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1999 Higher School Certificate Physics Examination Report

2 Unit

Section I – Part A Multiple Choice

The following table shows the correct answers and the percentage of the candidature selecting these answers.

QUESTION	CORRECT ANSWER	PERCENTAGE OF CANDIDATURE
1	B	71.2
2	B	66.7
3	C	62.2
4	B	55.5
5	C	64.5
6	A	75.6
7	A	62.5
8	D	83.8
9	D	56.2
10	A	52.1
11	B, C	35.9, 52.2
12	D	52.8
13	B	28.3
14	D	90.4
15	C	47.1

Section I – Part B

Question 16

This question required candidates to apply their knowledge of motion and its components.

(a) Most candidates successfully described projectile motion in terms of vertical and horizontal components. They were less able to place themselves in the position of the observer and describe the motion as seen by him.

(b) The majority of candidates demonstrated correct use of $s = ut + \frac{1}{2} at^2$ to calculate the height from which the parcel was dropped.

Question 17

This question required candidates to apply their knowledge of vectors.

(a) Most candidates experienced difficulty with vector subtraction $\Delta\tilde{v} = \tilde{v} - \tilde{u}$. Instead they simply added the vectors. The majority showed proficiency in the use of the cosine and sine rules but many candidates had difficulty working out the correct angles. The candidates were generally able to describe the direction of vectors in terms like $S25^0W$.

(b) Most candidates were able to use Pythagoras' theorem to calculate the magnitude of the resultant vector, but as in part (a), few correctly performed the vector subtraction $\tilde{v}_{\text{ball rel field}} = \tilde{v}_{\text{ball}} - \tilde{v}_{\text{field}}$. Many candidates mistakenly used the $\Delta\tilde{v}$ vector from part (a).

Question 18

This question required candidates to apply their knowledge of motion, force and vectors.

(a)(i) The majority of candidates completed the vector diagram accurately. Some candidates failed to indicate correct direction while others showed a lack of understanding of what was required.

(a)(ii) The majority of candidates was able to either calculate the friction force or determine its magnitude using the scale diagram. Some confusion, however, was evident in the use of the scale.

(b) The majority of candidates was able to calculate the change in friction, however a large number incorrectly used the change in friction in a further calculation. A significant number calculated the new friction as the change in friction.

Question 19

This question required candidates to apply their knowledge of force and momentum.

(a) The majority of candidates was able to substitute into a correct equation. A few candidates calculated acceleration while others failed to square quantities where required in substitution.

(b)(i) The majority of candidates experienced difficulty with this question. The more capable candidates were able to apply the conservation of momentum and kinetic energy to an unfamiliar situation. Some were also able to indicate the motion of P after it stops due to the force applied by the spring.

(b)(ii) The majority of candidates had difficulty with this question. More able candidates applied the principles of conservation in an elastic collision to report both the direction and magnitude of the motion of Q after the collision.

Question 20

This question required candidates to use their knowledge of momentum to solve a problem involving a 2-D collision.

The nature of the problem allowed candidates a range of up to six possible routes to the solution to part (b).

(a) Most candidates successfully substituted into the momentum formula although some did not convert g to kg and used incorrect units for momentum.

(b) Candidates used a variety of strategies to solve this problem – vector diagrams, conservation of KE, conservation of momentum in 2D from a vector diagram and using components. A large number of candidates was able to obtain a numerical value for the

magnitude of the velocity. Problems arose with the direction of the velocity with candidates either specifying the direction incorrectly or forgetting to give a direction.

Some candidates used linear equations for momentum conservation for the magnitude and then attempted to give an angle for that vector.

Candidates are encouraged to draw clear vector diagrams for this type of question and to use these as the bases for their solutions.

Question 21

This question required candidates to use their knowledge of energy, power and resistance.

(a) This question was well understood by most candidates, recognising that energy = power x time and that values could be obtained from the area under the graph. Most candidates achieved full marks. For those candidates who did not achieve full marks, frequent mathematical errors were common. Candidates often used the incorrect units for energy rewriting watts instead of joules.

(b) This question was generally well understood with most candidates being able to achieve full marks. Candidates who were not successful failed to recall the correct formula for resistance, power and voltage while others made mathematical errors.

Question 22

This question required candidates to apply the concept of electric current as a flow of charges, each with a unit charge, and their understanding of the work done by those charges.

(a) Most candidates experienced difficulty with this question. Many were unaware of the SI units.

(b) Many candidates experienced difficulty with this question. Students who understood that 'the number of electrons plus the charge of one electron' produced the charge that flowed, successfully determined the energy dissipated. Some attempted to use part (c) in trying to calculate an answer.

(c)(i) Many candidates successfully attempted this part of the question, which was a straightforward calculation for the vast majority.

(c)(ii) The majority of candidates experienced difficulty with this part of the question, demonstrating limited understanding of the concept tested.

Question 23

This question related to the effect of altering the current flowing in a circuit as a result of closing a switch. A parallel network of resistors is created, halving the resistance, thus increasing the current through the coil. As a consequence the magnetic field strength increases in a coil that completes the circuit.

(a) This part was generally well answered by candidates though some were unaccustomed to indicating the magnetic field direction within a coil.

(b) The majority of candidates stated and explained why the current increased when the switch was closed. Significant numbers, however, failed to adequately explain why the current increased.

(c) Many candidates failed to justify their answer and significant numbers either contradicted part (b) or quoted incorrect formulae such as Coulomb's law or $F = BI\ell$ rather than $\frac{\mathrm{K}I}{d}$ as part of their explanation.

Question 24

(a) The majority of candidates attempted this question and were able to select the correct formula and give both the magnitude and direction of the force on the slider.

(b) Most candidates were able to apply the force calculated in part (a) to determine the net force and the acceleration and then the velocity of the slider. A significant number of candidates calculated the force incorrectly, most often by using an inappropriate formula, but demonstrated that they understood the correct Physics to find a velocity for the slider.

It was disappointing that some students gave no direction for the force, despite being directed to do so by the question, or could not determine the correct direction of the force.

Question 25

(a) The majority of candidates experienced difficulty with this part of the question. The best responses related the wavelength of sound to the width of the door to explain the diffraction of the sound and also mentioned that the wavelength of light was very much smaller than this gap.

The majority of candidates stated that the fact that the TV could be heard but not seen at X was due either to the different natures of sound and light waves or their different speeds or that light could only travel in straight lines.

(b) This part was answered well with most candidates being able to draw the diffraction pattern although the standard of some drawings was barely acceptable.

(c) The majority of candidates experienced difficulty with this part of the question. Many confused the behaviour of electromagnetic waves and mechanical waves in solids. The question asked only for a comparison between the speeds, not a reason. Some students automatically applied the behaviour of light to sound waves in solids.

Section I – Part C

Question 26

This question was generally answered well by most candidates.

(a) Most students could correctly give the direction of the instantaneous velocity at position 4 and instantaneous acceleration at position 2. Many candidates were careless in their indication of magnitude of these vectors. Others represented the acceleration due to gravity in positions 3 and 4 rather than recognising the net acceleration as being zero in these positions.

(b)(i) Again most candidates answered this part well. Some candidates incorrectly used the vertical acceleration of $9.8 ms^{-2}$ to calculate the horizontal displacement. Some candidates incorrectly transcribed the data provided.

(b)(ii) A good response to this question included a clearly labelled velocity vector diagram. Some candidates incorrectly used the initial horizontal velocity in calculating the final vertical velocity. Many candidates used displacement vectors to calculate the angle rather than the velocity vectors. Other common errors included incorrectly identifying the vertical angle as the horizontal angle and incorrectly renumbering the equations of motion, while some candidates operated in the horizontal plane giving angles from the North, eg $N58^{0}31'S$

Question 27

(a) While the majority of candidates gave calculations involving two forces, a significant number did not identify them correctly.

(b) The majority of candidates experienced some difficulty with this question. Many candidates included contradictory information in their descriptions while others provided a minimal qualitative description of acceleration.

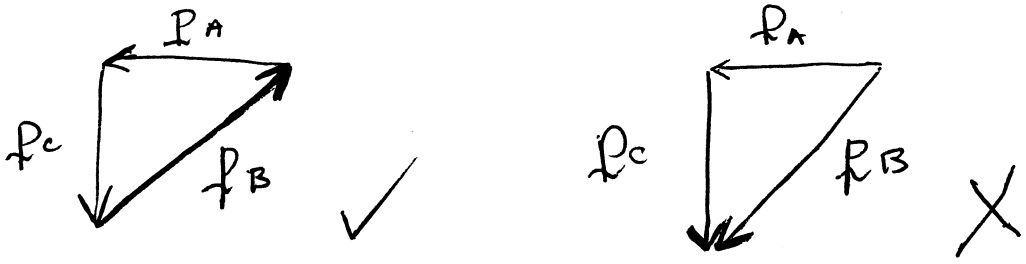
(c) Only a few candidates identified the incremental weight force component down the inclined plane. Many candidates did not identify a change in the angle of the plane as effecting the force down the plane.

Question 28

(a) A majority of candidates successfully demonstrated the use of vector equations and vector diagrams. However some used velocities rather than momenta which was not valid since the masses were unequal.

Many candidates understood that a zero resultant had the three vectors going clockwise around the closed triangle, showing both arrowheads and labels to indicate direction and the individual vectors.

A common mistake was that p_B was the resultant of the addition of the two known momenta.



Many candidates omitted direction of $v_{\sim\beta}$ or couldn't correctly state it.

(b)(i) Many candidates correctly calculated ΣKE, but a significant number used a vector addition of the scalar KE, rather than the arithmetic addition.

(b)(ii) A significant proportion of candidates correctly determined that the initial KE of the firework was zero (prior to explosion at maximum height). Others noted also their answer to (b)(i) was greater than zero. Some additionally pointed out KE wasn't conserved because chemical PE was converted to KE. Common mistakes included stating that KE was lost as other forms of energy or that the explosion was an example of an inelastic collision.

Question 29

(a)(i) Most candidates successfully identified resistors in series.

(a)(ii) Most candidates correctly identified the resistors in parallel, but some failed to include all the resistors in their answer.

(b) Most candidates calculated the answer correctly by recognising the current around the whole circuit and applying Ohm's Law accordingly. Some candidates used only one resistor referred to in the question to calculate the current.

(c) Most candidates correctly applied Ohm's Law in this question.

(d) Many candidates recalled the formula for finding the total resistance but some could not substitute the values correctly.

Question 30

This question was generally well answered by the majority of candidates.

(a) The majority of candidates successfully identified and employed an appropriate formula such as $\tau = \text{nBIA}\cos\theta$, although incorrect substitutions for θ resulted in a significant number of candidates asserting that the torque on the coil was zero.

Many candidates also did not substitute n=10, possibly because this information was integrated into the wording of the question rather than being stated numerically.

Some confusion between the quantities of flux and flux density was evident. Few candidates stated the correct unit for torque in their answers.

(b) While candidates were able to determine the direction of rotation of the coil, many experienced difficulty in communicating it unambiguously. Imprecise responses such as 'to the left' and 'towards the North pole' were extremely common.

(c)(i) The majority of candidates successfully identified the device at Z as a commutator or split ring. Many candidates attempted to describe the device rather than name it. 'Alternator' was a very common incorrect response.

(c)(ii) Many candidates described the role of the split ring commutator (eg 'it reverses the direction of the current in the coil') rather than attempting a full description of how it works.

Question 31

(a) While the majority of candidates successfully answered this part of the question some candidates had difficulty expressing the similarity clearly or relating their answer to both types of wave.

(b) The majority of candidates successfully answered this part of the question.

(c) The majority of candidates successfully attempted this part of the question. The most common error was candidates confusing the terms harmonic and overtone. A significant number of candidates drew the third harmonic in a pipe. Some students drew the second overtone.

(d) While this question was generally well answered a number of candidates gave an incorrect answer to (b) or a small number of candidates used the velocity of sound in air to calculate the frequency.

(e) The majority of candidates successfully answered this part of the question.

Section II – Electives

Question 32A – Gravitation

(a)(i)1. This question was answered correctly by the majority of candidates.

(a)(i)2. This question was answered correctly by the majority of candidates.

(a)(ii)1. This question was answered correctly by the majority of candidates.

(a)(ii)2. More able candidates linked the chosen Kepler's Law to observational evidence.

(b)(i) A majority of candidates recognised and named A and C. Some candidates recognised B as an equant. Other candidates interpreted B as a moon.

(b)(ii) A majority of candidates successfully explained the function of an epicycle in Ptolemy's model.

(b)(iii) The function of the equant in Ptolemy's model was poorly understood by the majority of candidates.

(c)(i) Candidates responses to this question were of varying standards with many failing to appreciate the mutually attractive nature of the gravitational force and that the r represented a distance between centres of masses.

(c)(ii) While some candidate responses demonstrated sound understanding of the concepts, some candidates showed no working and others did not recognise this question as application of Newton's law of universal gravitation.

(c)(iii) Some candidate responses recognised the hint required the use of Kepler's third law and knew that the periods of the planets were known from observation but others did not know Kepler's third law or confused 'parallax' with 'period of orbit'.

Question 32B – Nature of Light

(a)(i)1. This question was answered correctly by the majority of candidates with many candidates successfully using diagrams to illustrate their answers.

(a)(i)2. This question was well answered by the majority of candidates.

(a)(ii) This question was well answered by the majority of candidates.

(b)(i) A majority of candidates recognised and named the pattern Young observed on the screen.

(b)(ii) The majority of candidates experienced difficulty with this question. Most candidates could not apply the particle model of light to predict the result expected if Young's double slit experiment was performed under the conditions described in the experiment. Candidates had difficulty explaining the pattern and a diagram was very useful.

(b)(iii) Most candidates were able to identify an improvement on the work of Young made by Fresnel. Very few candidates, however, were able to recognise more than one improvement to Young's experiment.

(c)(i) Candidates responses to this question showed a clear understanding of the quantum model.

(c)(ii) Only candidates with a better understanding of the topic identified a contribution made by Planck to the quantum model of light.

(c)(iii) Only candidates with a sound understanding of the topic explained a contribution made by Einstein to the quantum model of light. A significant number of candidates did not clearly identify the further development of Planck's ideas by Einstein.

(d)(i) Most candidates responses to this question showed a clear understanding of the photoelectric effect.

(d)(ii) Only candidates with a sound understanding of the topic could explain why the photoelectric effect was not evident in this sample.

(d)(iii) Only a minority of candidates could explain the effect of an increase in light intensity as having no effect on the emission of photoelectrons because the frequency was below the threshold frequency.

Question 32C – Atomic Structure

(a)(i) The majority of candidates successfully identified Geissler's contribution in producing gas discharge tubes with extremely low pressure.

(a)(ii)1. The majority of candidates successfully answered this part of the question.

(a)(ii)2. A significant number of candidates were aware of the use of electric and/or magnetic fields to investigate the nature of the streamers. A small number was able to fully compare the properties of the streamers to those of electrons.

(b)(i) The majority of candidates was able to draw a diagram of the Thomson model but a significant number identified discrete positive particles (protons) as a feature of this model.

(b)(i) The Lenard model was explained well with regard to empty space but again a significant number of candidates identified discrete positive particles as a part of a dynamide.

(b)(iii) The majority of candidates' Geiger/Marsden and Lenard experiments were explained with reference to conclusions drawn instead of explanations of the experimental procedure.

(c)(i) The majority of candidates took the opportunity to provide a diagram to assist their answer and demonstrated an understanding of how energy was related to the electron movement but was unable in many cases to relate this energy to the formation of a spectral line.

(c)(ii) The majority of candidates successfully answered this question and was able to recall Rydberg equation and identify the correct transition.

Question 33 – Wave Properties of Light

(a) Many candidates had difficulty in answering this question. The main difficulties arose in drawing a correct Huygens construction to explain reflection. Many candidates did not draw a diagram in which the reflected wavefront was tangential to the reflected secondary wavelets. Many diagrams were poorly labelled.

Some candidates used Huygens to explain the propagation of the incident and reflected wavefronts without actually answering the question, ie explaining reflection.

Most candidates could state or show that the angle of incidence equals the angle of reflection.

A number of candidates concentrated on writing explanations rather than the required diagram.

(b) Most candidates were able to state that the function of the prism was to disperse light or refract light by differing amounts or produce different wavelengths/frequencies/colours of light. A number of candidates confused and incorrectly used the terms diffraction and scattering with dispersion and/or refraction of light.

Some candidates confused the telescope's function with that of the collimator and indicated that the telescope was directing light onto the prism. Another common error was to answer in terms of an astronomical telescope.

(c)(i) The majority of candidates was able to calculate the relative refractive index. A common error was to invert the calculation placing 1.4 over 1.6.

(c)(ii) Many candidates were able to use Snell's Law correctly to calculate the angle of refraction in the glass directly or by using two steps.

(d) The majority of candidates was able to explain a valid difference between Pyrex and soda glass immersed in the solution.

A few candidates seemed confused about the solution and incorrectly called it water. A small number of candidates described methods which failed to immerse the glass samples whilst others confused physical density with optical density and discussed floatation.

(e) The majority of candidates could draw comparisons with regard to width but most had difficulty comparing patterns further (or with regard to intensity and pattern structure). Many candidates described the pattern from one slit without comparing it with the second slit.

(f) Most candidates indicated that they understood the correct phase changes and other conditions needed to minimise reflection. Some candidates calculated the thickness for maximising reflection. There was a good understanding of the effect the refractive index of the coating would have on the wavelength of the light.

(g) While the question was well answered, a number of candidates confused the words 'slits' and 'fringes'. The majority of candidates described the separation of the fringes and explained it in terms of the appropriate equation. A small number of candidates used a diagram in their explanation.

(h) A significant number of candidates carefully followed the process of solving the problem. Some candidates had difficulty with manipulating the equation to find the slit width. A small but noticeable number of candidates interpreted the slit spacing as the number of lines per metre.

(i)(i) Most candidates realised that a test for polarised sunglasses was rotating them in front of a source of polarised light.

(i)(ii) The candidates who knew that reflected light could be polarised, drew adequate diagrams to illustrate this phenomena. Many candidates successfully explained adequately how a polaroid filter worked.

(i)(iii) The majority of candidates were familiar with Maln's Law, however most had difficulty determining which 'I' was the 'incident I'.

(j)(i) Few candidates were able to apply the Doppler Effect equation in the form given. Many candidates had difficulty distinguishing the observed frequency from the source frequency.

(j)(ii) Most candidates had a basic idea of 'red shift' although only a few gave a good, concise explanation.

Question 34 – Rotation

(a) The majority of candidates demonstrated an understanding of moment of inertia and the dependence of torque on angular acceleration and moment of inertia. The calculation of angular acceleration from the change in angular velocity (stated in rpm) was not a problem. It was disappointing that some candidates could not clearly describe the change in motion of the shuttle.

(b) A significant number of candidates stated that the angular momentum of the ball about the pivot was zero when it was unattached to the rotating system. It was disappointing that candidates did not include the direction of the angular momentum when a non-zero amount was calculated. Very few candidates were able to explain in part (vii) that the torque was zero as the only force acting is through the axis of rotation.

(c) Most candidates demonstrated that they understood the physics involved. Some did not complete the calculation in part (iii), only determining the amount of kinetic energy lost rather than the fraction of the initial kinetic energy. When asked to 'account for the loss of kinetic energy', candidates should avoid labelling the type of collision or repeating information from a previous part of the question.

(d) Most candidates successfully stated or applied the parallel-axis theorem. Some candidates were unable to state the ratio of the angular acceleration as they failed to cancel the constant torque. Candidates experienced difficulty recognising in part (iv) that the translational kinetic energy about a point of contact at rest was zero. Some candidates obtained the 1:1 ratio by laboriously calculating the angular velocities from the angular accelerations and hence the kinetic energy values.

(e) Candidates were generally familiar with the required closed vector diagram involving the angular momenta of a gyroscope although marks were lost through careless labelling and lack of arrows. The majority of candidates did not clarify whether the precessional motion they described was during or after the bump, failing to demonstrate an understanding that the precession of the gyroscope ceased when the 'upward bump' was no longer being applied as the displaced gyroscope is balanced.

Question 35A – Engineering Materials and Structures

(a) The majority of candidates experienced difficulty with this question. Many candidates incorrectly assumed that clockwise moments equalled anticlockwise moments.

Some students had difficulty taking moments about A. Many tried to take moments about the worker's left hand. The rotational sense of the moments was omitted by a large number of candidates while many candidates combined the moments to calculate a resultant which was not required.

(b)(i) Candidates gave general descriptions instead of specific information about the ribbon's response. The elastic limit was poorly understood and very little reference was made to the shape of the graph and what each part meant.

(b)(ii) While this question was generally well answered by the majority of candidates some candidates calculated the area incorrectly. A number of candidates substituted values for 'F' and 'e' which were beyond the elastic limit. Other candidates substituted 'F' and 'e' values which did not match up on the graph, possibly indicating poor graph reading skills. A significant number of candidates incorrectly used the peak of the graph to answer this.

(c)(i) Most candidates recognised that AC increased the stability of the structure, but many had trouble expressing this concept in words.

(c)(ii) This question was answered well with most candidates recognising the bar was in tension.

(c)(iii) Most candidates correctly chose the tube, but had difficulty justifying their choice. The concept of mass distribution around the neutral axis was poorly understood.

(d)(i) While most candidates described a model many failed to explain its purpose and some clearly had not built a model.

(d)(ii) The majority of students had difficulty explaining the performance of their structure in terms of stability and load-bearing characteristics which implied a poor understanding of these terms.

Question 35B – Optical Instruments

(a)(i) Candidates generally answered this question by using either mirror equations or ray diagrams. For those who chose the equations, more successful candidates took care to allocate the correct signs (+ve, -ve) to appropriate distances. A significant number of candidates who chose the ray diagram had not drawn a ray diagram for a mirror.

(a)(ii) Generally candidates were able to correctly describe the image consistent with their calculations or diagram.

(b)(i) Most candidates were aware of one (or more) problems associated with large refracting telescopes. Better candidates were able to clearly state how a reflecting telescope overcame the specific problem stated.

(b)(ii) The majority of candidates were aware of the nature and correct position of the components of a Newtonian telescope. Better candidates were able to correctly illustrate the path of the rays through the telescope and how those rays resulted in an image.

(c) Ray diagrams were generally very poorly drawn by a vast majority. Many candidates did not use a concave lens in their ray diagram. Better candidates took care to use the correct conventions in their diagrams. Generally most candidates were able to correctly describe the image they had drawn and to adequately justify their choice. Of those that did draw the correct lens many proceeded to treat it as a mirror or a convex lens.

(d)(i) The majority of candidates were aware of the phenomenon of chromatic aberration. Many candidates were aware that white light consists of different colours/wavelengths, with a different refractive index for each colour. Better candidates were able to relate this to the different foci.

(d)(ii) The majority of candidates understood the function of an achromatic doublet.

Question 35C – Transformation of Energy

(a)(i) While the majority of candidates answered this quite well, many responses focused on societal and environmental problems that can ensue from energy conversions. Better responses had a brief discussion of the physics of the limitation. Some candidates simply described each one of the 3 energy transformations.

(a)(ii) The majority of candidates successfully attempted this question. The most common problems were candidates not completing the question by not calculating power after having calculated energy and being unable to correctly determine mass.

(a)(iii) Most candidates successfully answered this question. A number of candidates who referred to ‘friction’ in their answer were further expected to relate it to the production of heat, sound energy, etc to have a correct response.

(b)(i) The majority of candidates experienced difficulty with this question with common errors being the poor recall and application of the power formula, and incorrect or absent units.

(b)(ii) In contrast to (i) above, most candidates were able to correctly recall and apply the gravitational potential energy formula.

(b)(iii) Most candidates correctly recalled and applied the efficiency formula. Sources of error were confusion over what constituted output energy and input energy, and incorrect recall of the formula.

(c)(i) Most candidates were easily able to answer this question. A few candidates used incorrect units in their answer.

(c)(ii) Most candidates were able to read the graph correctly, and apply the information to the efficiency formula. Again, some candidates demonstrated confusion over what constituted output power and input power.

(c)(iii) The majority of candidates successfully answered this question. The main errors were candidates either not converting their answers from (ii) above before substituting into the appropriate equation, or being unable to determine the correct mass of water to substitute into the equation. In many instances, candidates confused power and energy in their calculations.

Question 36 - Astronomy

(a)(i) This question was answered correctly by many candidates, who were able to overcome the complication of a red filter being used, rather than the yellow V filter, as used in the colour index formula. Candidates needed to show that they understood that Z was the bluest star, and therefore the hottest.

(a)(ii) Few candidates answered this correctly. Most candidates who did not gain this mark stated colour-dependent differences, which were ruled out by the question.

(b)(i) Many candidates were able to describe a gravitational contraction of a gas cloud/nebula. Some candidates were then able to demonstrate a knowledge of a subsequent temperature increase.

(b)(ii) Most candidates successfully demonstrated an understanding of the various differences between large and small main sequence stars.

(b)(iii) Many candidates answered this part correctly. Those that did not, failed to restrict their explanation to the main sequence.

(b)(iv) Many candidates were able to recall the four pieces of information.

(c)(i) Most candidates knew the definition of absolute magnitude.

(c)(ii) Most candidates were able to recall the correct formula and correctly substitute information into that formula. Few candidates were able to complete the mathematics successfully. As in previous years, changing the subject of a formula with log functions presents significant difficulties.

(c)(iii) Most candidates answered this question successfully.

(d)(i) Many candidates were able to correctly identify the globular cluster from the description. The most common incorrect answer was ‘galaxy’.

(d)(ii) Most candidates successfully answered this question. Some candidates were aware of other characteristics of globular clusters.

(e)(i) Many candidates demonstrated a sound knowledge of the production of absorption spectra in stars.

(e)(ii) The majority of candidates experienced difficulty with this question. Only some showed an understanding of the production of molecular lines in the spectra of stars and how this is related to temperature.

(f)(i) Most candidates were able to give a good description of distance estimation using cepheid variables. Some candidates were able to identify other valid techniques, but their depth of answer was usually deficient.

(f)(ii) The majority of candidates experienced difficulty with this question. Very few candidates realised that although the question asked for an explanation of 'any effect', the answer was that there would be no effect, and an explanation of this is what was sought.

(f)(iii) The majority of candidates experienced difficulty with this question. Few candidates were able to connect the red shift of the cluster with an increase in distance over time, and therefore a reduction in brightness/increase in average apparent magnitude.

(f)(iv) Most candidates were able to draw the shape of the light curve of a cepheid variable. Many candidates were then able to properly draw a set of scaled axes to accompany the light curve.

(f)(v) Most candidates were able to perform this calculation successfully.

(g)(i) Some candidates were able to correctly identify the p-p chain and the CNO cycle.

(g)(ii) Similarity: Some candidates could identify a similarity between the processes they named in (i).

Difference: Few candidates could successfully identify a difference between the processes they named in (i).

(g)(iii) The majority of candidates experienced difficulty with this question. Few candidates could identify and explain that temperature determines whether the p-p chain or the CNO cycle dominates in main sequence stars. Of those that did, many successfully used this also as a difference in (g)(ii).