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1997 HIGHER SCHOOL CERTIFICATE
EXAMINATION REPORT
PHYSICS

In 1997, 9149 candidates presented for the 2 Unit Physics examination at the Higher School Certificate; this was almost identical with the number of candidates presenting in 1996.

General Comments

Based on the number of non-attempts and the standard of answers from various centres, candidates found this year's paper more difficult than that of the previous year. It was often the context of the questions that confused candidates and resulted in their not being able to apply their knowledge of Physics in such a way as to score marks.

The following weaknesses were noted:

- Candidates had difficulty in clearly expressing explanations and descriptions.
- Many failed to bring a protractor into the examination and lacked experience in drawing vector diagrams to scale.
- While candidates were able to draw graphs satisfactorily, they had problems in relating the relationship shown in the graph to an equation involving the variables in the graph.
- The candidates were still confused in their use of units, while unit prefixes were often ignored or wrongly converted.
- The algebraic skills of many candidates were very poor and changing the subject of equations often led to errors. Students should be advised to substitute for all quantities before manipulating an equation.

CORE — SECTION I

PART A

The following table gives the percentage of the candidature selecting each alternative for the multiple-choice answers. The correct answer is marked with an asterisk.

Question	A	B	C	D
1	6.32	8.11	51.83*	33.64
2	19.99	59.00*	5.73	15.05
3	1.81	89.85*	4.65	3.45
4	2.11	5.72	81.11*	10.65
5	7.53	10.37	16.27	65.70*
6	16.99	43.71*	34.72	4.38
7	26.72	5.54	16.09	51.47*
8	46.14*	9.49	39.72	4.25
9	6.99	7.09	81.01*	4.67
10	7.14	77.39*	4.07	11.26
11	20.75	23.86	43.54*	11.19
12	40.38*	13.93	30.75	13.82
13	9.63	23.90	15.93	50.25*
14	23.59	19.87	11.17	45.06*
15	42.44*	21.36	26.00	9.87

PART B

Question 16

(a) Candidates had difficulty in drawing a vector diagram using the given scale. The use of realistic velocity magnitudes resulted in one of the vectors having a very small scaled magnitude, while many candidates lacked the skills (and the equipment) to produce an accurate diagram. Candidates must use arrowheads and label their diagrams clearly to avoid losing marks.

(b) Candidates possessed a good knowledge of how to resolve a vector into components. The majority found the easterly component by trigonometry and were not aware that this component could be measured directly from their scaled vector diagram. They had considerable difficulty, however, in deciding which vector should be resolved and many did not interpret the phrase *through the water* as meaning *relative to the water.*

Question 17

(a) The concept of adding 3 vectors to form a closed vector triangle was well understood by the majority (85%%) of candidates, although a small number drew a *situation* diagram showing the three forces acting on the picture.

(b) Candidates had little difficulty in stating that the tension increases when the support wires are shortened but a significant number could not draw a vector diagram showing the increased tension and a decrease in the angle (θ) of the support wires. Changing the magnitude of the weight vector was a common error, causing confusion between the shortening of the wire and the increased length of the tension vector.

Question 18

(a) Many candidates found the question quite difficult as it was of a different character from those set in past years. The arrangement in which one mass slides over the other caused confusion as shown by candidates who were unable to find the net force on one of the masses, even though its acceleration and mass were stated. The poor response to the simplest part of this question could also indicate that some candidates are still relying on formulae in tension problems rather than applying Newton's Second Law to each mass.

(b) It was unfortunate that some candidates who could write correct expressions to find the tension in the string failed to substitute correctly for *mass* and *acceleration*.

(c) A common error was using the wrong sign when substituting for the acceleration of the mass *X* Again, this error indicates that many candidates do not understand the application of Newton's Second Law.

Question 19

(a) Most candidates were able to perform a suitable calculation to obtain the distance although there were some incorrect attempts to apply equations of **accelerated** motion.

(b) Many candidates were able to draw correctly a vector addition diagram for the collision between the four balls, but a significant number did not label the vectors or indicate whether they represented velocity or momentum. Students should be encouraged to add units when labelling the magnitudes of vectors. (Although it is correct to add velocity vectors when all the masses are identical, it is suggested that candidates justify this solution method.) Some, who correctly used momentum in the vector diagram, failed to divide the resultant momentum by the total mass. There were also attempts at using linear addition and many candidates still had difficulty in using an angle on a diagram to determine the direction of a vector.

Question 20

(a) Candidates had little difficulty in calculating the ratio of the kinetic energy of the white ball before the collision to that after the collision.

(b) This part of the question was poorly answered, with many candidates failing to show working or wrongly assuming that the collision was elastic. From the number and variety of inaccurate responses for the position of the ball after the collision it was clear that candidates were guessing the position rather than applying the principle of conservation of momentum. Such candidates lost 2 marks.

Question 21

It was pleasing to find that most candidates found all parts of this circuitry question very easy and, therefore, gained full marks. Many responses, however, in spite of including the correct equations and substitutions were completed incorrectly, due to careless or wrong arithmetical procedures.

Question 22

(a) The better students had no trouble in applying the Preliminary Course concept of change in the energy of a charge moving through a potential difference. Many attempted to answer this question by applying the equations involving electric current and resistance in the X-ray tube to determine the energy of the electron when it reaches the anode. The most common error was the use of $P = VI$ to calculate energy.

(b) A number of students were unable to convert 6OμA correctly to amperes and failed to realise that *current is the charge per second*. It is clear that the equation $Q=nq_e$ is not well known since many variations were attempted to solve this part.

(c) By using voltage and current candidates were able to determine the power dissipated in the X-ray tube.

Question 23

(a) A large number of students (approx.. 60%) knew an equation for the magnetic force on a moving particle but were confused about which angle or trigonometric function-to use, since the velocity was not at right angles to the field. Students should be encouraged to calculate the component of velocity at right angles to the field and then substitute into the basic equation, $F = BQV$.

(b) When describing differences in direction of the motions of particles, students were careless when using the plane of the page as a reference. It is not sufficient to describe a direction as up as this expression may mean *up the page* or *up out of the page.* About 20% of the candidature referred to differences in the forces acting on the particles rather than specifically describing *differences in motions* as asked in the question. Many were unable to recall the differing charges and masses of the alpha and beta particles and to relate these to their motion in magnetic fields, resulting in a very low mean for the question.

Question 24

(a) Half the candidates did not recognise the fact that this uniform field would be found inside a solenoid. A significant number confused the field lines shown with wires carrying currents and others were not sure whether the question involved electrostatics or electromagnetism. In answers that showed a solenoid as the source of the magnetic field, the current direction was frequently incorrect or ambiguous. Candidates had great difficulty with drawing a solenoid in three dimensions so that the front and back of the loops were distinguishable.

(b) Generally this question was well answered, indicating an understanding of Ampere's experiment.

(c) Some students who performed well in parts (a) and (b) did not recognise the fact that this field diagram was the combination of those in parts (a) and (b), while others who failed to answer part (a) correctly were able to relate the three magnetic field diagrams.

Question 25

This question was poorly answered.

(a) Often students misused terms such as *frequency, beats, standing waves, pitch, wavelength* and *amplitude*. Very few students were able to recognise the significance of the interference of sound from the sources along the two paths (lines) and to describe the resulting patterns of loudness. At times it was evident that students had failed to read the question carefully as they did not separate *describe* and *explain* into the relevant parts of the question.

(b) The concept of interference was, in general, poorly understood. Many students believed that standing waves always form when two waves meet, or chat, at points equidistant from the sources, no interference would occur. Others attributed the changes in volume to the relative proximity of the speakers. Many used the wrong letters to refer to the paths and failed to score marks. Explanations frequency lacked detail or were ambiguous. The better candidates were able to explain the significance of path difference and to relate that difference to wavelength in order to determine whether *constructive* or *destructive* interference occurred at a point along the path.

Question 26

Most students scored well in this question.

(a) A large number of students failed to take into account the initial speed of the balloon and treated the balloon as accelerating down at $9.8ms^{-2}$ from rest.

(b) Most candidates gave the correct magnitude but not the direction of the velocity vector of the can. A significant number of students did not realise that the vertical component of the can's velocity was the same as that of the balloon from which it was released. There was some confusion about the term *component* and a number of students attempted to calculate the resultant velocity of the can.

(c) This part of the question was well done by most students. There were, however, a number of inconsistencies when applying vector directions to the equations of motion. Those using calculus or projectile motion formulae were generally not able to get the correct result. Students are well advised to solve projectile motion problems by applying the equations of uniform motion to the horizontal and vertical direction components of the motion.

(d) This question was well done. The majority of students realised that the horizontal component of the can's velocity remained constant.

Question 27

(a) Approximately two-thirds of the candidates showed the ability to calculate the period correctly by substituting into the stated formula for the period of a conical pendulum. Some confused the calculation of the frequency or angular velocity with that of the period while others had difficulty in rearranging the given formula to make *h* the subject.

(b) Many candidates made simple errors when substituting into the equation for centripetal force, often forgetting to square the velocity. Some left their calculation of centripetal acceleration as the answer for *force*.

(c) Most candidates included the weight force in their calculations and a wide variety of approaches was used to resolve the vectors in order to find tension. Simple trigonometric miscalculations were frequent.

Question 28

The format of this question might have caused candidates to assume wrongly that knowledge of nuclear physics was required rather than the application of the principle of conservation of momentum in an *explosion* situation. Almost 20% of the candidates made no attempt to answer the question. Those who did so either did very well (scoring 4 or 5) or very poorly (scoring 0).

(a) This part was well answered by those who did attempt the question. The most common error was incorrect substitution for the mass of the electron, using either the charge on the electron or the mass of the nitrogen nucleus.

(b) Many candidates believed that electrostatic repulsion was the cause of the recoil by the nitrogen nucleus, while others had difficulty in expressing clearly the principle of conservation of momentum in an initially stationary system. The concept of recoil in this situation was poorly understood.

(c) This part was very poorly answered, with many students not knowing where to start in order to find the recoil velocity of the nitrogen nucleus. Although it was a two- vector problem, many candidates used algebraic addition of momenta to find the resultant even if they had drawn a closed vector diagram. A number of candidates incorrectly used the value for momentum of the electron found in part (a) and divided it by the mass of the nitrogen nucleus, ignoring the momentum carried by the antineutrino..

(d) Poorly drawn vector diagrams prevented many candidates from scoring marks if they were using incorrect values from previous parts of the question. Moreover, failure to label vector diagrams correctly (including arrows for direction) led to ambiguity as to which angle was being used in the calculations. For closed vector diagrams, internal angles were frequently seen as the answer to the question. Students need to practise translating angles from vector diagrams to the situations described in the question and they must read questions carefully in order to determine the information required.

Question 29

(a) This part required the calculation of power, using voltage and resistance, and was well answered by most candidates. Incorrect units were common but were not penalised by the marking scheme.

(b) Candidates were generally able to relate the changes in voltage shown on the graph to the given values of the resistors and identified their order in the circuit, although some stated the value for resistor r instead of R.

(c) (i) This part was poorly answered by a significant number of candidates. The most common error was finishing the graph at C after the one remaining resistor and not proceeding along the X-axis to F where the circuit was completed at the battery. The majority of candidates who scored 4/5 for the question lost their mark in this way.

(ii) This part was fairly well answered. Some candidates correctly stated *the current increases* and then proceeded to give an unnecessary, incorrect or contradictory reason which lost them the mark. Many did not understand the concept of current flow around a circuit, stating that the current changes at some point in the circuit. A significant number of candidates divorced part (ii) from the stem of the question. They interpreted it as asking *How would you (or could you) change the current in the circuit?* and responded with *By placing r in parallel*.

(iii) This part was also fairly well answered. Many candidates had difficulty in interpreting the phrase *Explain how* and failed to give an explanation or reason for the change in the life of the battery. The concept of power as the rate of energy output and the difference between work and power were poorly understood by many candidates. A significant number believed that a battery was a *well* or *bank* of electrons which *get used up.*

Question 30

(a) The majority of candidates remembered to convert distance to S.I. units but a significant number did not attempt this part, either through lack of knowledge of the formula for the magnetic field near a current-carrying wire or through failure to realise that the data from the first row of the table was relevant. Candidates were not all aware that k $(\mu_0/2\pi)$ was available on the Physics Data Sheet and some thought that $\mu_o = 2 \times 10^{-7}$.

(b) In their attempts to use the whole grid supplied for the graph, candidates produced huge variations in scale intervals. Some used the Data Table values as equal intervals while others used decreasing values on the axes.

Errors in plotting the points were common, while plotted points were not always clearly denoted. The selection of unsuitable graduations disadvantaged many candidates who would have spent considerable time in determining the correct positions for their points.

Candidates were familiar with the concept of the *line of best fit*, though not all were sufficiently careful in drawing a single straight line with their ruler through most of the points.

(c) A minority of candidates did not follow the instructions and used results from the table rather than the slope of the graph. Others who used the slope did not read their B or I values carefully enough and hence used incorrect values in calculating the slope. A significant number did not recognise that the values of B had a factor of 10^{-6} and omitted it from their answer.

(d) Most students failed to recognise, therefore, that the slope of the graph is the numerical ratio B/I needed for substitution into the same equation used in part (a) in order to calculate the distance d from wire A. Candidates were confused by the presence of a second wire carrying a current and needed to understand that this produced the intercept on the field strength axis and could virtually be ignored.

Question 31

(a) The majority of candidates were able to interpret the diagram and successfully calculated the wavelength of the standing wave in the string.

(b) Most candidates were also able to determine the velocity of the wave in the string using the wavelength from part (a) and the given frequency. Some students recognised the pattern as being the third harmonic and used a more complex formula to find the velocity.

(c) The majority of students were able to identify the two changes to the apparatus that would produce the fundamental mode. A significant number discussed variables only in general terms without reference to the apparatus illustrated or were unable to identify correctly the direction of changes to these variables. Candidates need to supply precise information in order to score maximum marks, saying, for example, *increase the mass rather than change the tension*. Many candidates recognised that the formula provided in part (d) could be used to answer the question but had problems with the algebra required.

(d) Approximately half of the students answered this part correctly. Many failed to realise that the y-axis plotted $\sqrt{T}$ and not T. Students showed a lack of experience with graphed data containing square root functions. Some found μ and then obtained its square root, while some could not rearrange the formula to find μ or link the formula to the data provided.

SECTION II ELECTIVES

Question 32 History of Ideas in Physics

A Half-elective: Gravitation (attempted by 9.6% of the candidates)

(a) (i) Many candidates were able to draw a diagram showing the epicycle and the deferent but few were able to illustrate the concept of the eccentric on the one diagram. Second diagrams sometimes contradicted the first in terms of the position of the Earth. A number of candidates did not show an understanding of the Ptolemaic system, while others confused the path of the planet with the epicycle.

(ii) The majority of candidates were able to state that retrograde motion was a reason for the introduction of the epicycle/deferent model, while others made errors in their explanations, thus showing a lack of understanding of the term. Some referred to the motion of the stars and not of the planets. The difference in time between the autumnal and vernal equinoxes and variation in brightness of the planets were also cited as second reasons by a number of students.

(b) This part was poorly answered, with a majority of candidates failing to provide any answer that was more than a restatement of the stimulus material. Many did not recognise either the need for an explanation of the sequential nature of the phases of Venus or the fact that the full range of phases, including, significantly, a *full Venus* and a *new Venus,* was only possible with the Geocentric model. Diagram 1 confused candidates who did not recognise that the phases could still be seen from Earth and that the positions shown were of Venus on its epicycle path.

(c) (i) Most candidates were able to obtain the required formula involving centripetal acceleration and angular velocity but simple algebraic errors were common.

(ii) Again most students were able to substitute correctly for T^2 in the formula from part (i). Successful candidates realised that a was equal to g and defined the constant $k2$.

(iii) The majority of students were able to substitute the data into the expression.

(iv) Generally this part was poorly answered, with candidates quoting the complete Law of Universal Gravitation rather than describing the inverse square relationship of distance to force and comparing the force of gravity on Earth to the force of gravity on the Moon.

B Half-elective: Nature of Light (Attempted by 5.1% of the candidates)

(a) This question was answered poorly by the majority of candidates. Few knew Descartes' assertions about the speed of light and hence were unable to compare those assertions with the estimates of Roemer.

(b) Most candidates were able to discuss criticisms of the views of Newton and Huygens on light and received at least a portion of the marks for this question.

(c) In their answers candidates showed a pleasing knowledge about the nature and significance of Poisson's Spot.

(d) Although some candidates were able to describe features of Maxwell's theory of light, there was little knowledge of experimental evidence. It was disappointing that few appeared to have performed Hertz's experiment.

(e) The majority of candidates were able to use Einstein's theory of the photoelectric effect to account for some of the listed experimental observations. The observations were not numbered and, as a result, candidates often failed to identify which observation they were explaining.

C Half-elective: Atomic Structure (Attempted by 12.1% of the candidates)

(a) While most candidates were able to describe a feature of Dalton's atoms, few were able to recall any experimental evidence used by Dalton.

(b) (i) The majority of candidates were not familiar with Townsend's experiment but were able to state the assumption of equal charge based on the stimulus material.

(ii) Candidates were generally unable to explain how the charge on each drop was determined and often confused this experiment with that of Millikan.

(c) Most candidates were able to attempt a diagram but had difficulty in showing the 3-dimensional arrangement of the apparatus. The velocity filter and the purpose of the collimator were not well understood and the experiment was often confused with Thomson's cathode ray apparatus or the mass spectrometer.

(d) While Rutherford's model was reasonably well known, the experimental evidence for the model and the reasoning involved proved too difficult for many.

(e) (i) A number of the candidates did not understand the Bohr model well enough to attempt a description. Their answers would often have been improved by adding diagrams and more clearly showing the connection between the Bohr model and the Balmer series of lines.

(ii) While some candidates who knew the Rydberg equation were able to show that they understood the link between stationary states and spectral lines, others simply quoted the equation and made no attempt to apply it to the Bohr model.

Question 33 Wave Properties of Light

(Attempted by 37.6% of the candidates)

(a) (i) Most students were able to calculate the distance travelled by the wavefront..

(ii) Despite the fact that the diagram was geometrically incorrect, the marking scheme applied to this question allowed most candidates to gain full marks, depending on their understanding of the movement of the incoming and reflected wavefront.

(b) (i) Most of the candidates scored full marks. The most common error was the use of the relative refractive index for water and glass to calculate the speed of light within the glass. A small percentage of candidates used the speed of sound instead of the speed of light.

(ii) A significant number of students indicated a clear understanding of the physics involved here, but used the wrong angle when substituting for the incident angle and many could not subtract 65 from 90 correctly.

(c) (i) Candidates found both the diagram and the question confusing but were awarded marks for any relevant discussion of diffraction and interference. An insignificant number more correctly attributed the non-uniform intensity to an inverse square relationship as measured from the opaque straight edge.

(ii) The majority of students correctly attributed the light seen to the diffraction of light around the straight edge.

(d) (i) This question was unconventional as it required candidates to find the angle between the two first order *minima* in an interference pattern. Many students failed to double their calculated angle to obtain the correct answer.

(ii) The majority of candidates were able to provide the correct justification to obtain the mark that indicated a good understanding of the effect of wavelength changes on interference patterns.

(e) (i) Most candidates gained full marks here. Of those who failed to answer the question satisfactorily a significant number restated the stimulus material. Another common error was the incorrect use of the term *diffraction*.

(ii) A number of candidates repeated the given difference between spectra produced by prisms and diffraction gratings instead of describing another difference as asked in the question.

(f) (i) This part was quite well answered and most candidates were able to recall the appropriate diffraction equation.. A small number were unable to convert nanometres into metres.

(g) (i) Most students drew appropriate cross-sections and realised that reflected rays from the top and bottom surfaces of the oil were important in answering this question.

(ii) Many candidates attempted to explain the production of colour by concentrating on the phase changes that occur at the interfaces. Of those who correctly identified interference as the main cause, many failed to link the production of colour to the optical path difference and wavelength. A significant number of students tried to explain the colour as a dispersion effect rather than an interference effect.

(iii) This part was well answered, since candidates realised that the presence of different colours was related to the variation in thickness of the oil film.

(iv) Most candidates used the correct equation for constructive interference. A significant number incorrectly incorporated phase changes into their equations.. Others used the wrong refractive index to determine the wavelength of the light in the oil.

(h) (i) Many candidates simply restated the information found in the question.. The main error was the lack of reference to field vectors; this was necessary to explain *polarisation* at this level.

(ii) Although this was well answered, some candidates were confused about which angle to substitute in Malusí' Law or omitted the squared sign in the equation..

(iii) Candidates were generally able to determine how often intensity readings would be repeated when a polarising grid was rotated.

(i) The majority of candidates attempted to substitute values into the Doppler Effect equation.. Errors included incorrect substitution of data, selection of the wrong sign and the calculation of both possible answers but failure to identify the correct one. Some students used invalid approximations instead of the stated Doppler Effect equation.

Question 34 Rotation

(Attempted by 9.5% of the candidates)

Marks were awarded for the working of the problem and, therefore, the attempt by the candidates to write clearly the equation they wished to use and then to substitute was pleasing.

(a) Most candidates selected appropriate equations in this part but encountered difficulties if they did not realise that the force applied was a retarding one. This produced some incorrect substitution, and invariably led to an incorrect answer for part (ii). Very few candidates solved the problem by considering the change in angular momentum to be equal to the product of the torque and the time of the motion. A number of candidates, however, did answer this part very well.

(b) The majority of candidates who had problems with this part failed to realise that the friction force was responsible for the torque on the cylinder. Many students wrongly substituted the tension in the string into their torque equation. A large number also failed to realise that the total kinetic energy of the rolling cylinder was the sum of the translational and rotational kinetic energies.

(c) This question outlined a popular experiment used to determine the moment of inertia of a wheel. Many candidates were obviously familiar with the experiment and the majority scored well. The most common mistakes were the use of uniform circular motion equations to determine *acceleration* and failure to realise chat a *frictionless* wheel with hub and spokes would have a radius of gyration less than the radius of the wheel. This led to errors in deducing the correct response for part (iv). In the question the sentence *The friction of the axle was negligible* confused some candidates who might have considered *friction* as a reason for their answer for part (iv).

(d) Although very few could correctly write a description of the parallel axis theorem,, many could correctly write a mathematical equation and define the terms used. Those who could not define the terms often substituted *r/2 or 2r* in their equations. The use of the parallel axis theorem in part (ii) was generally very well done.

(e) Again, in this part, the use of appropriate language to explain an event was clearly beyond many candidates. More class-time should be devoted to assisting students in this regard. Some confused *conservation of momentum* with *conservation of energy or torque*. Others mentioned air resistance as a significant factor. In part (ii), the mathematics was very well done.

(f) (i) Most candidates were successful with this section and recognised that energy was conserved in part (i).

(ii) In part (ii), the manipulation of equations to determine the linear velocity or the angular velocity was well done and this led to a correct answer in part (iii).

(iii) Very few candidates realised here that the required percentage could be determined as a ratio and substitution could be avoided.

(g) This was the most poorly answered part of the elective. It required a non-mathematical answer and a discussion of the effect of certain conditions on the motion of the Earth. Again, the effective use of language was a stumbling block for most candidates. Very few could provide a direction for the torque vector in (ii). This indicated either a lack of knowledge of the right hand convention for angular vector directions or a poor understanding of how the torque on the spin axis of the Earth is applied. Interestingly, a significant number stated that the mass of the Earth would increase as a result of the melting of the ice-caps.

Question 35 Physics in Technology

A Half-elective: Engineering Materials and Structures

(Attempted by 3.1% of the candidates)

(a) Candidates were able to explain the position of door handles in terms of torque, moments, levers or mechanical advantage.

(b) Candidates have a good understanding of centre of mass although their working was often not shown.

(c) (i) This question proved difficult for 50% of the candidates who failed to equate the extensions using the Young's Modulus relationship.

(ii) Those who knew the relationship between stress/strain and Young's Modulus generally answered the question well. Some substituted values for both copper and steel in the one equation.

(iii) This question was poorly answered, as few candidates recognised the need to calculate the stress at the given load and relate it to the ultimate tensile strength.

(d) (i) Although most candidates realised that the diagonal was in compression, they failed to provide a reasonable explanation. Some thought that the side members at 45^0 were the diagonals.

(ii) Those who made use of the symmetrical nature of this frame found the required relationship easy to derive, but many others failed in their attempt to use both the cosine (cos) and sine (sin) rules.

(iii) Candidates were required to determine the tension in the side members and compare this value to the force in the diagonal, but very few correct responses were found.

B Half-elective: Optical Instruments (Attempted by 11.1% of the candidates)

(a) (i) Candidates showed a poor understanding of how to construct a labelled ray diagram to locate an image m a plane mirror.

(ii) This question was reasonably well answered, although a common error was stating that for a full image to be seen, the mirror length had to equal the height of the person.

(b) (i) Most candidates were able to name another optical instrument with the same components as the enlarger, but some based their answers on the enlarger lens.

(ii) The answers were often vague and did not clearly explain why the negative should not be placed further than twice the distance above the enlarger lens. The expected term *diminished* was infrequently used.

(iii) The majority of candidates could draw, to scale, ray diagrams for lens. Inaccurate results were caused by small diagrams and inadequate drawing equipment.

(iv) The use of the formula for magnification caused few problems.

(c) (i) Most candidates were familiar with the instruments illustrated and correctly determined which relied on mirrors for magnification.

(ii) The function of pairs of prisms was not well understood and many candidates discussed *prisms in general* rather than *pairs of prisms*.

(iii) Again many candidates failed to read the question carefully and described improvements that were not *optical* rather than stating the obvious answer of *chromatic aberration.*

(iv) Candidates preferred to describe the structure of each telescope rather than state an advantage of one over the other as asked.

C Half-elective: Transformation of Energy (Attempted by 12.0% of the candidates)

(a) (i) Most candidates were able to convert gigawatt-hours to joules; some, however, were confused by the prefix even though it was defined in the introduction to the question.

(ii) The concept of efficiency as a percentage of the total energy available was not clearly understood. Many candidates did not realise that the energy produced (found in part(i)) was equal to 35% of the total energy. It was very common for students to state that the wasted energy was 65% of the energy produced.

(iii) Very few candidates stated that the major loss of heat was in the operation of the cooling towers and, instead, gave less specific answers.

(b) (i) In spite of the fact that the concept of power per unit area was understood, a large percentage of the candidature did not recognise that the absorption area was a circle.

(ii) In determining the energy produced by the steam engine, students identified the increase in water temperature as a relevant factor but did not take into account the mass of the water.

(iii) About 50% of the candidature was able to state that, in the present day, solar (photovoltaic) cells would be used.

(c) (i) Very few candidates answered the question by comparing the three energy sources on one characteristic and, instead, gave a different advantage for each source.

(ii) The physical processes involved in converting energy to electrical energy were best understood for gravitational energy and few candidates were able to explain successfully the processes for fusion or fission which were often confused.

(d) (i) Many candidates were able to calculate the energy used by the electric fan.

(ii) Candidates had problems in converting their answer for part (i) from joules to kilowatt-hours in order to calculate the cost per year.

Question 36 Astronomy

(Attempted by 22.5% of the candidates)

It was pleasing to see the improvement in the standard of the responses this year.

(a) (i) Most candidates were able to state the difference between *apparent* and *absolute magnitude.*

(ii) This question was answered correctly by less than 50% of candidates, the most common error being the calculation of a magnitude rather than a brightness or intensity ratio. Many candidates were unable to complete correctly the mathematics involved.

(iii) Most candidates were able to calculate the distance to a star by using magnitude values.

(iv) This question was answered correctly by very few candidates, possibly due to an apparent contradiction in the question. The graph used the term *Average Visual Magnitude* in the tide, which could be interpreted as *apparent magnitude*. The vertical axis labelled *Absolute visual magnitude* contradicts the tide. This difficulty, combined with the fact chat the process was the reverse of that normally performed for Cepheid variable distance calculations, contributed to the poor response.

(b) (i) In fairness to the candidature a range of very basic answers was accepted. This question asked how astronomers could calculate the rate of the proton-proton chain reaction in the Sun and was extremely difficult because the given reaction occurs within the Sun's core. Only the neutrinos could be detected. (The other products would either remain in the core or interact with other particles within the Sun). Any other method relies on using observed *surface* parameters to estimate the energy of the core.

(ii) This question was generally well answered, with 60% of the candidates scoring full marks. Candidates were aware of the temperature dependence of the two mechanisms involved in converting hydrogen to helium.

(iii) This question was answered correctly by 30% of the candidates. Many confused force, energy and pressure. Candidates could not correctly identify the outward force and it was often incorrectly referred to as the *nuclear force* or the *nuclear explosion*.

(iv) While most candidates correctly stated that the Sun would evolve into a red giant, many could not give a satisfactory description and explanation of the process.

(c) (i) The wording of this question seemed to confuse many candidates who were unable to explain what information is needed for a binary system to be classed as *visual*.

(ii) This part was generally well answered, although many candidates stated that the secondary eclipse involved a total eclipse of the larger star by the smaller star. Some candidates confused the terms *brighter/larger* and *dull/smaller.*

(iii) Many candidates did not realise that the plane of a binary system as seen from Earth determines whether the stars eclipse and hence display a varying light curve.

(d) (i) Candidates were generally able to read the *H-R* diagram successfully to determine the brightest star.

(ii) A significant number of candidates carelessly ignored the stars above the main sequence when selecting the lowest temperature star.

(iii) Candidates described the stars in a cluster as being close to each other but often failed to relate this to their equal distance from the observer on Earth, hence accountability for the validity of using apparent magnitude in the *H-R* diagram.

(iv) Many candidates were able to use the *H-R* diagram to determine and explain the age of the cluster shown in the diagram.

(v) While most students showed knowledge of the correct distance equation and substituted correctly into it, they failed to carry out the necessary mathematical operations correctly. They had difficulty, especially with the *log* function.

(e) (i) Most candidates were able to use the diagrams to determine *B* and *V* and calculate the colour index.

(ii) This question was answered correctly by very few candidates. This might have been due to the failure of many textbooks to mention or explain that stars with hotter surface temperatures show fewer spectral lines than cooler stars because of the much greater degree of ionisation of the atoms.

(f) This question was correctly answered by most candidates. Those unfamiliar with ring nebulae were, nevertheless, able to construct a reasonable explanation for their formation.

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