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

General comments

The paper provided good syllabus coverage and proved to have good discrimination and a relatively high overall facility. The mean mark of 24.7 with a standard deviation of 6.6 showed that while some candidates found many of the questions difficult there were enough straightforward questions for the majority to find plenty to do. This year there were some very able candidates, with around 5% able to score 90% or more. This is an outstanding achievement, especially bearing in mind the pressure of time in answering forty questions in only one hour. At the bottom end of the ability range only 8.4% scored less than 40%. This again shows that the vast majority of candidates were well prepared for the examination and had reasonable knowledge of the topics which were being tested. There is a tendency with a multiple choice examination for candidates to work on numerical questions just with their calculator. They do need to see that this is a dangerous habit as many of the distractors are obtained simply by manipulating the data given in a plausible way. Candidates do need to work carefully and use units as a check if they are to avoid pitfalls. It is difficult to ascertain how the timing of the paper seemed to the candidates, but there was no direct evidence of candidates being unable to complete the paper in the allotted time.

Comments on specific questions

The questions which generally did not cause candidates any problems were **Questions 1**, **2**, **6***, **12**, **17**, **19***, **23**, **30**, **31**, **35***, **38*** and **40*** where the marks were correspondingly high. The starred questions have correct answers from more than 90% of candidates. This is particularly good for questions such as **38** and **40** as it indicates that candidates are familiar with standard terminology. It does however, mean that the discrimination is low for these questions.

The following questions were answered poorly.

Question 4, where candidates showed that they were often unable to work with percentage uncertainties. A 2% uncertainty in the time and a ¼% uncertainty in the distance gives a total uncertainty of 2¼% in the speed which is therefore 16.0 ± 0. 4.

Question 7, where candidates do not seem to appreciate that a body under conditions of free fall has a constant acceleration of g, and even when stationary at the top of its path its acceleration is still g because its velocity is still changing at the same rate.

Question 13, where particular care is required to get the moment of the 20 N force and to subtract the moments provides by the 5 N and 10 N forces. Many candidates ignored the 10 N force altogether.

Question 33, where **C** was the most popular answer. This implies that many candidates ignored the fact that if the length is doubled and the volume remains the same then the area of cross-section must be reduced to half its former value, giving a new resistance of 4R.

Question 39 was one of a very few questions where one of the distractors (**A**) had as many selecting it as the correct answer, but this may be because by this stage candidates were in a hurry and resorted to guessing.

Paper 9702/02

Structured Questions

General comments

There were sections of questions that were accessible to all candidates. On the other hand, some parts provided a challenge to the more-able candidates. There were some excellent scripts and several Centres where large numbers of candidates achieved a uniformly high standard.

Question 7 highlighted once again two areas of general weakness. First, the drawing of unjustified inferences from quoted formulae by considering two variables in isolation. Second, a lack of appreciation of significant figures both as regards premature ‘rounding’ at intermediate stages in calculations and also the number of significant figures that can reasonably be quoted in a final answer. Both aspects have been mentioned previously in reports.

There was no evidence that candidates were short of time. In scripts where the last two questions had not been completed, then almost invariably there were gaps in answers to earlier questions.

Comments on specific questions

Question 1

The speed of sound produced the most reasonable estimates and the density of air the least. For all four quantities there was a very wide range of inadequate estimates, many of which showed that the candidates had little or no appreciation for the physical magnitudes of the various quantities.

(a) Estimates ranged from 1.5 m s^{-1} to 3×10^{22} m s^{-1}.

(b) Estimates ranged from 1.7×10^{-31} kg m^{-3} to 8×10^{23} kg m^{-3}.

(c) Estimates ranged from 0.5 mg to 800 kg.

(d) Estimates ranged from 10^{-6} cm^3 to 10^{12} cm^3.

Question 2

(a) It seemed that few candidates had actually observed the Brownian motion of smoke particles. Although most candidates did make a reference to 'random' or 'haphazard' motion, they frequently then went on to state that this motion was due to collisions between smoke particles or between smoke particles and the walls of the container. Only rarely did a candidate mention that specks of light are observed, not the smoke particles themselves.

(b) Most answers did include a statement that the motion would still be random, but slower. Often, no explanation was given. Where explanation was provided, this was usually confined to a statement that greater mass would lead to smaller velocity changes. Very few candidates made any reference to greater surface area and that, because of the random distribution of velocities of air molecules, the effects of collisions of the smoke particle with air molecules would tend to average out. This greater rate of collision would lead to a smaller, rather than a larger, randomness of collision and hence motion of the smoke particle.

Question 3

(a)(i) Most candidates were able to calculate the change in energy. Errors were mostly due to inappropriate units for mass and/or vertical displacement.

(ii) In most answers, the change in gravitational potential energy was associated correctly with the kinetic energy of the block and bullet. A few candidates obtained the correct answer by unjustified use of equations representing uniform motion in a straight line.

(b) Candidates were instructed to use the principle of conservation of momentum and consequently, most answers were correct.

(c)(i) Very few candidates failed to calculate a value for the kinetic energy, based on their answers to **(b)**.

(ii) The majority of answers included a correct deduction that there would be a loss of kinetic energy and thus the collision is inelastic. However, some asserted that the evidence for a loss of kinetic energy was that some had been converted into potential energy of the block and bullet.

Answers: **(a)(i)** 0.51 J; **(b)** 390 ms^{-1}; **(c)(i)** 152 J.

Question 4

(a) With few exceptions, the glass was said to be brittle.

(b)(i) This calculation presented very few problems for candidates. The most common error was arithmetical.

(ii) Expressions quoted for the Young modulus were usually correct. Again, most errors were arithmetical, particularly amongst those candidates who did not make a separate calculation of the strain.

(iii) The majority did calculate an appropriate area of the graph provided or did use an equivalent correct formula. However, a significant minority either used the expression $\frac{1}{2} \times \textit{stress} \times \textit{strain}$, without realising that this is energy per unit volume, or merely calculated the maximum strain.

(c) In general, this was poorly answered. Despite the explicit information given in the question, many answers were based on an assumption that either the mass, the density or the kinetic energy would be different. Frequently, wording was imprecise. The hard ball was said to 'have more force' or the soft ball 'to use up its force in squashing'. Nevertheless, there were some good answers, based on either the times of collision affecting the rate of change of momentum and thus the force on the glass or the conversion of kinetic energy to strain energy in the balls affecting the strain energy within the glass.

Answers: **(b)(i)** 7.6×10^{7} Pa, **(ii)** 6.1×10^{10} Pa, **(iii)** 9.0×10^{-3} J.

Question 5

(a) Candidates should be encouraged to be as precise as possible with definitions and explanations. Most answers included a statement, with varying degrees of clarity, that diffraction is the bending or spreading of waves through a narrow gap or at an edge. However, wording was frequently ambiguous so that the explanation could apply to refraction. Statements such as 'change of direction when meeting an obstacle' are not acceptable.

(b)(i) This simple calculation caused many problems. Not only were there many errors involving powers-of-ten in otherwise correct calculations but also, many candidates thought that they must use the grating formula given in the question.

(ii) In most scripts where *d* had been calculated correctly, then the maximum value of *n* was also correct. However, candidates who had made errors in *d* by as much as factors of up to 10^{12} usually also calculated equally ridiculous answers for *n*, without comment.

(iii) Very few candidates recognised that the correct use of the formula relies on the fact that light incident on the grating has no path difference. Most candidates repeated the question by stating that the light is not normal to the grating.

(c) Many candidates gave at least one relevant difference, based on either angles of diffraction or intensity. A surprisingly large number of answers ignored the fact that the question specified the two wavelengths involved. Consequently, answers referred to different wavelengths, frequencies or colour. In others, there were vague mentions of angles, without a clear indication as to which angle reference was being made.

Answers: **(b)(i)** 1.33×10^{-6} m, **(ii)** 2.

Question 6

(a)(i) Candidates should be encouraged to use a ruler when drawing straight lines. In this case, it was expected that, by eye, the lines would be straight and equally spaced. A significant number of diagrams were unacceptable free-hand sketches.

(ii) Almost all candidates were able to derive the given result.

(b)(i) A surprisingly large proportion of candidates drew arrows that were either normal to the electric field or normal to the axis of the particle.

(ii) Although the majority of calculations were correct, there were significant numbers of answers with incorrect physics. Calculations of the Coulombic forces between two charged particles were not uncommon. Others introduced either a sine or a cosine term into the calculation.

(iii) Most candidates did multiply the force calculated in **(ii)** by a distance. However, very frequently this was not the perpendicular distance between the forces. In most of these scripts, this was not a matter of confusion between use of sine or cosine terms.

(iv) In the vast majority of scripts, it was realised that the forces would cause rotation. However, most answers gave the impression that the rotation would be continuous, with relatively few stating that the particle would align itself along the direction of the field.

Answers: **(b)(ii)** 2.4×10^{-12} N, **(iii)** $3.4(4) \times 10^{-15}$ Nm.

Question 7

(a) Many candidates gave unsatisfactory answers in terms of 'the hindrance' or 'the opposition to the current'. Of those who did attempt a definition in terms of a ratio, many were imprecise, either defining the unit rather than the property or, frequently, using the unqualified term 'voltage' when what was intended is the potential difference across the resistor.

(b)(i) The vast majority of answers were correct for the data point.

(ii) With few exceptions, the calculation was completed successfully.

(iii) This part of the calculation was more challenging and there were many well-expressed correct solutions. However, there were significant numbers of answers where work was laid out poorly. In such cases, many candidates failed to appreciate whether they were dealing with the e.m.f. of the battery, the p.d. across the resistor or the p.d. across the internal resistor. A small but significant number of candidates treated the external and internal resistors as if they were in parallel.

(c) This part was poorly answered with very few showing clarity of thought. Many candidates made no mention of internal resistance, simply quoting a formula for power dissipation, and concluding that the lower value of the p.d. across R would give a smaller power, ignoring the fact that both the value of the current and the resistance would change. Others stated that the larger p.d. across R would give greater power dissipation in R thus the power dissipation in the inernal resistor must be smaller. A minority of candidates argued, quite correctly, that a larger p.d. across R would give a smaller p.d. across the internal resistance and since internal resistance is constant and $P = V^2/r$, then the power dissipation in the internal resistor would be lower.

Answers: **(b)(i)** 1.13 W, 1.50 V, **(ii)** 1.99 Ω, **(iii)** 1.99 Ω.

Question 8

(a) Few candidates failed to plot correctly the position for the isotope of protactinium.

(b) The values of A and Z were given and consequently, almost all candidates who attempted this task did plot the position correctly. It was realised that the daughter product of plutonium would have the same value for A. However, opinion was divided as to whether Z should be 93 or 95.

Paper 9702/03
Practical 1

General comments

The overall standard of the work produced by the candidates was generally good, although as in previous years the performance variation was mainly by Centre (i.e. some Centres continue to prepare their candidates very well for this examination). It was pleasing to see fewer low scores (< 12) than in previous years and there were quite a lot of strong candidates scoring 21+. Most Centres had no difficulty with the apparatus requirements, although there were some cases where Centres had used spring balances calibrated in grams instead of Newtons. There were very few reports of Supervisors giving assistance to candidates. There was no evidence that candidates were short of time and no problems with the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the force required to maintain the equilibrium of a suspended mass depends on the angle between the line of action of the force and the horizontal.

In **(a)(ii)** many candidates stated the uncertainty in θ to be 0.5°, which was considered to be unrealistic as it was difficult to place the protractor in the correct position when measuring the angle.

In **(b)** the difficulties mentioned by candidates included thick string/difficulty of alignment of the Newton meter/holding the protractor steady whilst measuring θ/keeping AB horizontal, all of which were credited. Some answers were vague (e.g. 'it was difficult to read the scale on the newton meter' or 'parallax error' with no clarification). Oscillation of the string or the mass was not accepted.

Most candidates were able to set up the apparatus correctly and use it to obtain six sets of readings for F and θ. A number of candidates misread the scale on the protractor and obtained values of θ which were acute instead of obtuse. A few candidates calculated 1/sin θ using θ in radians instead of degrees.

Virtually all candidates presented the results in tabular form. Raw values of θ were sometimes given to an unreasonable degree of precision (i.e. to one or two decimal places). A number of candidates had impossibly large values for F, presumably because they had used spring balances instead of newton meters. These candidates were not penalised.

Candidates were required to plot a graph of F against 1/sin θ. 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). Points were usually plotted correctly, although it was sometimes difficult to see where the points had been plotted. It is expected that small crosses will be used. 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 or an error had been made in the read-offs (particularly when awkward scales had been used). The y-intercept was often read incorrectly from the graph because a 'false origin' had been used (i.e. the value was read from a line were $x \neq 0$). The more able candidates substituted values from a point on the line, together with the gradient value, into $y = mx + c$.

Two marks were 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 a line of best fit was small. Candidates lost marks if they used a narrow range of angles (a spread of < 10° was common).

The analysis section continues to differentiate well between candidates. The weaker candidates often did not attempt this section. The better candidates were able to equate mg with the gradient of the graph and k with the y-intercept. A significant number of candidates equated $\frac{mg}{\sin\theta}$ to the gradient. Candidates were instructed to use their answers from **(e)** to determine values for m and k. Many of the weaker candidates did not do this and attempted to substitute two sets of values into the given equation and solve the resulting equations simultaneously. Work of this kind was not credited.

It was expected that m and k would be given to a sensible number of significant figures (i.e. two or three significant figures) and that units would also be given. A large number of candidates failed to recognise that the unit of k is the Newton, and gave the value of k to one significant figure only.

It was pleasing to see many of the more able candidates scoring full marks in the analysis section.

Paper 9702/04
Core

General comments

All questions were accessible to better candidates. Weaker candidates tended to score the majority of their marks on the first four questions.

It was pleasing to note that the number of scripts where work is laid out well and adequate explanation is given is increasing. There were some outstanding scripts from a number of Centres.

Candidates appeared to have sufficient time to complete their answers. However, there were some instances where it appeared as if the candidate did not realise that a question was printed on the back page of the script, possibly because the penultimate question ended half-way down page 15 or because the subject material of the questions was not in syllabus order. Candidates should be encouraged to read carefully the question paper. On the cover page it stated that there are 16 printed pages in the question paper and on page 15, the instruction '**[Turn over**' was given.

Comments on specific questions

Question 1

(a)(i) Most candidates successfully calculated the magnitude of the angular velocity. A minority did confuse 'speed' with 'angular velocity'.

(ii) A correct formula was usually given. There were very few arithmetical errors. Some did substitute w for v in the expression $F = mv^2/r$.

(b)(i) It was expected that candidates would mention *gravitational* force. Some did merely state 'the Sun' but others gave more than required by stating that the gravitational force between the Sun and the Earth provides the centripetal force.

(ii) Most candidates did quote a correct expression for the gravitational force and, generally, the arithmetic was correct. A minority of candidates used the expression $GM = r^3 \omega^2$. This alternative approach could be awarded full credit.

Answers: **(a)(i)** 1.96×10^{-7} rads^{-1}, **(ii)** 3.46×10^{22} N; **(b)(ii)** 1.95×10^{30} kg.

Question 2

(a) Most candidates mentioned either the universal gas equation or individual gas laws. However, it was disappointing to note that very few stated that, for an ideal gas, the law(s) must be obeyed at all values of pressure, volume and temperature.

(b)(i) A significant number stated that $<c^2>$ represented the root-mean-square speed. Very few referred to the square of the mean speed.

(ii) There were some very pleasing derivations, with clear explanation at all stages. On the other hand, the work of some candidates lacked all meaning. It was common to find that density was defined as *M/V*, with *M* being used in the expression for the mean kinetic energy of an atom. The term *N* was then either ignored, cancelled or stated to be unity.

(c)(i) Generally, this calculation was completed successfully. The most common error was a failure to square the value for the speed.

(ii) It was pleasing to note that more-able candidates made reference to a distribution of speeds. A significant number of candidates thought that atoms with a lower speed would escape. There was a number of ingenious explanations, including the possibility of isotopes.

Answer: **(c)(i)** 1.9×10^4 K.

Question 3

(a) Definitions tended to lack precision. It was common to find that any reference to unit mass was omitted. Furthermore, weaker candidates tended to fail to state what is meant by fusion or thought that energy is required to convert liquid to solid.

(b)(i) Although the majority of answers were correct, a significant minority considered only the energy required to warm the ice or to melt it.

(ii) Most candidates did attempt the calculation, using their answer in **(i)**. However, very few took into account the energy required to heat the melted ice from 0°C to the final temperature.

Answers: **(b)(i)** 8700 J, **(ii)** 16°C.

Question 4

(a) In general, definitions were adequate. The most common failing was either to omit to give the relative directions of the displacement and the acceleration or to express them poorly.

(b) There were some very clearly expressed derivations. Weaker candidates tended to give some relevant expressions but were unable to link them. Candidates should always be encouraged to give as much relevant information as they can, since credit is often given for such expressions.

(c)(i) The majority of answers did include an acceptable value for either the period or the frequency of the oscillations. However, there were many answers where it appeared that the expression for the area was unknown. Besides confusing diameter and radius, it was not uncommon to find the expression $A = 4\pi r^2$. Candidates should be advised to use data given in the question paper. The use of $g = 10\ \text{ms}^{-2}$ is not acceptable where data for a calculation is given to two or more significant figures.

(ii) It was pleasing to note that very few candidates referred to displacement, rather than amplitude or peak height.

Answer: **(c)(i)** 0.0384 kg.

Question 5

(a) Answers were disappointing. Very few made reference to potential gradient or $\Delta V / \Delta x$. Most who attempted this part of the question stated $E = V/x$. This is, of course, incorrect since V is defined as potential and x as the distance from the centre of the sphere.

(b) Surprisingly few candidates knew that the electric field within the conductor must be zero. Most candidates drew a sketch similar to that in Fig. 5.2 or merely a curve starting at x = O.

Question 6

(a)(i) Generally satisfactory but it was evident that a minority of candidates had no real appreciation of concepts involving electromagnetic induction.

(ii) Most answers were based, quite correctly, on the equation $P = VI$. However, many failed to state that the output power would need to be constant.

(b)(i) Generally correct.

(ii) Most sketches did show an appropriate sinusoidal wave with the correct frequency. However, very few indicated the correct phase. Most indicated no phase difference with a few showing a π rad change between Fig. 6.3 and Fig. 6.4.

(iii) It was common to find that this section was not attempted. Of those who did give an answer, the majority failed to state a unit for the angle.

Answer: **(b)(iii)** $\frac{1}{2}\pi$ or 90°.

Question 7

(a) Surprisingly, many graphs were drawn without a scale on the y-axis. Consequently, only the general shape of the line could be given.

(b)(i) The initial number was calculated correctly in the majority of scripts. However, a significant number of candidates appeared to have little idea as to how to proceed with this basic calculation.

(ii) A significant number of candidates thought that they had to use an equation involving exponential decay. Of those who did use the correct equation, it was pleasing to note that most did determine the decay constant in s^{-1}.

(c) Many candidates did not appear to know how to proceed with this problem. Of those who did, the majority took the ratio N/N_o to be 1/9, rather than 1/10.

Answers: **(b)(i)** 1.5×10^{16}, **(ii)** 1.11×10^{12} Bq; **(c)** 8.63 hours.

Question 8

(a) Definitions were disappointingly poor. Many failed to make it clear that a ratio is involved. Consequently, in such statements it appeared that capacitance is an electric charge.

(b)(i) Most answers included, in some way, that there would be charge separation. However, very rarely was any explanation given as to how this charge separation leads to the storage of electrical energy.

(ii) Correct answers were in a minority. Many quoted $\frac{1}{2}CV^2$ as the energy stored in a charged capacitor but then assumed $\left(V_2{}^2 - V_1{}^2\right)$ is equal to $(V_2 - V_1)^2$. Others used the expression $\frac{1}{2}QV$ but assumed that Q would remain constant when V changed.

Answer: **(b)(ii)** 1.4 J.

Paper 9702/05

Practical 2

General comments

The general standard of the work done by the candidates was similar to last year, with quite a wide spread of marks. **Question 1** was relatively straightforward, although some of the weaker candidates found the analysis section challenging and gave very brief answers to **Question 2**. As in previous years, there was a significant range in performance. It would be helpful to candidates generally if attention could be drawn to the published mark schemes.

There were no reported difficulties from Centres in obtaining the necessary equipment for **Question 1**. Very little help was given to candidates from Supervisors in setting up the apparatus in **Question 1**. Supervisors are reminded that under *no circumstances* should help be given with the recording of results, graphical work or analysis.

A small number of weaker candidates appeared to be short of time. Answers to **Question 2** from these candidates was often very brief, or finished in mid-sentence.

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 loaded steel blade varies with the length of the blade.

(a) Virtually all candidates were able to set up the equipment without help from the Supervisor.

(b) In this part many candidates did not repeat the readings of raw times.

(c) Virtually all candidates were able to record six measurements of *d* and *t*. A few candidates did not divide the raw times by the number of oscillations and calculated log *t* instead of log *T*. Some of the raw times were too small (i.e. less than 10 seconds) because candidates did not allow the blade to perform a sufficient number of oscillations. Values of *d* were usually given to the nearest millimetre, although weaker candidates recorded their values of *d* to the nearest centimetre. It is expected that *d* will be recorded to the nearest millimetre as a millimetre scale had been used to make the measurement.

(d) Candidates were required to plot a graph of log T against log d. The most common error was probably the use of awkward scales which consequently resulted in the misplotting of points. Weaker candidates often 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. It is expected that all the observations will be plotted on the grid.

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 misread 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 with a point on the line and the gradient value. The most common error was in reading the y-intercept from a line where $x \neq 0$.

(e) In the analysis section weaker candidates were unable to state the logarithmic form of the given equation. A common misconception was $\log T = n\log k + n\log d$. Many did not equate the gradient with n and log k with the y-intercept.

(f) In this part it was disappointing to see so many candidates who were unable to use a micrometer screw gauge to measure the thickness of the blade. It was expected that the values would be reasonably close to Supervisor's values. In **(iii)** many candidates successfully calculated the percentage uncertainty in t^3. Common errors included an inappropriate value for Δt or omitting the factor 3 in the calculation.

(g) Many weaker candidates found this section difficult. There was much confusion of units resulting in power of ten errors. A number of candidates stated m = 0.050 kg instead of 0.100 kg, although this was not penalised, as the label on the diagram stated '50 g masses'. The algebraic rearrangement of the expression for E defeated many. The unit of E was often given incorrectly.

Question 2

In this question candidates were required to design a laboratory experiment to investigate how ionisation current depends on air pressure.

The context setting situation of smoke detectors and aircraft proved quite distracting for many of the weaker candidates, and resulted in answers where an experiment had either been done in an aircraft or a smoke filled room. However, most candidates identified the need for an alpha source (due to its strongly ionising properties) and gave a suitable circuit showing a sensitive current measuring instrument in series with a power supply unit and two plates. A few candidates attempted to use a Geiger-Müller tube to measure the ionisation current. A number of weaker candidates omitted the meter or the power supply, and a number of candidates placed all the equipment (including the source and a GM tube, and sometimes a CRO) in a series circuit.

It was expected that candidates would show a 'closed box' containing the source and plates, and that a pump would be used to increase/decrease the pressure. A number of candidates omitted the pump, or suggested changing the air pressure using a fan or a piston in a cylinder, which was considered to be inappropriate. Credit was given for a pressure gauge (either shown on the diagram or mentioned in the text).

A good, well-annotated diagram could gain half the marks for this question, whereas a poor one often received little or no credit.

Most candidates suggested a suitable procedure (i.e. measure the ionisation current and the air pressure; change the pressure and measure the new ionisation current and pressure). This mark could be scored even if the arrangement of apparatus was unworkable.

As in previous years many inappropriate safety precautions were given. The most common included lead suits; lead-lined laboratories; lead gloves; lead goggles (?) and film badges. Sensible ideas only were given credit (e.g. not looking at the source directly; use of a source-handling tool; not pointing the source at anyone; storing the source in a lead-lined box away from work areas etc.). A second 'safety mark' could be gained by an appropriate reference to the dangers of high/low pressures (e.g. container should be strong enough to withstand high/low pressures/use of safety screens/safety goggles etc.).

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

- use GM tube and scalar/ratemeter to monitor activity of source to ensure that it does not change
- use of source of long half-life
- place source close to plates (as range of alpha in air is small)
- tap gauge when taking readings (in case needle sticks)
- fix position of source relative to plates
- keep the separation of plates constant.

Many candidates scored the mark for suggesting the use of a source with a long half-life.

Paper 9702/06
Options

General comments

The overwhelming majority of candidates chose ***Options F*** and ***P***. These options appeared to be of an equal standard. The candidates who chose the other options did, in general, either score high marks or perform poorly.

It was pleasing to note that, with very few exceptions, candidates attempted two options. There was no evidence that candidates were short of time to complete their answers.

Comments on specific questions

Option A

Question 1

(a) With few exceptions, an appropriate position was marked on Fig. 1.1.

(b)(i) Although there were some answers within the accepted range, it was clear that many candidates had little idea as to the diameter.

(ii) As in **(i)**, answers varied very widely.

(c) Although there were some correct answers, it appeared that many candidates thought that there are very few galaxies in the Universe.

Question 2

(a) The same comments apply here as in **Question 1**. It appeared that answers were mainly guesswork.

(b)(i) The majority of answers were within the acceptable range of 10^{12} s – 10^{14} s.

(c) Again, poorly answered. There were very few candidates who had any real understanding of the concepts involved. Answers where the excess was thought to have occurred after the formation of galaxies were not uncommon.

Question 3

(a)(i) This was answered well by most candidates. It appeared that this standard calculation had been rehearsed by many.

(ii) Surprisingly, in many scripts the answer here was either wrong or the calculation had not been attempted.

(iii) Although candidates were being steered towards commenting on the development of the Universe by the wording of the question, very few accepted this advice. Comments were frequently without any real meaning.

(b) Full answers were very rare. Some did mention red-shift or time of travel of light but ideas were frequently vague. Many made reference to absorption or 'refraction' of light.

Answers: **(a)(i)** 1.6×10^{10} years, **(ii)** 0.79.

Option F

Question 4

(a) Most answers included a reference to either pressure difference or weight of displaced water.

(b)(i) With few exceptions, the relation between mass, volume and density was either given or clearly implied. The majority of answers were acceptable. The most common error being to give the incorrect density for the stated volume.

(ii) Most answers followed on from **(i)** and were acceptable.

(c)(i) Generally, the physics of the situation was appreciated in that the answers to **(b)(i)** and **(b)(ii)** were equated. However, many lost marks through careless arithmetic or through an inappropriate use of significant figures. Candidates should be advised not to reduce the number of significant figures to fewer than that given in the data before the end of a calculation.

(ii) Surprisingly, a significant minority of answers were incorrect. Weaker candidates appeared not to understand how to allow for the 28 m of the iceberg above the surface of the water.

Answers: **(c)(i)** 234 m, **(ii)** 0.89.

Question 5

(a) Most answers made a reference to internal friction but the effect of this was not always made clear.

(b) There were some very good answers where the variation of speed across the area of cross-section was described. However, many referred to the speed not being 'constant', without explaining in what way the speed would not be constant. Very few answers included a comment as to why volume flow rate would be more appropriate.

(c)(i) The vast majority of answers were limited to a calculation using the expression $P = h\rho g$. There were very few attempts to explain why this would be the pressure difference.

(ii) Candidates should be encouraged to practice substitution into formulae. Besides the usual problems associated with radius/diameter and powers-of-ten, many substituted the density of water for pressure p.

Answer: **(c)(ii)** 1.18×10^{-3} Nsm^{-2}.

Question 6

(a)(i) In many scripts, streamline flow was described, rather than a streamline. It was common to find streamline was defined as a path but it was not made clear what would follow that path.

(ii) This was frequently described in terms of a transition from streamline to turbulent flow. Even candidates who had described well a streamline in terms of an appropriate path did not appreciate that, if streamlines cross, a particle would follow two paths simultaneously.

(b) Again, the most common answer was in terms of turbulence. However, there were some very good answers where reference was made to tubes of flow and the equation of continuity.

Option M

Question 7

(a) A common fault was to discuss in general the use of MRI without including any of the processes used to obtain the image. A widespread misunderstanding was that the hydrogen nuclei would emit RF waves, without any need for pulsed RF to be applied. Furthermore, many did not mention hydrogen nuclei, believing that all atoms would emit the radiation.

(b) Generally, candidates could give at least one disadvantage. The most common were the length of time for the patient to remain inactive and the cost involved.

Question 8

(a)(i) Most answers were vague or imprecise. Candidates referred to 'radiation being deposited', rather than energy. Also, it was not always clear where the energy was being deposited and thus there was no clear distinction between exposure and absorbed dose. Rarely was there a reference to mass.

(ii) Again, answers were imprecise. The important factor here is density of ionisation. With very few exceptions, reference was made to 'amount of ionisation' of 'more/less ionising'.

(b) Candidates frequently referred to mutations or malignancy without making it clear that these are long-term effects.

Question 9

(a)(i) Most answers were correct.

(ii) Again, most answers were correct although, despite being told to give the answer in cm, some insisted on changing it to metres.

(b)(i) Candidates should be encouraged to use the terms 'long-sight' and 'short-sight'. Where they attempt to use a medical term, spelling tends to make the word unrecognisable.

(ii) The calculation was, in general, disappointing. There were very few statements that the far point would be at infinity. Where the formula was used correctly to determine the position of the near point, then very rarely was a statement made as to why the distance of 25 cm was being substituted into the formula.

Answers: **(a)(ii)** 40 cm; **(b)(ii)** ∞, 67 cm.

Option P

Question 10

(a) Most could state what is meant by resources and reserves but few then went on to make a distinction between them. The difference was there by implication.

(b) There were some good answers where rate of formation and rate of use were discussed clearly. However, some scripts indicated widespread misunderstandings as to the formation of fossil fuels. Some candidates stated that coal is formed within the bodies of dead animals or that fossil fuels can no longer be formed because bodies are buried.

Question 11

(a) This was completed successfully in most scripts.

(b)(i) There were a few correct answers but most indicated that the candidates had little real concept of the operation of a four-stroke petrol engine. Some thought that one cylinder would be connected to each wheel. 'Increased efficiency' and 'greater power output' were common statements that were made without any justification.

(ii) A common answer was to assume that the extra valves were there in case others failed. Alternatively, the extra valves would allow gases to move faster so that the engine would go faster. 'Increased efficiency' was frequently quoted, but without justification.

Question 12

(a)(i) Generally, candidates confined their explanations to environmental pollution and did not include health considerations.

(ii) Most candidates did give both examples, although sometimes with insufficient detail. For example 'volcanoes' was given as an example of natural pollution. Whether the volcano itself, or its emissions, was intended was left to the imagination of the Examiner.

(b) Most answers concentrated on descriptions of respiration, the greenhouse effect and also biodiversity. Rarely was the effect on climate discussed.

Option T

Question 13

(a) There were some very clear comprehensive answers. However, others indicated a complete lack of understanding. A statement such as 'the signal is passed through an analogue-to-digital converter' is of little value in answering the question.

(b) There was a tendency to confuse advantages of digital transmission with those of optic fibre transmission. However, the majority of candidates could give at least one advantage.

Question 14

(a) In general, both parts were completed successfully.

(b)(i) Weaker candidates quoted an appropriate equation for power in dB. However, for full credit, the correct substitution had to be shown.

(ii) A minority of candidates was unable to commence this calculation. However, the majority was successful. A common error was to invert the ratio, giving rise to a negative sign that was conveniently 'lost'. Others substituted the noise power rather than the minimum effective signal power into the equation.

(c) Nearly all candidates made reference to an amplifier but a significant minority did not state that amplifiers would need to be placed at regular intervals along the fibre.

(d)(i) Explanations were good, with most answers being given full credit.

(ii) Despite being instructed to consider times of transmission, the majority of answers were qualitative. Very few candidates gave estimates for both transmission times. Instead, they gave one only. It was common to find that candidates referred to the 'speed of transmission', rather than the delay between transmission and receipt of the signal.

Answer: **(b)(ii)** 80 km.