CONTENTS

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

General comments

The mean mark on this paper, out of 40, was 25.7 and the standard deviation was 7.2. The mean is slightly lower than last June and the standard deviation is slightly up. The distribution of marks effectively ranged from 10 to 40, with thirty two candidates scoring full marks – quite an achievement. All of the questions had facility between 33% and 91% which indicates that there was good discrimination. Too high a facility, with everyone getting a correct answer, does not make for a challenging test and a facility near 25% shows too much guessing. The few questions which were easy help to encourage the weaker candidates and are needed in a forty question paper on a restricted syllabus. There was very little evidence of guessing by the large majority of candidates. Their results indicate a workmanlike approach to the paper with considerable attention to detail. It is essential that candidates do work through all of the possible answers when these answers are verbal and write down calculations on the question paper when the answers are numerical. Working solely on a calculator can lead to many mistakes, particularly with powers of 10. It also helps to prevent careless errors if candidates cover up numerical optional answers while they are doing the question, as it is all too easy to be swayed to a particular value when it is visible.

Comments on specific questions

Some questions caused particular difficulties. These were:

Question 4

Too many candidates gave the answer **B**. This can be solved reliably by sketching on the graph a linear current scale and a few vertical and horizontal lines up and across to the *y*-axis. It seems that too many candidates do not write enough on the question paper itself while they are doing the test.

Question 6

Too many candidates gave the answer **A**. This answer is precise and accurate.

Question 7

Too many candidates gave the answer **A**.

Question 11

Too many candidates gave the answer **D**.

Question 18

Too many candidates gave the answers **B** and **C**, not appreciating the need to subtract 240 kJ from 360 kJ.

Question 20

Too many weak candidates just guessed and gave the answer **B**.

Question 21

Too many weak candidates thought that glass was crystalline rather than copper.

Question 28

Too many candidates gave the answer **B** as a result of not being careful enough with the algebra and getting 2/3 rather than 3/2.

Question 29

Too many candidates of all abilities gave the answer **B**. It is a very common misconception that an earthed plate must have no charge on it. The presence of the negatively charged plate would make the potential of the plate negative were there not some positive charge on it. Also, field lines to a negative charge must start from a positive charge.

Question 31

Too few candidates (42%) gave the correct answer, **C**.

Question 33

Too many candidates gave the answers **A** and **B**.

Question 37

Too many candidates gave the answer **C** by jumping to conclusions after considering only the top two resistors and not appreciating that the p.d. across the left hand pair of resistors is twice that across the right hand pair.

Paper 9702/02

Structured Questions

General comments

Overall, the performance of candidates on this paper was disappointing. Many scripts showed a lack of understanding of basic concepts and also an inability to correctly interpret simple equations when considering the change of one variable with the change in another. Answers to some questions (e.g. **Question 7**) suggested that the subject matter had received very superficial attention in some cases. Answers to **Question 3** showed that momentum concepts are still not understood by most candidates. It was refreshing to find that **Question 5** was well answered by the majority of candidates.

Presentation has been criticised in previous reports and there has been no noticeable improvement this year. In many scripts, sentences were meaningless. The candidate should have realised this, if an attempt had been made to read through the answer. In calculations, the use of the '=' symbol was clearly at fault when quantities were obviously not equal. For example '1.33 mA = 2V' is meaningless. Candidates should be encouraged to express answers using standard scientific notation with an appropriate number of significant figures. Too many mistakes are made by candidates who write out a string of zeros.

There was no evidence that candidates were short of time.

Comments on specific questions

Question 1

(a)(i) In most answers, reference was made to a zero error although some candidates did think that taking the mean of several readings would reduce this error.

(ii) Most answers could be interpreted as calculating the mean of several readings along the length of the wire. However, frequently ideas were expressed rather poorly.

(iii) Far fewer candidates mentioned that either the screw gauge or the wire should be rotated between successive readings.

(b)(i) Most candidates were able to calculate the uncertainty in the diameter.

(iii) Very few realised that the squaring of the diameter in order to calculate the area would simply mean that the uncertainty in the area would be double that in the diameter. Some attempts were based on calculations of areas using extreme, and average, values of the diameter. Frequently, these attempts lead to very unrealistic answers.

Answers: **(b)(i)** 4%, **(ii)** 8%.

Question 2

(a) The majority of candidates could state at least one of the many features common to the regions. A frequent error was to specify a common speed for waves throughout the spectrum with no mention of the medium in which the waves are travelling.

(b) The unit conversion from nanometres to metres presented very few difficulties. A surprisingly large number of candidates then failed to complete the calculation. Eight significant figures for the answer was common.

(c) Most answers were within acceptable limits. However, it was clear that a minority had no appreciation of the wavelengths. Values more appropriate to long-wave radio were not uncommon.

Answer: **(b)** 2.02×10^6.

Question 3

(a) The vast majority of candidates did give an acceptable answer by making reference to either constant gradient or a straight line.

(b) Interpreting the graph to read off the times presented very few problems.

(c) The problem could be approached by considering either the areas of triangles on the graph or by using the equations of motion. Regardless of the approach, this question was, in general, poorly answered. Despite relevant times being given in **(b)**, very few used those answers in the calculation. Very many calculated the area of the smaller triangle and thus determined the maximum height above the girl's hand. Others either found the sum or the difference of the areas of the two triangles. Rarely was there any explanation as to what the candidate was attempting.

(d) Candidates were much more successful in finding the magnitude of the change in momentum. The neatest solutions were in those scripts where change in momentum was equated to the impulse applied to the ball, realising that the gravitational force (weight) acted for 4.0 s. Candidates adopting this approach also avoided the common pitfall of failing to recognise the vector nature of momentum.

(e)(i) Most candidates had some idea as regards the principle but ideas were poorly expressed. Many gave their statements in terms of colliding bodies, rather than the general interaction of bodies within an isolated system. Frequently, statements did not include the fact that the system must be 'isolated' or that there must be no resultant external force acting on it.

(ii) Logical comment was limited to a minority of answers. Two approaches were acceptable. First, the ball and the Earth could be identified as the closed system to which the principle could be applied. Second, it could be argued that the principle does not apply to the ball because it is not an isolated system. Many answers were inadequate in that they were not based on a full statement of the principle. A common answer was to state that the principle does not apply because the ball is not suffering a collision.

Answers: **(b)(i)** 1.2 s, **(ii)** 4.4 s; **(c)** 51.2 m; **(d)** 10 Ns.

Question 4

(a) Opinion was equally divided as to whether the distance between the fixed points represented a half wavelength or one wavelength.

(b) With few exceptions, candidates knew and applied the correct formula relating speed, wavelength and frequency.

(c) There were very few good answers. The majority of candidates completely ignored the instruction to refer to the formation of a stationary wave and thus were unable to discuss the relevance of the speed in **(b)**. Some did mention the speed of a progressive wave, without mentioning its connection to a stationary wave but many thought that the speed referred to the speed of a particle on the stationary wave.

Answers: **(a)** 150 cm; **(b)** 540 ms^{-1}.

Question 5

(a) The expressions were known by most candidates. It was pleasing to note that very few confused stress with strain.

(b)(i) Most candidates did multiply together the three quantities to obtain the correct result. However, rarely was there a clear argument. Candidates should be encouraged to explain clearly their working, especially where they are asked to 'show' the derivation of a given result.

(ii) There was the usual problem associated with changing the subject of an equation. Apart from this, candidates successfully calculated the tension.

(iii) The problem could be approached by calculating either the stress in the wire (assuming it does not snap) or the tension equivalent to the ultimate tensile stress. There were many correct answers with good valid arguments based on an initial calculation. Some candidates attempted to equate tension with stress and others were confused by the fact that the unit of the Young modulus is the same as that of stress.

Answers: **(b)(ii)** 660 N, **(iii)** wire will snap.

Question 6

(a)(i) There were very few correct answers. Most candidates stated, or implied, that resistance is related to the gradient of the line, rather than to the co-ordinates of the point on the line. Many suggested that resistance would decrease because gradient is increasing.

(ii) Most candidates did calculate the resistance correctly, although a significant number read the current from the graph as being 2 A, rather than 2 mA.

(b)(i) A surprisingly large number of candidates made no attempt to draw the required line. Most other candidates did draw a straight line through the origin, but in many cases, the choice of gradient appeared to be rather arbitrary.

(ii) Only a minority of answers indicated that the total current in the battery would be the sum of the currents in the two components. Most candidates gave the current in the resistor as the total current. Where an attempt was made to calculate the total circuit resistance, many either considered the two components to be in series or assumed the resistance of C to be that calculated in **(a)(ii)** and then went on to use the expression for resistors in parallel.

(c) This section was very poorly answered. Most candidates failed to realise that, with components R and C now in series, there would be the same current in each. Furthermore, many assumed that there would be the same p.d. across each. Although most answers included a correct expression for rate of dissipation of energy, most drew unwarranted conclusions. General qualitative and incorrect statements were common, despite the fact that candidates were directed towards use of information from Fig. 6.1.

Answers: **(a)(ii)** $2000 \pm 50\ \Omega$; **(b)(ii)** 2.1 mA.

Question 7

(a) Few candidates appeared to have significant knowledge of the conclusions drawn from the scattering experiment. Many answers ignored evidence related to the nuclear atom but instead, discussed properties of α-particles. Others quoted characteristics of the nuclear atom but attributed evidence for the characteristics to the wrong observation. Candidates should be discouraged from stating that ‘the atom is mostly empty space’. Instead, the relative diameters of the nucleus and the atom should be discussed.

(b)(i) There were very few good diagrams showing the paths of the particles. The paths should show symmetry with respect to the position of the nucleus. This was rarely the case. The path starting along CD should have a smaller deviation than that starting along AB but in many scripts, CD was drawn parallel to AB.

(ii) This path should indicate a deviation much greater than 90° in a ‘downwards’ direction. Instead, many showed a deflection in an upwards direction and, not infrequently, the α-particle ‘bouncing’ off the nucleus.

Paper 9702/03
Practical 1

General comments

The overall standard of the work produced by the candidates was similar to last year, and the paper produced good differentiation between candidates. Disappointingly there were a number of candidates who found the paper quite difficult (scoring marks of less than 10) although it was pleasing to see many strong candidates with scores of 22+. Most Centres had no difficulty with the apparatus requirements, and very little help was given by Supervisors to enable candidates to carry out the experiment. There was no evidence that the more able candidates were short of time, although many weaker candidates did not attempt the analysis sections **(f)** and **(g)**.

Comments on specific questions

Question 1

In this question candidates were required to investigate the oscillations of a pendulum with a yielding support.

Virtually all candidates were able to set up the apparatus without help and measure six sets of values of *d* and *t* as the length *d* was changed.

The majority of candidates were able to calculate the percentage uncertainty in the first value of *d* correctly, although a number of candidates were over-optimistic in the estimation of Δd. It was expected that the uncertainty would be one millimetre (half a millimetre uncertainty at each end of the rule was felt to be the best achievable). The most common error was to use a value for Δd of 1 cm. Sometimes the calculation was not attempted by the weaker candidates.

Almost all candidates were able to measure the time for a suitable number of oscillations of the pendulum and calculate the period *T* for six different values of *d*. It was expected that the readings would be repeated and that there would be sufficient oscillations for a reasonable time interval to be measured (i.e. at least 20 s). A number of weaker candidates did not record the raw values of time. Some candidates calculated values of t^2 instead of T^2 (i.e. did not divide the raw times by the number of oscillations). Some of the very weak candidates attempted to time one oscillation only. Values of d^3 were usually calculated correctly, although a number of weaker candidates recorded values of d^2 instead of d^3.

Virtually all candidates presented the results in tabular form. Sometimes the units for T^2 and d^3 had been omitted, or recorded incorrectly as T^2/s and d^3/m. Raw values of *d* were sometimes given to the nearest centimetre instead of the nearest millimetre. It is expected that the values will be given to the nearest millimetre as a rule with a millimetre scale is being used to make the measurement).

A number of candidates gave the values of d^3 to an inappropriate number of significant figures. If the raw values of *d* are recorded to two significant figures, then it is expected that the calculated values of d^3 will be recorded to two (or three) significant figures. A number of weaker candidates recorded the values of d^3 to one significant figure which usually resulted in increased scatter of points on the graph. Other candidates wrote down the reading in the calculator display, which was often to four or five significant figures.

Candidates were required to plot a graph of T^2 against d^3. Common errors made by the weaker candidates included poor choice of scales (i.e. where the plotted points occupied less than half the graph grid in both the *x* and *y* directions) or where the scales were awkward (e.g. one large square on the grid corresponding to three units). Candidates should be encouraged to use simple scales such that the points fill most of the graph grid. Points were usually plotted correctly. When plotting errors occurred it was usually because awkward scales had been chosen. It is expected that candidates will plot six points since six observations have been made. Candidates who did not plot all their observations were penalised. Most of the better candidates were able to determine a value for the gradient of the line correctly. When the mark was not awarded it was usually because the triangle that had been used was too small. It is expected that the hypotenuse of the triangle will be greater than half the length of the candidate's drawn line. The *y*-intercept was usually read correctly from the graph or found using the co-ordinates of a point on the line and the equation of a straight line. A number of weaker candidates incorrectly read the intercept from a line which was not the *y*-axis.

One mark was available for the 'quality of results'. This was judged on the scatter of points about the line of best fit. Candidates who had done the experiment carefully were able to score here if the scatter of points about the line of best fit was small.

The analysis section **(f)** and **(g)** continues to differentiate well between candidates. Weaker candidates often did not attempt this part of the question. The better candidates were able to equate *k* with the gradient of the graph and $\frac{4\pi^2 l}{g}$ with the *y*-intercept. A number of the weaker candidates did not use the gradient and *y*-intercept values and attempted to calculate values for *k* and *g* by substituting table values into the given equation. This was not accepted as candidates had been instructed to use their answers from **(e)(iii)** to obtain values for *k* and *g*. Sometimes the units of *k* and *g* had been omitted. However, the most able candidates usually scored full marks in this section.

In **(g)** candidates were asked to use the results of their experiment to calculate a value for *d* that would give a period of two seconds for the pendulum that they had used. Many candidates substituted *T* = 2.0 s into the given equation, but incorrectly used a length of one metre. It was expected that the length from **(a)(i)** would be substituted into the equation. In **(g)(ii)** it was very common to see candidates confuse *d* with the length of the pendulum. Good scripts showed a clear understanding of the implications of decreasing *l* and increasing the depth of the housing of the clock.

Paper 9702/04

Core

General comments

The performance of candidates was very similar to that in previous years. There were parts of some questions that required little more than knowledge of bookwork but parts of other questions were testing for the more able candidate.

It was rare to find a script where the performance was of a uniformly high standard. Most candidates had weaknesses in some areas of the syllabus. In particular, candidates find it difficult to apply concepts to unfamiliar situations. More emphasis needs to be laid on the understanding of basic concepts.

There has been little, if any, improvement in layout and in the amount of explanation given in calculations. Candidates should realise that marks are given for correct working and not just for answers.

Candidates appeared to have sufficient time to complete their answers.

Comments on specific questions

Question 1

(a) With few exceptions, the correct answer was given with adequate explanation.

(b)(i) Apart from those who disregarded the requirement for three significant figures, this was answered well.

(ii) Some candidates did find difficulty in understanding what is meant by a percentage error. Others used more than three significant figures when determining the difference, thus leading to a different answer. This was acceptable, if the candidate gave some explanation as to the source of the numbers.

Answers: **(a)** 0.180 rad; **(b)(i)** 0.182, **(ii)** 1.1%.

Question 2

(a)(i) Most candidates did quote an appropriate expression and then calculated the energy. However, a significant minority confused potential with potential energy. Substitution into the formula also indicated a lack of understanding. When substituting for mass, it was frequent to find that either nucleon numbers were used without multiplication by u or proton numbers were used rather than nucleon numbers.

(ii) There were similar misunderstandings in this part of the question. Potential was calculated, rather than potential energy and proton numbers, multiplied by e, were frequently not used for the charges.

(b) Answers were disappointing. Many merely stated that gravitational effects are negligible. It was expected that a reference would be made to energy. As has been stated in previous reports, candidates must be encouraged to make comparisons. It is insufficient merely to state that the energy is negligible. Rather, they should state that the gravitational potential energy is very much smaller that the electrostatic potential energy.

(c) Again, answers were disappointing. Many answers made reference to the α-particle being too small. Candidates were expected to determine the energy of the α-particle in J (or the electric potential energy in MeV) so that a direct comparison between these energies could be made. Thus, they would realise that the α-particle had insufficient energy to make a close approach to the nucleus.

Answers: **(a)(i)** 1.51×10^{-47} J, **(ii)** 3.79×10^{-12} J.

Question 3

(a)(i) Candidates did need to draw a line with a reasonable shape, passing through the origin and ending at the correct positions. Frequently, sketches were too poorly drawn to be given credit.

(ii) A common error was to draw a straight line at the correct height, but extending across the whole grid. This was not acceptable.

(b) Some candidates did not commence the task by writing down relevant equations. In general, these were the candidates who failed to arrive at an answer. There were many errors associated with powers-of-ten.

(c)(i) There were some very good explanations but many gave the impression that the decrease in amplitude, or the decrease in energy, is a 'one-off' situation. It is necessary that the continuous nature of any change is emphasised.

(ii) Answers were, in general, disappointing. Despite giving a correct expression in **(b)**, the majority of candidates assumed that, in order to calculate the new amplitude, then amplitude would be proportional to total energy.

Answers: **(b)** 8.94 rad s^{-1}; **(c)(ii)** 4.5 cm.

Question 4

(a)(i) There were very few problems associated with reading the graph, apart from some confusion as regards conversion of mT to T.

(ii) Answered well by most candidates. A minority did lose marks through failing to give adequate explanation.

(b) A minority confused Faraday's law with Lenz's law. Candidates need to be reminded that Faraday's law is defined in terms of induced e.m.f., not induced current.

(c)(i) Generally, there were few problems with this calculation. A significant minority did calculate the flux at x = 15 cm and then subtracted this from the flux linkage at x = 5 cm.

(ii) With few exceptions, candidates divided their answer in **(i)** by the time of 0.3 s and thus scored full marks.

(d) Answers were very disappointing. Few candidates noted that the flux density decreases with increasing x. Thus, to maintain a constant rate of change of flux, the speed of the coil must increase. The usual answer was to state, quite wrongly, that the speed must be constant in order to maintain a constant rate of change of flux.

Answers: **(a)(i)** 50 mT; **(c)(i)** 2.52×10^{-4} Wb, **(ii)** 8.4×10^{-4} V.

Question 5

(a) Most candidates were able to give the correct direction.

(b)(i) As in all such questions where a derivation is expected, explanation is essential. Many candidates lost a mark because they did not explain their working. Rather, the derivation was started by merely writing down $Bqv = mv^2/r$.

(ii) Although this calculation was completed successfully by the majority of candidates, a significant number attempted to calculate the charge, rather than the specific charge of the particle.

(c)(i) It was expected that the mass would be calculated in terms of u. However, some calculated the mass in kg and then gave this as the answer.

(ii) Despite calculating the mass as 2u, some candidates stated that the nucleus is made up of protons and neutrons, rather than giving the number of each. It was pleasing to note that there appeared to be less confusion between the terms *neutron* and *nucleon*.

Answers: **(b)(ii)** 4.82×10^{7} C kg^{-1}; **(c)** 2 u.

Question 6

(a)(i) Candidates who attempted to define decay constant in terms of probability of decay of a nucleus frequently failed to make it clear that the probability is per unit time.

Some candidates attempted the definition in terms of activity and number of undecayed nuclei. Marks were awarded for this approach. However, most candidates gave a relevant equation but then failed to explain the terms adequately.

(ii) There were very few convincing answers. Opinion was almost equally divided between the two isotopes. For credit to be given, candidates needed to give some relevant explanation for their choice. Very few went beyond a statement that the α-particle emitted by Ra-224 has a higher energy. The fact that this increased α-particle energy indicates that Ra-224 is less stable and hence more likely to decay was seldom included.

(b)(i) This calculation presented very few problems apart from a failure by some to include a unit for the decay constant.

(ii) There were some very good, well explained answers. A common error was to calculate the amount of substance in mol and then fail to multiply this number by the Avogadro constant in order to calculate the number of atoms.

(c) Those candidates who used the exponential equation for radioactive decay frequently found this calculation to be difficult and consequently made mistakes. Others used the expression $0.5^n = 0.1$ and were usually successful. Some gave the answer as 3 half-lives, without explanation.

Answers: **(b)(i)** 0.193 day^{-1} or 2.23×10^{-6} s^{-1}, **(ii)** 1.3×10^{13} Bq; **(c)** 3.32.

Question 7

(a) A significant number of candidates mis-read the question and wrote down general disadvantages of a thermocouple, rather than the disadvantages apparent on Fig. 7.1 when the e.m.f. is about 1.0 mV.

(b) Inappropriate answers frequently included ‘better range’ or ‘better accuracy’ or ‘greater sensitivity’. Answers based on small physical size and small thermal capacity were expected.

Paper 9702/05
Practical 2

General comments

The standard of the work by the candidates was similar to last year and the paper produced a wide spread of marks. **Question 1** proved to be accessible to most candidates. However, as in previous years, many of the weaker candidates found the design question quite challenging.

Most candidates appeared to have sufficient time to complete all sections of the paper.

Comments on specific questions

Section A

Question 1

In this question, candidates were required to investigate how the force acting on a bar magnet placed in a current-carrying coil is related to the current in the coil.

Virtually all candidates were able to set up the circuit correctly and take six sets of readings for F and I. In **(b) (iii)** candidates were asked to explain how they ensured that the centre of the magnet was located at the top of the coil. The weaker candidates gave vague responses such as ‘*I positioned the magnet carefully.*’ It was expected that some reference would be made to placing the eye level with the top of the coil to avoid parallax error. A few gained the mark by giving an acceptable sketch.

Most candidates presented the results in tabular form with correct column headings. Values of F and I were usually given to an appropriate degree of precision. A surprisingly large number of candidates did not repeat the readings.

Candidates were required to plot a graph of F against I. It was pleasing to see that there were few graphs with an incorrect trend. The graphical work was generally done quite well by the majority of candidates, although there were a number of awkward scales on the axes. Lines of best fit were drawn reasonably well. In the calculation of the gradient, the weaker candidates tended to use points on the line that were too close together, resulting in inaccurate values for Δx and Δy. It is expected that the hypotenuse of the triangle used will be greater than half the length of the line that has been drawn. The y-intercept was usually read correctly. The 'quality of the results' was judged by the scatter of points about the line of best fit. Most candidates who had done the experiment reasonably carefully produced graphs with a small scatter of points and were awarded this mark.

The analysis section proved to be quite challenging again. Although weaker candidates were able to identify k with the gradient and W with the y-intercept, many candidates did not include units with their answers. k was sometimes given to an inappropriate number of significant figures.

Part **(g)** was not done well. Most candidates did not realise that the total downward force was equal to the weight of the magnet and the force of attraction between the magnet and the coil. Deducting the weight of the magnet from F to give the force of attraction between the magnet and the coil should give a straight line graph passing through the origin. There was much confusion between the terms 'linear' and 'direct proportion'.

In **(h)(i)**, the majority of candidates were able to calculate the current in the coil for a reading of 10 N on the Newton-meter by substituting the values of k and W into the given expression. Typically, the value obtained was quite large (~ 50 A).

In part **(h)(ii)**, most candidates commented on an inadequate range of the ammeter or power supply. It was expected that some reference would be made to the heating effect of such a large current.

Question 2

In this question, candidates were required to design a laboratory experiment to investigate how the frequency of a sound wave depends on the pressure of air.

Answers to this question were quite variable. It was clear that significant numbers of candidates had never used an oscilloscope to measure frequency. Many candidates used a bell as the source of sound instead of the expected loudspeaker and signal generator, and a few candidates confused 'bell' and 'bell jar'. Generally the answers given by many candidates were too superficial and lacked detail.

It was expected that candidates would draw a diagram showing a container connected to a pump so that the pressure could be varied. Many candidates either drew a small piston and cylinder connected to the chamber, or drew a large piston in the lower half of the apparatus instead of a pump. A pressure gauge was often not shown.

In **(c)**, candidates were required to explain how the frequency of the sound would be measured using a CRO. Most candidates did not attempt this part, and just stated that '*the frequency would be measured using the CRO*'. A number of candidates were given some credit for '$f = 1/T$' ideas, but usually very little detail was given. It was expected that the length of the trace on the screen would be measured, together with information from the timebase setting, to find frequency. Many candidates thought that the CRO could give a direct reading of period or frequency. A number of candidates attempted to use the CRO to '*find the wavelength*' (?) and substituted into '$v = f\lambda$' to give frequency.

Some candidates predicted an outcome and attempted to give theory to back up their predictions. There is no credit for this in a planning exercise.

Few candidates made any mention of safety precautions, even though this had been asked for in the question. It was expected that candidates would suggest the use of safety screens or goggles since there is a danger of implosion due to the low pressure.

Candidates were given credit for a variety of 'good design features'. Examples of creditworthy points are given below:

- apply vacuum grease to the base of the bell jar
- allow time between readings for the apparatus to warm up/cool down
- monitor the temperature inside the container
- increase *P* as well as decrease *P* to give a wide spread of readings
- source of sound and microphone both shown inside the container
- avoid unwanted sounds/use soundproof room/do the experiment in a quiet place etc.
- difficulty with detecting sounds of low intensity at low pressures.

Paper 9702/06
Options

General comments

As in previous years, the general standard of answers is disappointing. The impression gained from many scripts is that sufficient emphasis is not being placed on the study of the option material.

Candidates appear to have insufficient knowledge of the work so that their understanding of underlying concepts is very superficial. It should be remembered that examination at this level requires the development of the skills of application and extension of knowledge. Many candidates do not appear to have any appreciable development of these skills with respect to the options.

There was no evidence of a shortage of time for candidates to complete their answers.

Comments on specific questions

Option A

Astrophysics and cosmology

Question 1

Some answers were correct for all four distances/diameters. However, it was the incorrect answers that were revealing. Clearly, some candidates had no appreciation of distances involved in the subject that had been elected for study.

Question 2

Most candidates could state one or two reasons. However, explanations were frequently either omitted or were invalid. For example, although candidates had heard of light pollution, the effect on observations was unknown. Similarly the effects on observations of irregular atmospheric refraction were not appreciated.

Question 3

(a)(i) This part was answered well by many candidates in that they described the fate of the Universe for densities greater and less than the critical density.

(ii) It was expected that candidates would recall that, in order to derive the given expression, it is assumed that the kinetic energy of galaxies is converted to gravitational potential energy as the Universe expands. Furthermore, the expression for gravitational potential energy involves *G*. Very few candidates were able to attempt this part of the question.

(b)(i) Candidates were warned that Fig. 3.1 is a lg-lg plot. However, many did not heed this warning and, consequently, calculated that H_0 has a numerical value of 2. This low value did not cause any consternation. Having obtained a value for H_0, most candidates were able to determine a value for the age of the Universe and for the mean critical density.

(ii) Most candidates realised that they had to divide the answer in **(i)** by *u*. Frequently, the answers given, without comment, indicated that candidates have little appreciation for the situation in the Universe.

Answers: **(b)(i)1** 3.1×10^{17} s, **2** 1.86×10^{-26} kg m^{-3}, **(ii)** 10.

Option F

The Physics of fluids

Question 4

(a) Opinion was equally divided as to whether M should be located at the top or at the bottom of the scale.

(b)(i) There were some good, well explained answers. A common error was to assume that the whole of the hydrometer consisted of a uniform stem, rather than a bulb and stem.

(ii) With few exceptions, candidates divided their answer in **(i)** by the area of cross-section of the stem.

Answers: **(b)(i)** 15 cm^3, **(ii)** 20 cm.

Question 5

(a) Diagrams were disappointing in that very few were acceptable. Candidates failed to realise that the velocity vectors would be parallel and would decrease progressively in length from the centre to the edge. It was not expected that candidates would indicate zero velocity at the edges.

(b)(i) A simple statement that there is no unique value of speed was required. Some answers were given, misguidedly, in terms of change of speed with change in cross-sectional area.

(ii) There were very few problems when answering **1.** Some candidates did not attempt **2.** The most common error was to assume that the volume flow rate increases by 2×0.05^4, rather than 2×1.05^4.

Question 6

(a) In most answers, there was a realisation that turbulence involves erratic fluid flow. However, many stated that streamlines would cross. A small number of answers did include the fact that the speed at a point would vary continuously, both in magnitude and direction.

(b)(i) There were some logical well-explained answers. However, many gave less than adequate explanation. All too often, some mathematics would be evident to relate *F* to v^2, (or to show *F* is not related to *v*) but a conclusion would then be given without explanation.

(ii) Despite reaching the conclusion that the air is turbulent, a significant number then assumed *F* proportional to *v* in order to determine the maximum speed.

Answer: **(b)(ii)** 58 ms^{-1}.

Option M

Medical Physics

Question 7

(a) There was a small number of very good answers. However, a significant minority insisted on describing the production of ultrasound. Many more did not include the nature of the information that can be obtained.

(b) The calculation presented very few problems, apart from a failure to express *x* in metres.

(c) The great majority of answers were incomplete in that attenuation of the reflected beam was not included.

Answers: **(b)** 0.28; **(c)** 0.027.

Question 8

(a)(i) Candidates should be encouraged to draw rays using a straight edge. Some diagrams were very poorly drawn. A surprisingly large number of candidates thought that the rays would converge onto the retina.

(ii) Depth of focus was understood by very few candidates. There was widespread confusion between depth of focus, depth of field and accommodation. Very few candidates understood that there is a range of image distances for which the image appears to be tolerably focused, without alteration of the power of the eye lens.

(b) Ideas were very confused with many explanations based on the 'control of the amount of light entering the eye'. Very rarely did a candidate discuss the out-of-focus image forming a patch on the retina and that the diameter of this patch would depend on the width of the cone of light entering the eye.

Question 9

(a) There were many well-explained correct solutions. The most common error was to substitute the sound power, rather than sound intensity, into the intensity level formula.

(b) Some sensible comments were made. It was interesting to note that, even when the calculated intensity level was very low, candidates still reported that deafness would be likely to ensue.

Answer: **(a)** 97 dB.

Option P

Environmental Physics

Question 10

(a) Although there were some good descriptions, many lacked detail. Candidates should realise that fission occurs with massive nuclei, that the nucleus divides into two parts of approximately equal mass and that energy and neutrons are released.

(b) This part of the question was answered well. Very few confused the functions of the moderator and the control rods.

Question 11

(a) In both parts of this derivation, the majority of the candidates appeared to be well-versed in the mathematical procedures. However, many lost marks because they failed to explain the physics behind what they were doing.

(b) The suggestions made by many indicated that they were confused between tidal power and wave power. Furthermore, candidates should be discouraged from making generalisations. Comments such as 'damages wildlife' are not given credit.

Question 12

(a) Diagrams were, in general, poorly drawn and without full labelling. Some did not indicate an input and others had more than four outputs. Candidates need to be reminded that the relative widths of the arrows indicate the relative percentages of the outputs.

(b) Many answers were disappointing. Statements were made without being justified. For example, ‘more heat is lost through the steel kettle’. In this illustration, there is no comparison with the plastic kettle and no reason is given for the greater loss. Answers in which the heating of the water was discussed were in a minority. It was important to realise that the electric heater provides direct heating of the water whereas with the gas ring, much thermal energy is lost immediately to the surroundings as heated air.

Option T

Telecommunications

Question 13

Not widely known. Some candidates attempted to score marks be completing more than one box for each means of communication.

Question 14

(a) Many candidates scored few marks here, possibly because they did not read the question and note the mark allocation. The command word in the question is ‘explain’ (not ‘state’) and four marks were allocated. Clearly, a statement such as ‘the frequency of the carrier wave varies in synchrony with the information signal’ is insufficient for four marks. Further information as to how the displacement and the frequency of the signal are carried is required.

Candidates should always be encouraged to pay attention to the command words and the mark allocations.

(b) Surprisingly few candidates calculated the correct period. They should, of course, find an average period over the 16 μs time interval. Many failed to do this. Although there were some correct answers for the frequency of the information signal, most candidates either left the section blank or made a wild guess.

(c) It was pleasing to note that most candidates did score full marks in this part.

Answers: **(b)(i)** 1.25 MHz, **(ii)** 125 kHz.

Question 15

(a)(i) Generally, candidates were able to read off the correct sampling time and hence determine the sampling frequency.

(ii) The majority of answers were correct.

(iii) There were surprisingly few correct responses. A common answer was 10.

(b) Candidates scored very few marks in this section. It was expected that candidates would recognise that the sampling time must be shorter than the smallest peak-trough time interval and that the voltage interval must be less than the smallest peak-trough voltage interval. Most answers appeared to be guesswork. Some candidates did mention the Nyquist criterion, but they were unable to apply it to this situation.

Answers: **(a)(i)** 2.0 kHz, **(ii)** 1.0 V, **(iii)** 4 bits.