PHYSICS

GCE Advanced Level and GCE Advanced Subsidiary Level

Paper 9702/01

Multiple Choice

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

General comments

The paper proved to be very satisfactory, with good discrimination and a relatively high overall facility. The mean mark was 27.3 with a standard deviation of 6.8. It was particularly pleasing that every question gave positive discrimination. Where a question was difficult it was only the able candidates who were able to answer it. There was no question where weak candidates were able to score more highly than able candidates. Approximately 40% of the candidates scored 30 or more. This shows that the vast majority were well prepared for the test and knew the fundamental facts of most of the syllabus items. Each section of the AS syllabus was covered by the test and the intention is that, within each section, there should be a progression of difficulty starting with easier questions and proceeding to more difficult ones. It is difficult to extract any evidence of candidates running out of time on the test but it is important for Teachers to brief their candidates never to spend an undue length of time on any particular question. If a candidate gets stuck on a question just leave it until the end and come back to it if there is time. In this case, be particularly careful to leave a blank box on the answer sheet, hence ensuring that each subsequent answer goes into the correct box.

Comments on specific questions

Questions 1, **10**, **12**, **16**, **17**, **19**, **22**, **24**, **26**, **27**, **30**, **33**, **38** and **39** were straightforward and the marks were correspondingly high.

Question 2 is on a topic which is one of the most intellectually difficult parts of the syllabus yet still 40% of candidates managed to get it right. There are two alternative ways of thinking about vector subtraction. They are; what needs to be added to vector *Y* to get vector *X* or, and more common, but less easy to use in practice, vector *Z* = vector *X* + (- vector *Y*).

Algebraic questions generally prove to be more difficult for candidates than arithmetical ones so perhaps more practice needs to be done on questions like **Questions 11**, (59% correct), **14** (43% correct) and **21** where there were only 16% correct answers, the lowest figure on the paper.

Candidates must be careful to answer the question set. It would help if they realised that all the data which they are given is going to be used somewhere in the question. In **Question 32** far too many candidates (32%) ignored the factor of 16 and just worked out the resistance of the bulb when hot, 576 Ω. In general, questions on electricity scored less highly than those on other topics.

The unfamiliar nature of **Question 40** did not discourage candidates. 67% of them managed to get **C** as the correct response.

Paper 9702/02

Structured Questions

General comments

The overall standard of the candidates' work varied widely. There were some very good answers, showing clear understanding of the underlying concepts and thorough preparation for the examination. On the other hand, some candidates were unaware of basic ideas and consequently, scored very few marks.

It was pleasing to note that the general level of explanation given in calculations and descriptive parts of questions is improving. However, questions where a descriptive answer is required are still a general weakness. Candidates could benefit from further practice at such questions.

There appeared to be sufficient time for candidates to complete their answers. Where candidates cannot complete a section of a question, they should be encouraged to write down any *relevant* physics that they know. A blank answer paper will always score zero.

Comments on specific questions

Question 1

Only a minority of candidates scored full marks in this question and, although two parts could be answered by calculation and not estimation, many scored fewer than two marks. Since estimates were being asked for, the marking scheme allowed for a range of answers. The vast majority of candidates were either within the range or were several powers of ten away from an acceptable answer. For example, in **(d)**, answers varied from 10^{-4} Pa to 10^{15} Pa.

Question 2

(a) With few exceptions, candidates realised that the zero error would introduce a systematic error. However, their reasoning was frequently suspect. An answer such as 'because the error is in the instrument' is insufficient. Candidates should be encouraged to think about such an error as being constant in magnitude and in one direction only.

(b) Candidates were expected to state what aspect makes the readings precise (reproducibility of the reading) and what causes the readings to be inaccurate (zero error). This distinction was frequently unclear. An answer such as 'the readings are precise because a micrometer is a precise instrument' was not acceptable.

Question 3

(a) Candidates should be encouraged to give brief but precise explanations/definitions. Answers from weaker candidates often made reference to 'weight acting over a region'. It should be realised that 'the weight may be considered to act at this point'.

(b) In part **(i)**, it was surprising how many answers were not correct. Automatically, candidates seemed to think that the readings on the two meters must be equal, rather than consider the equilibrium of the plank. Similarly, in **(ii)**, most showed the centre of gravity at the geometrical centre. In the calculation in part **(iii)**, candidates were expected to state about which point they were taking moments. There were some very good clear answers. Equally, some responses consisted of a series of numbers, not including all of the relevant moments and with the moments taken about a number of different points.

Answers: **(b)(i)** 380 N, **(iii)** 108 cm.

Question 4

(a) This section could be answered either by energy considerations or by use of an equation of motion. Both approaches were equally acceptable and the majority of answers were correct. Candidates should be discouraged from using the value of 10 m s^{-2} for g, unless they are told to do so or they are carrying out an estimate. Using g = 10 m s^{-2} and then giving an answer to three significant figures is clearly incorrect.

(b) In part **(i)**, most candidates actually calculated 90% of the kinetic energy and then equated this with the change in gravitational potential energy. This involved much work and was unnecessary. They should have realised that the new potential energy would be 90% of the initial potential energy and hence the ball would rises to 0.9 times the initial height. It was not uncommon to find, either here or in **(c)**, that the mass was not expressed in kilograms. In part **(ii)**, those who had completed part **(i)** were usually able to complete this calculation.

(c) Answers here were disappointing. With very few exceptions, candidates did not appreciate the vector nature of momentum and consequently subtracted the final momentum from the initial value. Clearly, the consideration of direction should be emphasised.

(d) Answers to this section were very disappointing. In general, it was stated that momentum had not been conserved and consequently the collision is inelastic. Others realised that momentum must be conserved and then said that the change calculated is small! There appears to be little understanding that momentum is conserved only in a complete system. Candidates were expected to make reference to the Earth/plate and that the Earth/plate experiences a change in momentum equal in magnitude but opposite in direction to that of the ball.

Answers: **(a)** 5.6 m s^{-1}; **(b)(i)** 1.4 m, **(ii)** 5.3 m s^{-1}; **(c)** 0.80 N s.

Question 5

(a) There were few correct answers here. Many did not give a response or merely 'moved the piston'. It was expected that the cylinder would be raised vertically.

(b) The majority of candidates stated that the piston would be moved out in order to increase the volume. It was not expected that they should make a reference to the speed of the change.

(c) As in **(b)**, most candidates gave a correct response.

Question 6

(a) In part **(i)**, most candidates showed the top plate as being positive. Although most answers in part **(ii)** were correct, a significant minority either did not express the separation in metres or became confused with the algebra when re-arranging the expression $E = V/d$.

(b) The calculation provided very few problems for average and above average candidates. A common error was to assume that the force is given by the product of potential difference and charge.

Answers: **(a)(ii)** 360 V; **(b)** 5.3×10^{15} m s^{-2}.

Question 7

(a) The standard of the drawings frequently indicated that little care had been taken. It was expected that constant wavelength would be indicated. In some diagrams the wavelength varied by a factor of two or three and was nothing like the incident wavelength. For the narrow slit, the circular wavefronts were seldom centred on the slit. As regards the wider slit, the majority of drawings did indicate plane wavefronts in the central region. However, the extremes of these wavefronts were often shown as straight. Seldom were they shown as arcs of circles. Also, attention should be paid to the extent to which the wavefronts are diffracted into the geometrical shadow.

(b) Most candidates could recall the formula for the diffraction grating and a pleasing number arrived at the correct answer. The most common error was in the identification of the correct angle. It was common to find that either 162° or 136° was used. Very few used the first order rather than the second order.

(c) Although a minority of candidates made reference to more slits allowing a higher intensity of light to pass through, most had no real understanding of the situation. It was common to find a response based on 'the amount of diffraction' of light.

Answer: **(b)** 5.6×10^{-6} m.

Question 8

(a) As was to be expected, parts **(i)** and **(ii)** were completed successfully by most candidates. In part **(iii)**, some did not attempt an answer. However, there were many ingenious solutions based on a large number of resistors. Any correct solution was given full credit. A significant minority did solve the problem using only four resistors.

(b) In most scripts, part **(i)** was completed successfully. A minority assumed that the given power was dissipated in the whole circuit. A common error in part **(ii)** was a failure to realise that only half of the current calculated in **(i)** would be seen in each of the 25 Ω resistors.

Answers: **(b)(i)** 0.90 A, **(ii)** 0.51 W.

Question 9

Answers to this question were, with few exceptions, disappointing. Candidates gave superficial answers that were below the standard expected.

(a) Most candidates stated that α-particles will not pass through aluminium. They were expected to realise that, even with no thickness of aluminium, the α-particles could not be detected since the air gap between the source and detector is too large. The graph does start at $x = 0$.

(b) Part **(i)** was frequently dismissed with a comment to the effect that 'β-particles can't pass through aluminium' or 'β-particles can pass through only a few mm of aluminium'. Candidates were expected to comment on the possible range of β-particles in aluminium and then to make reference to the rapid decline in count rate up to $x = 2$ mm.

(c) The most common answer here was to state that the count rate does not change after $x = 2$ mm and that γ radiation is not stopped by aluminium. Candidates were expected to realise that the count rate decreases gradually for $x > 2$ mm and that this can be attributed to the high penetration of γ radiation in aluminium.

Paper 9702/03

Practical 1

General comments

The paper proved accessible to the vast majority of candidates, and there were only a few reported cases of assistance being given to candidates by Supervisors.

Most Centres were able to obtain the specified apparatus without difficulty. There was no evidence that candidates were short of time.

It was pleasing to see many of the able candidates scoring marks which were close to the paper maximum. A number of the very best candidates were able to achieve full marks.

A number of candidates continue to be well prepared in basic practical techniques, which usually results in a high mark.

Comments on specific questions

Question 1

In this question candidates were required to investigate the torsional oscillations of a loaded rod suspended by a spring. Most candidates were able to assemble the apparatus without help and perform the experiment as instructed.

Most candidates were able to take six sets of readings of d and t and correctly calculate values of d^2 and T^2 from the results. A few candidates did not realise that the raw times had to be divided by the number of oscillations, and used values of t^2 instead of T^2.

A number of weaker candidates timed too few oscillations, which resulted in raw times that were too small. Generally it is expected that the raw times will not be less than twenty seconds. Very weak candidates attempted to measure the period directly by timing just one oscillation.

Most candidates presented the results in a table. Weaker candidates often omitted the units of T^2 or d^2 or both in the column headings. A solidus notation is preferred (e.g. T^2/s^2).

It is expected that candidates will record the raw readings to an appropriate number of decimal places. Values of d were often given to the nearest centimetre instead of the nearest millimetre. Generally it is expected that values of d will be recorded to the nearest millimetre if a rule with a millimetre scale is used to make the measurement.

Weaker candidates measured one raw time for each value of d, and did not repeat the measurement. Average times are expected, and should be given in the table of results.

Candidates were required to justify the number of significant figures, which they had given for d^2. Many of the weaker candidates omitted this section or gave vague responses such as 'I have given d to three significant figures' without stating <u>why</u> they had done so. All that was required is a simple statement, which related the number of significant figures in d to the number of significant figures in d^2 (e.g. 'I have given the values of d^2 to three significant figures because the values of d have been given to three significant figures' would get full credit).

In the table of results the values of d^2 should be recorded to the same number of significant figures, or one better than, the raw values of d. Weaker candidates are still confused between decimal places and significant figures.

Candidates were required to plot a graph of T^2 against d^2. Generally this was done quite well, although the weaker candidates often chose to use compressed scales (where the plotted points occupied less than half the graph grid in either the x or y directions, or both). The graph grid measures eight large squares (in the x-direction) by twelve large squares (in the y-direction) and therefore it is expected that the plotted points would occupy at least four large squares in the x-direction and six large squares in the y-direction. The scales should be easy to work with (i.e. scales of 2:10 or 5:10 and not 3:10 or 6:10) and labelled regularly.

Points were usually plotted correctly (allowing a tolerance of half a small square) and lines of best fit drawn quite well. It may be helpful to candidates if they could be encouraged to use clear plastic rules when drawing lines of best fit. This is because all the points can be seen when the line is drawn, and therefore it is easier to judge the balance of points. The line of best fit mark was sometimes not awarded because points that were not on the line were all to one side of the line (either above or below) instead of being reasonably scattered about the line.

Two marks were available for the 'quality of results'. This was judged on the scatter of points about the line of best fit. The candidates who had done the experiment carefully were able to score both of the quality marks if the scatter was small.

Candidates were instructed to find the gradient of the line. It is expected that candidates will use reasonably well-spaced co-ordinates on the line when determining the gradient. Generally it is expected that candidates will use triangles where the length of the hypotenuse is at least half the length of the line, which has been drawn. A number of weaker candidates calculated $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$.

It is sometimes the case that the scales are such that the origin is not on the graph grid. In this case it is expected that the co-ordinates of points on the line will be substituted into $y = mx + c$ and the y-intercept calculated. However, the majority of candidates were able to read the y-intercept directly.

The weaker candidates found the analysis section difficult, and many did not make any attempt to find k or I_o. It was expected that the gradient would be equated with $\frac{8\pi^2 m}{k}$ and the y-intercept equated with $\frac{4\pi^2 I_o}{k}$. Quite a few candidates attempted to use simultaneous equations after substituting data into the formula. This usually resulted in complex algebraic working which did not gain any credit. The equation had been given to candidates in the form $y = mx + c$ to try and avoid this.

Many candidates omitted the units of k and I_o with their values.

It was pleasing to see that almost all of the more able candidates were able to find a value for T when the were no balls on the rod by either finding the square root of the y-intercept or by substituting $m = 0$ and values of k and I_o into the given equation.

Paper 9702/04

Core

General comments

There were some well-prepared candidates who scored high marks. At the other end of the scale, some scripts indicated very little understanding of basic concepts.

Where a question asks for candidates to *show* a particular result, then they should realise that credit is given for the explanation and not for a statement of the result.

Candidates appeared to have sufficient time to complete their answers.

Comments on specific questions

Question 1

(a) Most candidates gave a relevant algebraic expression for g and then made a correct substitution of numerical values. The data were given to three significant figures. Consequently, a penalty was imposed where the value of g was said to be 10 m s^{-2}.

(b) Part **(i)** was completed successfully by most candidates although a minority took the period of rotation to be 1.0 year. Part **(ii)** proved to be more difficult. Some could not equate centripetal force to gravitational force. Of those who did substitute correctly into a relevant formula, there were problems with taking a cube root.

Answers: **(b)(i)** 7.3×10^{-5} rad s^{-1}, **(ii)** 4.2×10^{7} m.

Question 2

(a) Some candidates were unable to distinguish between external work done and change in internal energy. Consequently, they made vague references to changes in energy when bonds are broken. In **(i)**, they were expected to make reference to an increase in volume on evaporation and thus the external work done against the atmospheric pressure. In part **(ii)**, the usual answer was a vague reference to internal energy being the sum of the (random) kinetic energies and potential energies of the molecules. Candidates were expected to state that the kinetic energy would be constant (the temperature is constant) and that the potential energy would increase (bonds between molecules are 'broken'), leading to an increase in internal energy. A significant number of answers involved, quite wrongly, change in temperature on boiling.

(b) Answers to this section were also, in general, poor. Most candidates could do little more than give an algebraic expression relating change in internal energy to heating and work done. The signs in the expression were not explained nor was any argument given as to why thermal energy must be supplied.

Question 3

(a) A significant number of candidates failed to make a reference to *mean* or *average* kinetic energy. Furthermore it was not made clear that it is the atoms or molecules of the substance that are considered. In part **(ii)**, the majority of candidates were able to give a satisfactory answer, although there were a number of references to the triple point of water or its freezing point.

(b) It was pleasing to note that very few candidates failed to use kelvin temperature in the equation. As a result, this part of the question was answered well. In **(ii)**, a significant minority did not appear to know how to attempt the question. However, there were many correct solutions with adequate explanation.

Answers: **(b)(i)** 0.93 mol, **(ii)** 1.4×10^{5} Pa.

Question 4

(a) In part **(i)**, most candidates did make reference to both the magnitude and the direction of the acceleration. However, a minority indicated a very superficial knowledge. 'Up-and-down' motion was not uncommon. In **(ii)**, there were many sketches involving sinusoidal waves rather than a straight line with negative gradient, passing through the origin. Candidates should be advised to ensure that the amplitude in the positive and negative directions are made equal.

(b) A sinusoidal waveform with troughs at E_P = 0 was seen infrequently. The most common sketch was that of 'full-wave' rectification. Maxima and minima were usually shown in the correct positions.

(c) Usually the period was said, quite correctly, to be shorter. However, there appeared to be some guesswork involving the amplitude. The amplitude would be larger and the oscillations would be about the horizontal position of the metal strip.

Question 5

(a) With few exceptions, reference was made to work done. However, many failed to mention either that unit charge must be considered or that the charge is positive.

(b) This section of the question was done well by most candidates. It was pleasing that in the majority of scripts, the explanation given in part **(iii)** was more than adequate.

(c) In part **(i)**, many candidates calculated correctly the capacitance in farads but were then unable to convert the value into μF. In **(ii)**, a correct expression for the energy was usually given. However, many calculations involved finding the potential of the sphere, resulting in arithmetical errors. It may have been preferable to use the expression $E = Q^2/2C$.

Answers: **(c)(i)** 1.7×10^{-5} μF, **(ii)** 0.12 J.

Question 6

(a) Answers to this section were, generally, disappointing. Many thought that the induced e.m.f. would be proportional to the current in the coil. Candidates were expected to realise that, when the current is constant, the induced e.m.f. is zero. Marks were given for realising that the two 'pulses' would have opposite polarities and also for the correct shape for one of the two pulses.

(b) In general, candidates were able to give correct responses for parts **(i)** and **(ii)**. In part **(iii)**, the majority could give the correct position for the smoothing capacitor. However, explanations were usually inadequate. A common answer was 'the capacitor discharges when the voltage drops'. As is often the case where explanation is required, a reasonably annotated sketch diagram is highly beneficial.

Answer: **(b)(ii)** 8.5 V.

Question 7

(a) With few exceptions the phenomenon was identified correctly.

(b) In part **(i)**, some attempted to answer the question without drawing a best-fit line on Fig. 7.1. The line was also required in order to answer part **(ii)**. A significant minority attempted, quite wrongly, to determine *h* by using one point only from the graph, rather than using the gradient of the line.

(c) Most candidates did draw a straight line with the correct gradient and intercept. Those answers where the two lines on Fig. 7.1 were not parallel were usually found in low-scoring scripts.

(d) It was expected that candidates would realise that, where an electron interacts with a photon on the surface of a metal, the electron will have maximum kinetic energy. The electron has less than this maximum energy when the interaction takes place below the surface. Few answers were along these lines. Despite being told in the question that the radiation is of one frequency only, most attempted an explanation in terms of a range of incident frequencies.

Answers: **(b)(i)** $(6.8 \pm 0.4) \times 10^{14}$ Hz, **(ii)** $(6.6 \pm 0.4) \times 10^{-34}$ J s.

Paper 9702/05
Practical 2

General comments

The paper proved accessible to the vast majority of candidates, although there were a few reported cases of assistance being given to candidates by Supervisors in **Question 1**. This was usually in the construction of the circuit (e.g. the voltmeter or ammeter had been placed incorrectly). It is important that Supervisors be especially vigilant at the start of the experiment to ensure that candidates have connected the circuit correctly. It is not the intention of the Examiners that candidates should spend too much time struggling with the wiring. It is much better that Supervisors give the minimum amount of assistance to candidates in order that they may obtain a set of results. The type of help given should be detailed in the Supervisor's Report and sent with the scripts. The penalties for Supervisor help are not large (one mark deducted for minor help, perhaps reconnecting the voltmeter, or two marks will be deducted if the Supervisor has to construct the circuit for the candidate). However, Supervisors are reminded that under *no circumstances* should help be given with the recording of results, graphical work or analysis.

Most Centres were able to obtain the specified apparatus for **Question 1** without difficulty, although some of the bulbs used by candidates were not of the specified rating, and some power supplies were not able to deliver currents in the range given in the question paper. In cases such as these candidates should be informed of the change before the start of the Examination, and what the new range of currents will be. They should also be told that no penalties will be incurred as a result of the changes. This procedure is quite acceptable provided that the *form* of the experiment is *unchanged* (i.e. both bulbs are of the same type and the same power rating, and a graph of lg (I/A) against lg (V/V) gives a straight line which does not pass through the origin). Supervisors should trial the experiment beforehand and submit a sample set of results with comments as necessary. Supervisors should contact the Physics Product Manager at CIE if changes need to be made.

There was no evidence that candidates were short of time, although many of the weaker candidates omitted the analysis section in **Question 1**.

It is apparent that significant numbers of candidates are experiencing problems with the design **Question 2**. Answers showed lack of familiarity with basic equipment and techniques, and many candidates did not address the question that had been set. Often the weaker candidates did not attempt the question at all.

Comments on specific questions

Question 1

In this question candidates were required to investigate the characteristics of two filament lamps. Most candidates were able to assemble the circuit without help and perform the experiment as instructed. The experiment itself was quite straightforward, and it did not take long for candidates to take the required set of results using the apparatus. However, two graphs had to be plotted, and there was quite a lot of analysis to do. Some of the weaker candidates used the first bulb in the circuit, and then replaced it with the second bulb to give an identical set of results (i.e. did not use the bulbs in parallel).

Most candidates presented the results in two tables. Column headings were usually correct, although weaker candidates often gave raw values of V or I to an inappropriate number of decimal places. Values of I were sometimes given to varying numbers of decimal places, even though the same meter had been used to take the readings. Candidates were told to calculate values for $\log_{10}$ (I/A) and $\log_{10}$ (V/V), but quite a few used $\log_e$ instead of $\log_{10}$.

Candidates were required to plot a graph of lg (I/A) against lg (V/V). Generally this was done quite well, although the weaker candidates often chose to use awkward scales, which made the plotting of points difficult. The scales should be easy to work with (i.e. scales of 2:10 or 5:10 and not 3:10 or 6:10) and labelled regularly.

Data values were usually plotted correctly (allowing a tolerance of half a small square) and lines of best fit drawn quite well. It may be helpful to candidates if they could be encouraged to use clear plastic rules when drawing these lines. This is because all the points can be seen when the line is drawn, and therefore it is easier to judge the balance of points. The line of best-fit mark was sometimes not awarded because points that were not on the line were all to one side of the line (either above or below) instead of being reasonably scattered about the line.

One mark was available for the ‘quality of results’. This was judged on the scatter of points about the lines of best fit. The candidates who had done the experiment carefully and read the meters correctly were able to score this mark if the scatter of points about each line was small. A number of candidates read incorrect columns from the table of results and plotted I against V or lg (I/A) against V. In these cases the quality of results could not be judged from the graph, since the points gave a curved trend.

Candidates were instructed to find the gradient of each of the lines. It is expected that candidates will use reasonably well-spaced co-ordinates on the line when determining the gradient. Candidates should use triangles where the length of the hypotenuse is at least half the length of the line that has been drawn.

The weaker candidates found the analysis section difficult, although quite a number were able to make a good start by expressing the given equation in logarithmic form (i.e. $\lg I = n \lg V + \lg k$) but many did not go on to find values for n or k. It was expected that the gradient would be equated with n and the y-intercept equated with lg k. Values for n in the range $0.45 \leqslant n \leqslant 0.60$ were credited.

Many candidates were able to state that the values of n were unchanged and the value of k doubled when the two bulbs were placed in parallel. The weaker candidates tended to be rather vague here. 'n is unchanged, but k increases' was a common response. The better candidates went on to suggest that $I = mkV^n$ would be the relationship for m lamps in parallel.

Question 2

In this question candidates were required to design an experiment to investigate how the magnetic field strength of a magnet depends on the temperature of the magnet. Answers were very variable, but generally rather disappointing. Use of a calibrated Hall probe was expected (as detailed on page 8 of the syllabus, Section 2; Measurement Techniques), but in fact a large variety of unworkable responses were seen. It was common to see a bar magnet wired in series with a power supply and meter. Other unworkable methods involved counting the number of paper clips attached to the magnet, plotting compasses, nails, measuring the distance between magnetic field lines (using iron filings), or very confused arrangements involving $F = BIL$. It was common to see the magnet being heated in a solenoid.

Only workable procedures were credited.

A number of the better candidates (who had clearly never seen a Hall probe) made valiant efforts to adapt something that they had seen to the new situation. Complex arrangements involving current balances were quite common, and were quite acceptable if done well. A small number of responses were seen where a search coil had been employed, but many candidates had little idea of how to use it.

A well-drawn diagram showing a Hall probe connected to a micro-ammeter and power supply, where the plane of the conducting slice was shown to be perpendicular to the magnetic field lines, could score several marks if some kind of constant temperature enclosure had been indicated (e.g. an oven). Candidates should be encouraged to include a detailed labelled diagram wherever possible.

A surprisingly large number of candidates used a water bath to heat the magnet to 200 °C. It was clear that some candidates were under the impression that the temperature of the water would become higher if the water were heated for a longer time.

The question stated that a temperature range of 0 °C to 200 °C was to be used. Credit was given for a suitable type of thermometer (e.g. thermocouple or thermistor thermometer). There were many incorrect circuits involving thermocouples and it was clear that few candidates had actually seen or used a thermocouple in an experiment. If a mercury-in-glass thermometer had been suggested, then it was expected that some reference would be made to the range (as an 'ordinary' mercury-in-glass thermometer usually has a range from about –10 °C to 110 °C which is not sufficient in this case).

Quite a number of candidates stated that the magnet had to be left for some time in order to reach thermal equilibrium with the surroundings. Candidates who suggested heating the magnet directly with a Bunsen burner could not score here. An oven or oil bath was an acceptable response.

Candidates were directed in part **(e)** to control of variables. Candidates were rewarded if they stated that the distance from the Hall probe to the magnet must remain constant during the experiment.

Marks were available for good further detail. Examples of some creditworthy points made by candidates are as follows:

- Explanation of how the Hall probe is calibrated
- Use fridge/freezer/ice bath to achieve 0 °C
- Attach the thermocouple/thermistor to the magnet to give a good thermal contact
- Awareness of possible problems with the Hall probe if it is allowed to reach a temperature of 200 °C
- Perform the experiment away from other magnetic materials
- Any relevant safety point (e.g. handle the hot magnet with tongs or gloves).

Paper 9702/06

Options

General comments

The overall standard of the candidates' work was somewhat disappointing. There were some well-prepared candidates but a significant minority did not appear to have a sound understanding of the underlying concepts. It was noticeable that in Centres where candidates had concentrated on only two Options, the general level of performance was usually significantly better than in Centres where most or all of the Options were answered.

Of the 160 marks available for the theory papers, 40 are allocated to this Paper. Candidates should be advised to give the Options appropriate emphasis in their studies.

It was pleasing to note that, with very few exceptions, questions on two Options were answered. The most popular Options (F and P) were not necessarily the Options with the highest mean marks. Many weaker candidates attempted Options F and P, perhaps in the mistaken belief that they could pick up some marks for generalised statements where explanation was required.

Comments on specific questions

Option A

Astrophysics and Cosmology

Question 1

(a) Many candidates thought that the diameter of the Earth's orbit is the AU and consequently, did not score the mark.

(b) In part **(i)**, definitions were generally poor. The majority of candidates made reference to one second of arc without stating what distance (1.0 AU) subtends this angle. In part **(ii)**, some candidates recalled the magnitude of the parsec. Of those who attempted to answer the question, many became confused when making the approximation that $\tan\theta = \theta$ (rad) when θ is small.

Answers: **(a)** 1.49×10^{11} m; **(b)(ii)** 3.1×10^{16} m.

Question 2

(a) Most answers included a reference to the fact that 'all' galaxies are moving away from one another. However very few made a reference to the Cosmological Principle.

(b) This section of the question was answered well.

Question 3

The whole question was poorly answered by the vast majority of candidates. The general impression gained was that the labelling was done by guesswork, as illustrated by the fact that position G would be shown before position D.

Question 4

A common answer was to state that, because the galaxies are very distant, the light has only just arrived at the Earth. Most candidates realised that the detectors would be outside the Earth's atmosphere. However, the reasons for this were seldom made clear.

Option F

The Physics of Fluids

Question 5

(a) Most diagrams showed the metacentre as being 'vertically' above point B and on the line of symmetry of the ship. However, the positioning of the centre of buoyancy (point B) indicated a lack of understanding on the part of many candidates.

(b) Nearly all answers made reference to either increased restoring couple or increased stability, or both. The effect on the ship when in high seas of having too large a restoring couple was appreciated by only a few candidates.

Question 6

The general impression gained was that many candidates work through a derivation of the Bernoulli equation without understanding what they are doing. Consequently, the structuring of the derivation, as in this question, demonstrated this weakness.

(a) Surprisingly few answers were correct.

(b) In part **(i)**, an equation for kinetic energy was given in most answers. However, only a minority could arrive at a satisfactory expression. For part **(ii)**, candidates who appreciated that energy conservation is involved, could write down the answer that they had obtained in **(i)**. Others derived an expression such as $p_1A_1v_1 - p_2A_2v_2$ and were also awarded full credit.

(c) This section involved the part of the derivation that had not been given in **(b)(ii)**. Many candidates did not score full credit here. Although they could derive an expression by equating change in kinetic energy to the product of pressure and volume, they were unable to make the necessary simplification using the equation $A_1v_1 = A_2v_2$. In part **(ii)**, most could give an assumption but in a significant number of scripts, this was the assumption given in the stem of the question (incompressibility).

Question 7

(a) As is often the case where a sketch graph is required, it had been drawn with insufficient care by many candidates. It was expected that the line would be a smooth curve, starting at the origin and approaching a constant velocity.

(b) There were many instances where it appeared as if the candidate understood the situation but did not write down the necessary information. Most did identify the three forces on the sphere, although a significant number did not include drag and, instead, assumed that the upthrust would increase with increasing speed. Then, instead of considering the resultant force and acceleration, most merely stated that the speed would increase, giving rise to an increased drag force. Finally, the forces leading to equilibrium were considered.

Option M

Medical Physics

Question 8

(a) Some candidates mis-read the question and described the generation of ultrasound. There was much emphasis placed on the use of a gel but few mentioned that the ultrasound must be pulsed. Most candidates stated that the signal would be processed. However, few made reference to the time delay between incident and reflected pulses giving information as to the depth of the boundary. This was also true of the intensity of the reflected pulse providing information about the nature of the boundary.

(b) In part **(i)1**, candidates frequently stated that there would be high absorption and consequently no reflection. They should have realised that much of the ultrasound pulse would be reflected and very little transmitted. In part **(i)2**, reference should have been made to the heating effect. The most common answer was that the bones would shatter due to a resonance effect. Part **(ii)** was done well by some candidates who scored few other marks in this Option. The most common problem was in dealing with the mathematics of the situation.

Answer: **(b)(ii)** 2.9.

Question 9

(a) With few exceptions, the defect was identified as being myopia, or short sight.

(b) Surprisingly few candidates obtained the correct answer to this simple calculation. Some failed to include the minus sign but many attempted to involve the near point as well as the far point in the calculation.

(c) Most candidates realised that the object could be focused at a point closer to the eye than for normal vision. Unfortunately, almost without exception, they referred to a 'clearer' image, rather than a larger (angular) magnification.

Answer: **(b)** - 1.33 D.

Question 10

(a) The definition of intensity level was not known well. Vague statements such as 'the loudness of the sound' were common. Candidates must be prepared to give concise definitions.

(b) Answers were disappointing in that they lacked detail. Many were restricted to saying that there is a 'loss of hearing'. Others, quite wrongly, said that the threshold of hearing was lower. Candidates were expected to realise that frequencies above 10 kHz, rather than about 15 kHz cannot be heard and that the threshold of hearing at 3 kHz is above normal (a loss of sensitivity).

Option P

Environmental Physics

Question 11

(a) Many misconceptions became apparent, such as confusion between tidal power and wave power. Rarely did a candidate give a clear distinction between the two. Rather, candidates wrote briefly about each and in isolation from one another. Examiners were instructed to award marks even where a distinction was not made clear.

(b) In part **(i)**, there were a number of candidates who did not attempt the calculation. However, there were many correct answers. The most common error was a failure to find the weight of the mass of water. Part **(ii)** revealed a lack of understanding of the situation. Frequently, the difference was identified as the energy required to pump the water back to the upper reservoir. Very few stated that the output must be less than the input and that energy would be lost as, for example, the kinetic energy of the water emerging from the turbine.

Answer: **(b)(i)** 140 MW.

Question 12

(a) All too frequently, candidates could manipulate the algebra to obtain the correct expression. However they failed to gave adequate explanation, particularly as regards introducing power, rather than just energy.

(b) The calculation presented very few problems. The most common error was to divide the input power by 0.55, rather than multiply by this factor.

(c) Most candidates realised that there would be increased stresses on the turbine, and this was expressed in a number of different ways, such as the turbine collapsing or turbine blades snapping off. Very few mentioned that the blades would be 'feathered'. Instead, they referred to this modern turbine as having holes in its blades.

Answer: **(b)** 14 kW.

Question 13

(a) Many candidates gained full credit in this section, making either two comments in support of the statement, or two against or a mixture of both.

(b) Fewer gained full credit here since many candidates were content to make one comment only, despite two marks being allocated to the section. As is always the situation in questions such as this, any relevant comment is given credit.

Option T

Telecommunications

Question 14

(a) Surprisingly, some thought the modulation to be FM.

(b) Only a minority of candidates correctly determined the two frequencies. The most common answer for the transmission frequency was 5 kHz and for the modulating waveform, 2.5 kHz.

(c) There was a wide variety of answers here, from sinusoidal waves to straight horizontal lines. A minority did show correctly the three vertical lines, but rarely could numerical values be given.

Answers: **(b)(i)** 50 kHz, **(ii)** 5.0 kHz.

Question 15

(a) Candidates divided into two distinct groups. Those who were able to manipulate the power equation (the majority) and those who could not. In general, explanation was adequate.

(b) The most common error here was to use 73 μW, rather than 23 mW, as the minimum power.

(c) Candidates appear to have been well versed in the advantages of optic fibre transmission and many scored full credit with great ease.

Answer: **(b)** 5.0 km.

Question 16

(a) Two possible uses of polar satellites were known by most candidates.

(b) As in **(a)**, answers were generally quite adequate.

(c) Only a minority could give an appropriate value for the wavelength. Estimates ranged from km to nm. Most candidates were aware of the problem associated with swamping.