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FOREWORD

This booklet contains reports written by Examiners on the work of candidates in certain papers. **Its contents are primarily for the information of the subject teachers concerned**.

PHYSICS

GCE Advanced Level and GCE Advanced Subsidiary Level

Paper 9702/01
Multiple Choice

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

General comments

This paper proved to be satisfactory in every way from a statistical point of view. The mean mark out of 40 was 27.4 and the standard deviation was 7.0. The results showed that fewer than 1% of candidates scored less than 15/40 and that there were 72 of the candidates who scored 40/40. The implication of these figures is that the able candidates were able to show their ability and that the less able candidates still had something positive to do and, hopefully, were not disillusioned by the paper.

There were a few questions which were easy and which resulted in high facility. These were mostly questions at the start of each new topic within the paper and are designed to test basic facts. There was good evidence this year of candidates taking more care not to make careless mistakes. If candidates do double check their work as they go by looking critically at every answer to see that it makes sense then they will avoid mistakes on several questions during the course of answering the paper. Questions such as **Question 4** had a facility of 0.92, which is good, since it is all too easy to see 2.7 mA and 2.35 mA as answers to this type of problem in practice. Other answers which had similar high facility were **2**, **3**, **7**, **15**, **20**, **24**, **32**, **37** and **40**. Some questions which ought to have been in this batch, but were not, were **Questions 1**, **22**, **29** and **39**. In many cases more writing of details on the exam paper itself, by the candidates, would help many candidates. This also applies to questions which proved to be difficult. **Question 25** proved to have the lowest facility, 0.32, of the entire paper. If only candidates had used their pencils to draw in, on the paper itself, the new wave a little bit later in time they would have seen clearly that P must go down and that Q barely moves - if they tried Q down as well they would not have been able to give that as an answer because it is not there. When a multiple choice paper like this is finished candidates should find that their question paper is covered with working - *not* rough working but real accurate, essential working out of the answers. Too many candidates spend too long just using calculators and trying to keep ideas in their heads. It is much better with information written down.

There were no questions where a wrong answer was more popular than the correct one, no indication of large scale guessing on any question and no question where the discrimination was below the design limit of 0.25. In some cases popular misconceptions were noted. These were mainly because:

- in **Question 10** too many candidates do not understand Newton's third law
- in **Question 16** too many candidates did not appreciate that potential energy increases linearly with distance, but not with time
- in **Question 21** lack of working often gave **D** as the answer
- in **Question 31** the same lack of working often produced **B** and **C** as answers
- in **Question 33** checking from the equation would have eliminated **D**
- in **Question 39 D** could have been realised as a problem connected with size of nucleus and not structure.

Paper 9702/02

Structured Questions

General comments

This paper, as usual, gave candidates the opportunity both to reproduce standard formulae and bookwork that they had memorised and also to show understanding of the underlying concepts. Generally, recall was satisfactory but an understanding of concepts was less convincingly demonstrated. For example, in **Question 6**, almost all candidates could give the formula to calculate slit separation. Comparatively few showed sufficient understanding of the formation of the interference pattern in order to allow them to deduce the effect of the listed changes.

There were many excellent scripts showing a good understanding of all the topics. Such scripts were generally well presented and clearly argued. However, clarity of argument, particularly in calculations, was usually disappointing. In numerical questions, attempts were often a muddle of incomplete formulae and sections of speculative calculations, sometimes contradicting each other.

A significant proportion of candidates failed to complete the paper. A number of candidates showed little familiarity with the concept of the potential divider and consequently, the failure to complete the paper may have been due to a shortage of time or to an inability to attempt an answer to the last question.

Comments on specific questions

Question 1

(a) Almost all candidates stated satisfactorily the difference between scalar and vector quantities. Candidates should be encouraged to use correct terminology. For example, 'magnitude' rather than 'size' or 'value'.

(b) Most candidates did construct a parallelogram or a triangle with directional arrows on the vectors. There were some very good, accurately drawn figures but many wrongly assumed that the lengths of the given dotted lines were appropriate for the sides of the parallelogram or triangle. They then gave the answer as the length of the 'resultant', without any regard for scale. A significant number calculated the resultant, having drawn an appropriate diagram. Others, however, disregarded the instruction and calculated the resultant, without drawing even a sketch diagram.

Answer: **(b)** 13.2 ± 0.2 N.

Question 2

(a) With few exceptions, candidates read correctly the wavelength from the graph and completed the calculation to obtain the frequency.

(b) Relatively few sketches indicated a wave with an appropriate amplitude. Many candidates did indicate, either by formula or by words, that the square of the amplitude is proportional to intensity. However, this fact was rarely translated to the sketch. The majority of sketches did show the correct phase for the new wave.

Answers: **(a)(i)** 0.60 m, **(ii)** 550 Hz.

Question 3

(a) Some candidates attempted to explain what they understood by 'random' and 'systematic' without making the required reference to the features of the graph. Of those who did refer to the graph, the majority adequately associated random error with the scatter of the plotted points about the straight line. Many did associate a systematic error with an intercept although statements tended to be imprecise, such as 'the time does not start from zero'.

(b)(i) Most candidates read correctly the co-ordinates of two well-spaced points on the line and hence calculated the gradient. The most common errors were either mis-reading the scales or using plotted points, rather than points on the line.

(ii) The majority of candidates thought that the gradient represented the acceleration and all that was necessary was to adjust the units. Comparatively few attempted to use an appropriate equation of motion to show that the acceleration is, in fact, twice the gradient of the line.

Answers: **(b)(i)** 10.6 cm, s^{-2}, **(ii)** 0.212 ms^{-2}.

Question 4

(a) Most candidates knew the formulae for both momentum and kinetic energy and were able to make the simple substitution to arrive at the expression given. However, the presentation of this proof was frequently illogical and difficult to follow.

(b)(i) In most answers, the calculation began with an attempt to determine either the change in momentum or the average acceleration experienced by the ball whilst in contact with the plate. It was very common to find that the vector nature of the velocities was ignored. Other common errors were either to fail to convert the mass to an appropriate unit or to use the weight of the ball, rather than its mass, when calculating the average force. Most did realise that the plate would exert an upward force on the ball.

(ii) The majority of calculations were correct. However, a significant minority assumed that $(v^2 - u^2)$ is equal to $(v - u)^2$.

(c) There were very few good answers to this section. Many confused momentum and kinetic energy, stating that momentum is not conserved because the collision is inelastic. Others merely stated that momentum is always conserved in a collision. Very few argued that momentum is only conserved in an isolated system and then discussed what constitutes the isolated system in this example.

Answers: **(b)(i)** 2.0 N upwards, **(ii)** 0.14 J.

Question 5

(a) A surprisingly large number of candidates failed to write down the distance as being equal to *n* times the circumference of the disc. Furthermore, a large number failed to multiply the force by their answer for the distance.

(b) This section was very poorly answered. The vast majority considered the work done by one force only and then contrived to arrive at the answer by defining torque as the product of the magnitude of one force and the radius.

(c) The majority of candidates did use the formula given in **(b)** to find the work done per unit time. A surprising number did, however, appear to ignore this formula and used the given values of torque and r.p.m. in apparently quite arbitrary ways. Work done was sometimes equated to torque and time to r.p.m.

Answer: **(c)** 1.2×10^5 W.

Question 6

(a) There were some very clear concise statements of the principle. However, there were many muddled versions which failed to make clear that the principle applies to the effect at a point in a medium of two or more waves meeting at that point. The waves do not 'interact', but produce a resultant displacement that is the vector sum of the individual displacements at that point. Many candidates referred, quite wrongly, to amplitude rather than displacement.

(b) Most candidates were able to identify a line along which there would be constructive interference but far fewer gave a correct direction for destructive interference. Many did, in fact, draw a second line where constructive interference would be observed. Others drew lines where the waves from the two openings did not overlap.

(c)(i) There were some scripts where an incorrect formula was quoted and, sometimes, units were muddled. However, the majority of calculations were correct.

(ii) This was not answered well and indicated that many candidates did not understand the basic concepts.

Answer: **(c)(i)** 1.1×10^{-3} m.

Question 7

(a) These simple calculations were completed successfully in most cases. It is surprising that, at this level, there is a small minority that believe that current and voltage are related by the expression $V = I/R$.

(b) The majority of the calculations of the length were correct. Most failures were accounted for by wrong formulae, inconsistent units or an incorrect expression for the cross-sectional area of the wire.

(c) Most comments on the answer for the length of the filament did not attempt to relate its suitability for the household electric lamp and were simply 'it is short' or 'it is long'. A small number did state that the filament, longer than the diameter of the lamp, would be coiled.

Answers: **(a)(i)** 0.25 A; **(b)** 0.137 m.

Question 8

Candidates who fully understood the principle of the potentiometer found all three parts of this question quite straightforward and many answers were very clearly presented. On the other hand, there were, quite evidently, some candidates who had little or no experience of analysis of circuits.

(a) The answer was provided in the question and, consequently, credit was given for a clear explanation as to how the answer was derived. Weaker candidates frequently made incomplete attempts to apply Ohm's Law to various parts of the circuit, with little or no explanation. Generally, the correct conclusion was reached, but by incorrect or dubious means.

(b) A common error was to assume that the current, as calculated in **(a)**, would remain the same, despite a change in resistance. There were some well-explained answers, based on a calculation of the current in the circuit and application of Ohm's law to the resistor R.

(c) Most candidates who attempted this part of the calculation were successful in calculating the combined resistance of the voltmeter and the resistor R. A surprisingly large number then calculated the potential difference across a resistance of 7800 Ω as being the voltmeter reading.

Answers: **(b)** 1.29 V; **(c)** 0.75 V.

Paper 9702/03

Practical 1

General comments

The overall performance of the candidates was similar to last year, although perhaps not quite of the same standard. There was a disappointingly long tail of weak candidates scoring very low marks. It was evident that these candidates had little experience of basic practical physics.

The experiment required a certain amount of manual dexterity, and it was quite difficult for candidates to gain good quality results from the apparatus provided. There was some evidence that the weaker candidates were short of time. A number of scripts were seen in which the analysis section had not been attempted, but often the Examiners were unable to ascertain whether this was due to the difficulty of the section or a lack of time.

Very little help was given to candidates by Supervisors.

Most Centres were able to provide the apparatus required for the examination, although in some Centres there were insufficient numbers of fifty gram masses.

Comments on specific questions

Question 1

In this question candidates were required to determine the density of water by lowering a mass suspended by a spring into a beaker of water and measuring the depth of immersion of the mass and the length of the spring.

(a) Most candidates were able to set up the apparatus without difficulty and record readings from the pointers A and B. Some candidates did not give the readings to the nearest millimetre (which is expected as a rule with a millimetre scale is being used to make the measurement) although nearly all did a correct subtraction to give a value for the extension of the spring.

(b) In this part candidates were required to find a value for the spring constant. The most common error was to use F = 2.96 N instead of F = 0.98 N (i.e. the total force applied to the spring rather than the force required to produce the extension measured in **(a)**). A number of candidates gave the value of k to an inappropriate number of significant figures (only two or three significant figures was accepted, as the extension can only be measured to two significant figures).

(c) Candidates were required to use the vernier callipers to measure the diameter of one of the masses and determine the percentage uncertainty in their measurement. The more able candidates were able to make the measurement successfully (to within 0.2 mm of the Supervisor's value) and give a sensible value for the uncertainty in the measurement (0.1 mm or 0.2 mm was acceptable) leading to a percentage uncertainty of about 0.3%. Weaker candidates often did not attempt this section.

The cross-sectional area was usually calculated correctly, although there were a number of candidates who used an incorrect formula for the area (e.g. $2\pi r$) or made a power of ten error in the conversion of units.

(d) Candidates were required to take six sets of readings for d and l and record the results in the space provided. Most candidates took six sets of readings from the apparatus, but many did not record the pointer readings, so the value for the distance between the pointers could not be checked. This incurred a one mark penalty. Some candidates gave their values to an unreasonable degree of precision (readings to the nearest millimetre were expected).

(e) Candidates were instructed to plot a graph of l against d. Large numbers of candidates chose to use compressed scales on the y-axis, which often resulted in all the plots occupying less than one large square in the y-direction. This is considered to be bad practice and was penalised. Candidates should be encouraged to use scales such that the plotted points occupy at least half the graph grid in both the x and y directions. Weaker candidates tended to use awkward scales (e.g. fifteen small squares corresponding to an interval of 0.1). This was also penalised.

Most candidates plotted the points correctly and drew lines of best fit. Candidates who had made serious systematic errors in the experiment usually obtained a curved trend of points. In these cases the line of best fit mark was not awarded and the 'quality of results mark' was also not awarded. Candidates who had done the experiment well usually obtained a good linear trend of points with relatively small scatter.

Candidates were required to determine the gradient of the line. Many of the weaker candidates omitted the negative sign. Others used triangles which were far too small. Generally it is expected that the hypotenuse of the triangle will be at least half the length of the drawn line. Candidates are expected to read the co-ordinates of the vertices to a precision of half a small square. Weaker candidates often misread the scales.

(f) In this section candidates were required to find a value for the density of water. It was expected that the gradient would be equated with $\frac{-\rho_w A g}{k}$. The more able candidates were able to use their values of k, A and gradient and calculate a value for the density in the range 800 kg m^{-3} to 1200 kg m^{-3}. Weaker candidates often did not use their gradient and substituted values into the given equation. Sometimes this section was not attempted.

(g) Candidates were asked to state one difficulty that they had when carrying out the experiment and one improvement that they would make if extra apparatus were available. Generally candidates' answers in this section were quite weak. 'Vibrations of the mass' or 'waves in the water' were common answers. There were occasional references to unsteady hands holding the rule suggesting poor technique in the primary length measurement. Sometimes candidates were too vague for marks to be given. Answers such as 'It was difficult to measure the distance' with little clarification were not credited. Better answers usually involved refraction or parallax errors, and possible ways in which the error may be reduced (e.g. use a thinner beaker with graduations on the side). Many candidates did not register the fact that they were meant to discuss problems in measuring d, and discussed problems with the pointers or the spring.

Paper 9702/04

Core

General comments

The paper offered the opportunity to candidates to demonstrate their factual knowledge and to show their understanding of the underlying concepts. There were some excellent scripts that showed a sound in-depth study of all the topics in the syllabus. In general, such scripts were well presented. There were, however, many candidates who did not appear to be well-prepared for the examination. Such candidates lacked factual knowledge in various topics and were unable to make reasoned arguments.

There was no evidence that the vast majority of candidates had insufficient time to complete their answers.

Comments on specific questions

Question 1

(a) The majority of answers made reference to quantisation of charge or to the charge on the electron. However, a significant minority referred to the charge on an oil drop.

(b) Answers were frequently disappointing. Only a minority considered all the data provided and then gave adequate explanation. Many merely averaged the two lowest values. Furthermore, there was little or no regard for the number of significant figures quoted in many answers.

Answer: **(b)** 1.6×10^{-19} C.

Question 2

(a) Most candidates did realise that the quantity is a mean square. Some thought that *c* represented the speed of light whilst others thought that $<c^2>$ referred to one atom/molecule rather than all the atoms/molecules in the sample of gas.

(b)(i) The number of correct answers was disappointingly small. Many left the answer as $<c^2>$, rather than the r.m.s. speed. Amongst weaker candidates it was thought that the density is m/V, rather than Nm/V. The quantity N was then assumed to be either the Avogadro constant or to be equal to 1.0.

(ii) This part of the question was completed successfully by only the more able candidates. Many assumed that the kelvin temperature is proportional to the r.m.s. speed.

Answers: **(b)(i)** 500 ms^{-1}, **(ii)** 1200 K.

Question 3

(a) Most answers to this part of the question were correct. The most common error was a failure to include subscripts.

(b) The calculation presented very few problems. However, many lost some credit here because they gave the answer as 4.9 rad s^{-1} when, to three significant figures, the answer is 4.99 rad s^{-1}.

(c)(i) Many attempted, quite wrongly, to equate either gravitational field strength at C or gravitational potential. Of those candidates who did equate the centripetal forces at C, very few gave any explanation of their reasoning.

(ii) Despite the algebra involved, most answers were correct.

(d) Those candidates who followed instructions and wrote down the algebraic equation before substitution usually arrived at the correct answer. The majority of errors arose as a result of incorrect substitution or a failure to square one or more terms. Amazingly, answers of less than 1 kg were accepted by candidates without comment.

Answers: **(b)** 4.99 rad s^{-1}; **(c)(ii)** $R_1 = 8.0 \times 10^{10}$ m $R_2 = 2.4 \times 10^{11}$ m; **(d)(i)** 3.06×10^{29} kg, **(ii)** less massive.

Question 4

(a) Most answers included a comment to the effect that y_0 is not constant. A reference to damping was accepted. It was common to find statements to the effect that the wave is not sinusoidal. Candidates should realise that both a sine wave and a cosine wave are sinusoidal. In this question, if the wave is a sine wave, then the curve should start at the origin.

(b) Generally well done although a minority gave the period as 0.3 s or 0.75 s.

(c) A significant number of candidates did not draw on Fig. 4.2 (as instructed). Instead, they drew a sketch, without quantities on the axes, in the space below the question. Sketches were, in general, poor. Candidates should realise that a sketch must indicate the important features. In this case, most did show the correct period. However, in most sketches, the peak heights did not relate correctly to those on Fig. 4.2 and did not show a progressive decrease.

Answer: **(b)** 10.5 rad s^{-1}.

Question 5

(a) Most candidates did realise that the rating had something to do with the value of an equivalent direct current. However, many expressed their ideas very poorly. It was obvious that some Centres had insisted on a careful learning of this definition and this paid dividends here.

(b) There were very few wrong answers, apart from some where it was stated that the r.m.s. current is proportional to the peak value.

(c)(i) Most candidates gave an appropriate expression for power. However, the determinations frequently lacked clarity of explanation, leading to the inverse of the correct answer.

(ii) Despite being told to discuss a.c. *in the home*, many candidates concentrated on distribution. There seemed to be widespread uncertainty as to whether appliances in the home operate on d.c. or a.c.

(d) With very few exceptions, candidates gave the correct answer in **(i)**. However, in **(ii)**, invariably the square-wave nature of the waveform was ignored and the answer given was 1.12 A.

Answers: **(c)(i)** 2.0; **(d)(i)** 3.0 A, **(ii)** 3.0 A.

Question 6

Marks ranged from zero to six. The heating of the solid proved to be the easiest to answer correctly. The compression of the gas caused most problems.

Question 7

(a) The correct expression was given by most candidates. However, a minority wrote down the momentum as *mc*, giving *m* as the mass of a photon and *c* as the speed of light. Most referred simply to ‘wavelength’, ‘momentum’ and ‘the Plank constant’ and did not consider wave-particle duality.

(b) There were some very clear derivations given by more able candidates. Others produced a mass of unexplained algebra from which emerged the correct expression.

(c) The main obstacle for some candidates was in recognising that the kinetic energy of the electron is given by the product *qV*. There was a significant number of calculations where errors were made either in the algebra or in the numerical substitutions. However, it was pleasing to note the large number of correct answers where the candidates had laid out their work in a clear logical fashion. This approach should always be encouraged.

Answer: **(c)** 9.4 V.

Question 8

(a) With few exceptions, S was shown close to the peak on the graph.

(b)(i) Despite being given the nucleon numbers, there was considerable doubt as to where the two nuclei would be positioned. Some even suggested that they would be to the left of S.

(ii) 1 The majority of candidates merely considered the binding energies per nucleon, without involving nucleon number. Some did use proton numbers. Candidates who calculated binding energies by calculating the product of the corresponding binding energy per nucleon and the nucleon number were in a minority.

2 Most candidates recalled correctly the expression for mass-energy and carried out the necessary calculation, giving an answer consistent with their value in **(ii)1**.

(iii) There were some correct responses based on the idea that the neutron is a single particle. However, most answers were in terms of the neutron having no charge or negligible mass.

Answers: **(b)(ii)1.** 3.04×10^{-11} J, **2.** 3.38×10^{-26} kg.

Paper 9702/05

Practical 2

General comments

The general standard of the work done by the candidates was similar to last year. **Question 1** was discriminating and differentiated well by outcome. However, many candidates found **Question 2** challenging and the marks for this question were often disappointing.

There were no reported difficulties from Centres in obtaining the necessary equipment for **Question 1**.

There was no evidence that candidates were short of time, although many of the weaker candidates did not attempt the analysis section in **Question 1** and gave very brief answers to **Question 2**.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the period of oscillation of a suspended metre rule depends on the distance from the point of suspension to the centre of the rule.

(a) Virtually all candidates were able to set up the equipment without help from the Supervisor. However, many candidates did not realise the purpose of the pencil. Incorrect answers included 'to ensure that the rule was vertical' or 'to mark the position of maximum displacement of the rule'. Many answers were vague and failed to suggest that the pencil should be placed at the centre of the oscillation.

Virtually all candidates were able to record six valid measurements of d and t. The readings were usually repeated. A few forgot to divide their times by ten or twenty and recorded values of t^2d instead of T^2d. The weaker candidates often omitted the unit in the column heading for T^2d. Values of d were usually given to the nearest millimetre, although perhaps one in ten candidates recorded their values of d to the nearest centimetre. Weaker candidates tended to give too many significant figures in the values of d^2. It is expected that the number of significant figures in d^2 will be the same as, or one better than, the number of significant figures in d. When asked to justify the number of significant figures given in the values of d^2 many vague answers were seen. Weaker candidates gave answers such as 'appropriate to plotting the graph' or 'the same sf as in the raw data' and did not relate the sf in d to the sf in d^2. A number of candidates were confused between significant figures and decimal places.

(b) Candidates were required to plot a graph of T^2d against d^2. The most common error was probably the use of awkward scales which consequently resulted in the misplotting of points. Some weaker candidates used compressed scales which resulted in the plotted points occupying only a small part of the graph grid. It is expected that scales will be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. A few candidates used scales that resulted in points beyond the grid. In these cases the plotting marks were not awarded. Most candidates were able to draw an acceptable line of best fit. The correct method was usually used in the determination of the gradient, although weaker candidates tended to use small triangles or mis-read co-ordinates. It is expected that the length of the hypotenuse of the triangle used will be greater than half the length of the drawn line. The y-intercept was usually read correctly or $y = mx + c$ used effectively. The most common error was in reading the y-intercept from a line where $x \neq 0$.

(c) In the analysis section weaker candidates did not realise that the expression had to be multiplied by d throughout in order to equate k with the gradient and A with the y-intercept. Many of the weaker candidates did not attempt the analysis section at all. The better candidates found values for k and A although sometimes the units had been omitted or were incorrect.

(d) Candidates who had completed **(c)** correctly usually scored in this section, although sometimes there was confusion over units (in converting centimetres into metres) leading to power of ten errors in the value of the period.

Question 2

In this question candidates were required to design a laboratory experiment to investigate how magnetic flux density affects the angle through which beta particles are deflected when they pass through a uniform magnetic field. Almost all candidates identified the need for a source, magnetic field and a detector, although many of the weaker candidates got no further than this. Candidates were directed in part **(b)** to state a method by which beta particles *only* would be detected. It was common to see answers where a lead plate had been placed in front of the source to 'absorb the gamma radiation' making the experiment unworkable. The better candidates correctly used paper (or a few centimetres of air) to absorb the alpha particles although they were generally less confident about what should be done with the gamma radiation. The quality of diagrams was variable. A good, well-annotated diagram could gain half the marks for the question, whereas a poor one received little or no credit.

There was much confusion about the detection of radiation, and it was clear that a significant number of candidates had little or no experience with radiation experiments of any kind. Quite a lot of designs involved the whole experiment being done in a cloud chamber or bubble chamber, and spectrometers/CRO's/ travelling microscopes were often stated as detectors of radiation.

In the measurement of the angle of deflection, candidates' answers tended to be very vague. 'I would use a protractor to measure the angle' was common. The better candidates suggested measuring lengths and using a trigonometrical ratio. Some of the weaker candidates attempted to use a formula to 'measure' the angle. $F = BIL\sin\theta$ was often stated.

In part **(d)** candidates were required to give details of the method of production of a uniform magnetic field. Many of the weaker candidates suggested using permanent magnets and increasing the separation of the pole pieces. This was not accepted unless it was clear that the magnets were quite large so that the field remained reasonably uniform. Common unworkable suggestions included bar magnets surrounded by a current-carrying coil; electromagnets using a.c.; charged electrical plates (i.e. using an electric field instead of a magnetic field). In some answers the orientation of the magnetic field was incorrect. This was usually when the beta particles were directed along the axis of a current-carrying solenoid. The more able candidates usually suggested the use of Helmholtz coils.

It was pleasing to see significant numbers of candidates suggesting the use of a Hall probe to measure the magnetic flux density. A few candidates mentioned search coils and current balances, both of which were accepted.

As in previous years many inappropriate safety precautions were given. The most common included lead suits; concrete boxes; lead-lined laboratories; lead gloves; lead goggles and film badges. Sensible ideas only were given credit (e.g. do not look at the source directly; use of a source-handling tool; do not point the source at anyone; store the source in a lead-lined box away from work areas etc.).

As in previous years marks were available for good further detail. Some suggestions made by candidates that were credited are as follows:

- Repeat readings to allow for the randomness of the activity of the source.
- Calibrate the Hall probe before use.
- Details of how the calibration would be carried out.
- Plane of the semiconductor slice in the Hall probe must be perpendicular to field lines.
- Use of a collimated beam of beta particles.
- Separation of Helmholtz coils is equal to the radius of one of the coils.
- Relevant detail relating to the use of Fleming's left hand rule for deflection of beta particles.

Paper 9702/06

Options

General comments

The overall standard of the work in this paper was somewhat disappointing. The mean mark was considerably lower than in Paper 4. Candidates who appear to be performing well in Paper 4 frequently score low marks in this paper.

Candidates do not appear to be giving sufficient emphasis to the preparation for this paper. In many instances, basic knowledge was far from satisfactory. The Options provide the opportunity to apply physics theory to more practical situations. In sections of questions where candidates are asked to 'discuss' or to 'suggest', it becomes abundantly clear that many have little or no appreciation of basic concepts. On the other hand, there were some scripts that were very pleasing. These candidates had a thorough knowledge of the relevant physics and were able to apply this knowledge sensibly.

The most popular options were ***Options F*** and ***P***. However, high-scoring candidates were not limited to these Options. There was no evidence that the vast majority of candidates had insufficient time to complete their answers.

Comments on specific questions

Option A

Question 1

(a) There were some very good statements. A common misconception was to state that the night sky should be bright because all light from the stars should end up on Earth.

(b) In general, not well answered. Candidates failed to appreciate that an expanding Universe would not be infinite. Furthermore light from distant galaxies may not, as yet, have reached Earth.

Question 2

(a) There were many correct answers but candidates tended to make difficulties for themselves. Rather than use the fact that 1 pc is 3.26 ly, they converted both the light-year and the parsec to metres.

(b) Disappointing, with very few correct answers. Many did not realise that the base line for measuring the angle is 2 AU. Rather than use the definition of the parsec to determine this angle, they once again attempted to convert all distances to metres.

Answers: **(a)** 4.9 pc; **(b)** 0.41 arc sec.

Question 3

(a) The majority of candidates scored one mark because they failed to state the condition for the Universe to appear to be isotropic. That is, the Universe must be considered on a sufficiently large scale.

(b) Most candidates did mention 3 K, but many gave the impression that they did not understand what this meant. The significance of the uniformity of the radiation was not appreciated by most candidates.

Question 4

(a) In general, few marks were scored in this part of the question. Most candidates did little more than state that planets do not give off their own light. The consequence of this statement was not discussed. Furthermore, the fact that the planets are, by comparison, small and cannot be resolved at such great distances was not appreciated.

(b) Again, answers lacked detail. Some answers made reference to 'orbits of the stars', but in general, statements were vague. It was expected that candidates would discuss either 'wobble' in the position of a star or changes in the intensity of the starlight.

Option F

Question 5

(a) There were very few correct answers to this relatively straight-forward calculation. Most answers involved finding either the volume of polystyrene or the volume of water that would have a weight of 25 N. A significant number of answers did not involve *g*. Others used the approximation $g = 10\ \text{N kg}^{-1}$. Candidates should be advised to use the data as provided on page 2 of the paper.

(b) The majority of candidates failed to read the question and, instead of discussing the use of the polystyrene in the event of capsize, they discussed stability of the upright boat. A common response here was a statement to the effect that polystyrene should be placed at A to lower the centre of gravity.

Answer: **(a)** $2.6 \times 10^{-3}\ \text{m}^3$.

Question 6

(a) There were some good answers to this part. However, some attempted an explanation without any reference to air and others considered the speed of molecules, rather than any bulk effect. Frequently, candidates failed to mention that, for the Bernoulli effect to apply, the air must be undergoing streamline flow.

(b) The fact that many candidates failed to mention streamline flow in **(a)** may account for the poor quality of the responses in this part. Very few considered the spoiler as producing turbulence. Rather, the spoiler was thought to prolong streamline flow, directing the air upwards.

Question 7

(a) Many marks were lost through a failure to appreciate that, in streamline flow, the streamlines are smooth. Frequently, sharp bends were seen and the diagrams did not show any symmetry. Others maintained a constant separation between the lines, rather than a reduction near the sphere.

(b)(i) Many quoted the correct formula without any explanation and then proceeded to calculate the correct answer. There were, however, answers where candidates should have realised that there was an error. Speeds in excess of the speed of light are not reasonable!

(ii) There were many incomplete attempts at the calculation. Where an answer was obtained, this was usually the fraction that had settled, rather than the fraction that remains suspended.

Answers: **(b)(i)** $1.35 \times 10^{-6}\ \text{ms}^{-1}$, **(ii)** 0.39.

Option M

Question 8

(a) It was pleasing to note that the majority of explanations were good, with many achieving full credit.

(b)(i) There was widespread confusion as to which trace-length should be used. This was compounded by a widespread failure to halve the total distance in order to find the thickness.

(ii) Again, there was confusion as to which trace-length should be used, with many choosing the distance between the largest peaks. Furthermore, many did not realise that the speed in fat would be different to the speed in muscle, despite being given the data in the stem to the question.

Answers: **(b)(i)** 0.29 cm, **(ii)** 4.1 cm.

Question 9

(a) Explanations tended to be vague, with statements such as 'ability to focus at different distances'. It should be realised that accommodation is the ability to form focused images on the retina of objects at different distances from the eye. Some candidates concentrated their answers on the effect of the ciliary muscles on the lens.

(b)(i) In general, a sensible range was given.

(ii) Although there were some correct answers, the majority of candidates failed to consider any sign convention when substituting values into the lens formula.

(iii) There were some good answers to this part. Generally, a sketch diagram was drawn and the two sections of the bifocal lens were identified correctly.

Answers: **(b)(ii)** 3.17 D, - 0.25 D.

Question 10

Candidates were expected to recall the frequency range for normal hearing and to realise that, at 3 kHz, the *I.L.* for normal hearing is about 0 dB. They could then comment on the given curve. In fact, very few candidates gave any detail. Most were content merely to say something to the effect that only loud sounds could be heard.

Option P

Question 11

(a)(i) Most answers involved solar power per unit area. However, very few made it clear as to either the angle between the direction of the radiation and the area or the location of the unit area.

(ii) There were comparatively few correct answers. Most candidates used the formula πr^2 for the area and thus obtained an answer of approximately 5.5 kW m^{-2}.

(b) Many candidates thought that N would be closer to the Sun and consequently, solar power would be greater. There were numerous references to $1/\cos\theta$, with no clear explanation as to the meaning of θ. Others stated that the area would be larger, without giving any further explanation. Candidates should be encouraged to draw simple sketches to illustrate their work.

Answer: **(a)(ii)** 1380 Wm^{-2}.

Question 12

(a) Generally, candidates did make two relevant points. Frequently, however, the same point was made twice, with slightly different wording.

(b) Many candidates gave the impression that they thought the energy used to pump the water from the lower to the higher reservoir was 'free' and frequently, it was stated to be pollution-free. The fact that the system can be used to provide power at short notice when there is a sudden increase in demand was made clear in relatively few of the scripts.

Question 13

(a)(i) With few exceptions, candidates gave a correct expression for work done. However, the substitution leading to the given answer was sometimes suspect.

(ii) There were very few correct answers here.

(iii) Most candidates thought that the total energy input was 2500 J, thus failing to include the work done when compressing the gas.

(b) With few exceptions, adiabatic compressions or adiabatic expansions were identified as a similarity. There were some very good descriptions of the difference, related to the stage AB of the cycle. However, there were many who did not appear to recognise the difference in the shape of the indicator diagram.

Answers: **(a)(ii)** 1275 J, **(iii)** 56%.

Option T

Question 14

(a) With very few exceptions, the correct expression was given.

(b) The calculation was completed successfully by most candidates.

(c)(i) Candidates should make reference to signal power, rather than signal 'strength'.

(ii) With few exceptions, candidates arrived at the correct answer. However, rather than divide the answer to **(b)** by 3.2, many proceeded to re-calculate the power loss in dB.

Answers: **(b)** 14 dB above; **(c)(ii)** 4.4 km.

Question 15

(a) Explanations were, in general, very good. It appeared that many candidates had committed to memory this particular description.

(b)(i) There were some errors associated with powers-of-ten, but otherwise, the calculation presented few problems.

(ii) Most did give the bandwidth as 7 kHz, but a significant number quoted 3.5 kHz.

(iii) There was much confusion here, with the most popular answer being 53.5 kHz.

Answers: **(b)(i)** 6000 m, **(ii)** 7.0 kHz, **(iii)** 3.5 kHz.

Question 16

(a) Most answers included the fact that the orbit is equatorial with a period of 24 hours. Only a minority gave the direction in which the satellite must move i.e. from west to east.

(b)(i) There were some very unusual suggestions here. The most common error was confusion between MHz and GHz.

(ii) Most candidates seemed to be familiar with the term 'swamping'. However, it was not always clear what was being swamped, and by what.

(c) This part was not done well by many candidates. There was confusion between advantages and disadvantages and some misconceptions. It was common to find that it was thought only one geostationary satellite would be required for world-wide cover. These same candidates would then state that communication with polar regions would not be possible.