lines which did not reach the sphere. Weaker candidates drew curved lines or circles around the sphere and a few candidates had arrows pointing away from the centre of the sphere.

(c) Only stronger candidates drew an arrow along a radial line from the centre of the sphere, through Z and pointing away from the sphere. The two most common errors were to draw an arrow pointing towards the centre of the sphere or to draw the force as a horizontal line from Z.

Question 8

(a) (i) Most candidates recalled the equation Q = It, correctly substituted the numbers and correctly gave the unit as Coulombs. Some candidates gave an incorrect unit or omitted the unit in their answer. Candidates who did not calculate the correct value could still gain some credit for writing the formula in words or symbols. However, an equation written with units (instead of words or symbols) was not given credit. Weaker candidates tried to use an incorrect equation, such as *E=Vit*.

(ii) Most candidates realised that they needed to use the equation V = IR and so gained at least partial credit. Many of them correctly calculated that the total resistance of the circuit was 6.0 Ω. Candidates who scored full credit realised that the resistance of P had to be subtracted from this total resistance to get the resistance of the clay cylinder.

(b) Many candidates were able to apply their knowledge of the relationship between resistance and length, and resistance and area, to calculate the resistance of the new cylinder of clay as 4 times the value calculated in **(a)(ii)**. Only the strongest candidates realised that this was not the resistance of the complete circuit and others were unable to calculate the new value of current to use with Q = It to find the time for the charge to flow through the circuit. Many weaker candidates made no attempt at this question.

Question 9

(a) (i) Many candidates misjudged the specificity of this question. They were asked to state how the composition of a nucleus of americium-241 differs from the composition of a nucleus of americium-242. Stating that it contains a different number of neutrons was insufficient to gain credit. This question required the clear statement that americium has one less neutron in its nucleus (or americium-242 has one more neutron).

(ii) Stronger candidates recognised that both the number of protons and the number of neutrons would be different. Candidates who stated, for example, that there will be more protons, were given full credit only if they stated that there will be fewer neutrons. Weaker candidates often mentioned changes to the number of electrons or tried to suggest different properties of the elements and therefore did not answer the question.

(b) (i) Most candidates were able to complete the nuclide equation for the decay of americium-241 with emission of an alpha particle correctly and gained full credit.

(ii) Many candidates recognised that being less penetrative, slower or more massive contributed to greater ionisation and these were all creditworthy ways of expressing the syllabus statement linking greater ionisation to greater kinetic energy. Few candidates made a clear statement that alpha particles have a greater magnitude of charge than beta particles.

(iii) Candidates needed to read the information given carefully. The neptunium with the long half-life is a waste product which, when it decays, will produce a more harmful radiation. Therefore, the advantage of this long half-life is that there will be very few emissions per unit time or a low initial activity and this means an old smoke detector is less of a hazard either to human health or for safe disposal. Most candidates misread the question and thought the long half-life would mean the smoke detector lasts a long time. Weaker candidates were also likely to incorrectly state that a long half-life meant that the neptunium would not emit radiation for a long time or that the long half-life meant that there will be few emissions, without making any reference to a time period.

Question 10

(a) Stronger candidates described how hydrogen nuclei fuse to produce helium nuclei in the core of a stable star. Candidates gained credit for mentioning that nuclear fusion occurs. However, spelling of this technical term was critical to be sure that candidates did not mean fission. Therefore, fussion was not an acceptable spelling. Weaker candidates often described atoms fusing instead of nuclei. Some candidates misread the question and described the evolution of a star through its different stages which did not answer the question.

(b) (i) Many candidates were able to gain credit here recognising that the observed light has an increased wavelength. Those that did not give the precise difference often gained partial credit for recognising that the light was shifted towards the red end of the spectrum. A common error was to describe the difference in terms of brightness of the light.

(ii) Only the strongest candidates stated that the quantity used to determine the speed at which the galaxy is receding is the change in wavelength and this was most often expressed as the redshift. A variety of incorrect responses included, light year, Hubble constant and 3×10^8 m / s.

(c) (i) Many candidates gained full credit here, recalling the equation $H_0 = v / d$ and rearranging and substituting the values to give the correct distance. A common error was to omit the unit in the answer. Some candidates made errors in handling indices leading to a power of ten error in the final answer. Most candidates attempted this question, even those who omitted all the other parts of **Question 10**.

(ii) The strongest candidates used the formula approximate age of universe = $1 / H_0$ and converted their answer in seconds into years to gain full credit. A few candidates also gained full credit with a correct answer with no working shown, suggesting recall of a learned fact. Weaker candidates often gave the answer in seconds without conversion to years.

PHYSICS

Paper 0972/51
Practical Test

Key messages

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

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:
- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- handling practical apparatus and making accurate measurements
- choosing the most suitable apparatus.

It is assumed that, as far as possible, the IGCSE course will be taught so that candidates undertake regular practical work as an integral part of their study of physics. Questions on experimental techniques were answered much more effectively by candidates who showed evidence of regular experience of similar practical work.

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 candidates.

Comments on specific questions

Question 1

(a) Most candidates recorded realistic *a* and *b* values and gave them to the nearest mm.

(b) Most candidates labelled the graph axes correctly and drew them the right way round. Some candidates chose a scale that resulted in the plots occupying too small a proportion of the graph grid. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting is clear. Most candidates obtained a realistic set of readings that resulted in plots producing a good straight line. However, some candidates drew a line that did not match the plots or a series of straight lines joining each plot to the next.

(c) Most candidates drew a clear triangle on the graph to show how to obtain the gradient information. A more accurate result was obtained by drawing a large triangle but a significant number of candidates drew a small triangle.

(d) Candidates were expected to correctly calculate 2G and include the unit, N.

(e) Here candidates were expected to comment on their experience of doing the experiment. The most obvious response was that it was difficult to obtain exact balance (due to the instability of the arrangement) but other relevant comments were also given credit.

Question 2

(a) Most candidates recorded a realistic current with the unit, A and a set of increasing potential differences. The calculations of resistance R and the ratio R / l were completed successfully by many candidates. The units for length, cm, potential difference, V and resistance, Ω were given correctly by most candidates but a significant number appeared to have missed the instruction to complete the column headings. Candidates were expected to deduce the unit for R / l from the units given for R and l.

(b) Candidates were expected to write a conclusion that matched the results. For a correctly worked experiment, the resistance increases with length. The justification needed to include results quoted from the table.

(c) Candidates were expected to obtain a value for R_2 that was double the resistance at length 100cm, within ± 10 per cent. This could be deduced in a variety of ways and all suitable methods of working were given credit.

Question 3

(a) Most candidates obtained a value for h_O within the acceptable range and the majority of these included the appropriate unit (cm or mm).

(b) In the table, candidates were expected to record two values for v with the second value smaller than the first value. Most candidates achieved this. Correct values for the magnification m were obtained by many candidates. The two values of image height h_I should both have been greater than h_O.. A significant number of candidates did not achieve this which was probably due to not moving the screen to the position giving the most clearly focused image. Candidates who carried out the experiment with care and accuracy accurately obtained values of h_I/h_O equal to m within ± 10 per cent.

(c) (i) Here candidates were expected to write a statement matching their results and to justify the statement by quoting the appropriate results from the table.

(ii) Candidates were expected to state that extra results were required. Some answers were too vague. Candidates were required to make it clear that different readings are required, not the same value for u repeated several times.

A few candidates gained full credit for stating that at least five different readings should be used.

Question 4

Candidates who followed the guidance in the question were able to write concisely and addressed all the necessary points. Some candidates copied the list of apparatus and other information given in the question. This was unnecessary and often introduced a vague explanation of the investigation.

A concise explanation of the method was required. Candidates needed to concentrate on the readings taken and the essentials of the investigation. It may have benefitted candidates to plan their table of readings before writing the method to help them to consider the measurements that needed to be taken in order to address the subject of the investigation.

Many candidates stated that a stopwatch was required for the investigation. Candidates needed to refer to measuring the time taken for all the water to evaporate whilst being heated. Then candidates needed to explain that the process should be repeated with either different volumes of water or different distances between the heater and the water surface. A vague reference to repeats was not sufficient as it was not clear whether the candidate was referring to using different volumes or heights or repeating the measurements with the same volume or height.

Some candidates assumed that a cooling experiment with temperatures recorded at fixed time intervals was required with many of these not continuing until all the water had evaporated. Although this was the wrong investigation, credit was awarded where possible for relevant answers, for example, for the control of variables.

Candidates needed to specify a variable to keep constant – either the height of the heater or volume of water depending which of those was chosen in the method. Credit was also given for a second possible variable to keep constant. Room temperature, surface area of the water, avoidance of draughts were among the relevant suggestions.

Many candidates drew a suitable table. They were expected to include columns for time and their chosen variable with appropriate units.

Candidates were expected to explain how to reach a conclusion by drawing a graph of the chosen variable against time or by comparing the values from the table. The question did not ask for a prediction. Some candidates wrote a prediction but no explanation of how to reach a conclusion.

PHYSICS

Paper 0972/61
Alternative to Practical

Key messages

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

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:
- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- handling practical apparatus and making accurate measurements
- choosing the most suitable apparatus.

It is assumed that, as far as possible, the IGCSE course will be taught so that candidates undertake regular practical work as an integral part of their study of physics. Questions on experimental techniques were answered much more effectively by candidates who showed evidence of regular experience of similar practical work.

Some candidates appeared to have learned sections from the mark schemes of past papers and produced responses that were not appropriate to the questions in this question paper.

The practical nature of the examination should be considered when explanations, justifications or suggested changes are required, for example in **Questions 1(e)**, **1(f)**, and **3(c)(i)** and **(ii)**.

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.

Comments on specific questions

Question 1

(a) Most candidates recorded *a* correctly.

(b) Most candidates labelled the graph axes correctly and drew them the right way round. Some candidates chose a scale that resulted in the plots occupying too small a proportion of the graph grid. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting is clear. Most candidates obtained a realistic set of readings that resulted in plots producing a good straight line. However, some candidates drew a line that did not match the plots or a series of straight lines joining each plot to the next.

(c) Most candidates drew a clear triangle on the graph to show how to obtain the gradient information. A more accurate result was obtained by drawing a large triangle, but a significant number of candidates drew a small triangle.

(d) Candidates were expected to correctly calculate $2G$ and include the unit, N. Candidates who had plotted the graph with care and accuracy obtained a value within the tolerance allowed.

(e) Here candidates were expected to comment on their experience of doing similar experiments during their course of study. The most obvious response was that it was difficult to obtain exact balance (due to the instability of the arrangement) but other relevant comments were also given credit.

(f) Candidates were expected to write about balancing the rule (with no loads) on the pivot and the balance point indicating the centre of mass.

Question 2

(a) Most candidates recorded the current and potential difference correctly. The calculations of resistance R and the ratio R / l were completed successfully by many candidates. The units for length, cm, potential difference, V and resistance, Ω were given correctly by most candidates but a significant number appeared to have missed the instruction to complete the column headings. Candidates were expected to deduce the unit for R / l from the units given for R and l.

(b) Candidates were expected to write a conclusion that matched the results. For correctly worked results, the resistance increases with length. The justification needed to include results quoted from the table.

(c) Candidates were expected to obtain a value for R_2. This could be deduced in a variety of ways and all suitable methods of working were given credit. The answer was expected to be quoted to one or two significant figures as the question asked for an estimate.

Question 3

(a) Most candidates obtained a value for h_O within the acceptable range and the majority of these answers included the appropriate unit (cm or mm). Some candidates appeared to have measured the height of the illuminated object on **Fig. 3.1** instead of on **Fig. 3.2** as requested.

(b) Most candidates measured u correctly**.** Many candidates deduced the value of V correctly, but some did not include their working. In the table, the correct value for the magnification m was obtained by many candidates. The value of h_I / h_O needed to be given to two significant figures.

(c) (i) Here candidates were expected to write a statement matching the results and to justify the statement by quoting the appropriate results from the table.

(ii) Candidates were expected to state that extra results are required. Some answers were too vague. Candidates were required to make it clear that different readings are required not the same value for u repeated several times. Only a few candidates went on to state that at least five different readings should be used.

Question 4

Candidates who followed the guidance in the question were able to write concisely and addressed all the necessary points. Some candidates copied the list of apparatus and other information given in the question. This was unnecessary and often introduced a vague explanation of the investigation.

A concise explanation of the method was required. Candidates needed to concentrate on the readings to be taken and the essentials of the investigation. It may have benefitted candidates to plan their table of readings before writing the method to help them to consider the measurements that needed to be taken to address the subject of the investigation.

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