BOARD OF STUDIES
NEW SOUTH WALES

2013 HSC Physics
Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

Question	Answer
1	B
2	D
3	A
4	A
5	D
6	C
7	A
8	D
9	B
10	C
11	B
12	A
13	D
14	B
15	A
16	D
17	D
18	C
19	C
20	B

Section I, Part B

Question 21 (a)

Criteria	Marks
• Provides an outline of one contribution of the named scientist to the development of space exploration	2
• Identifies a contribution of one of the listed scientists	1

Sample answer:

von Braun	Launched the V2 rocket demonstrating the use of gyroscopes to stabilise large rockets.

Answers could include:

Scientist	Contribution
Tsiolkovsky	Calculated the speed a rocket would need to escape the Earth's atmosphere.
Oberth	Theorist who promoted interest in rocketry, developed equations for spaceflight.
Goddard	He launched the world's first liquid fuelled rocket, using alcohol and liquid oxygen to reduce the overall mass of the rocket.
Esnault-Pelterie	Experimented with various liquid fuel mixes.
O'Neill	Suggested the idea of space stations at Lagrange points.

Question 21 (b)

Criteria	Marks
• Outlines a valid method to ensure reliability of secondary sources of information about the scientist	2
• Shows some understanding of reliability	1

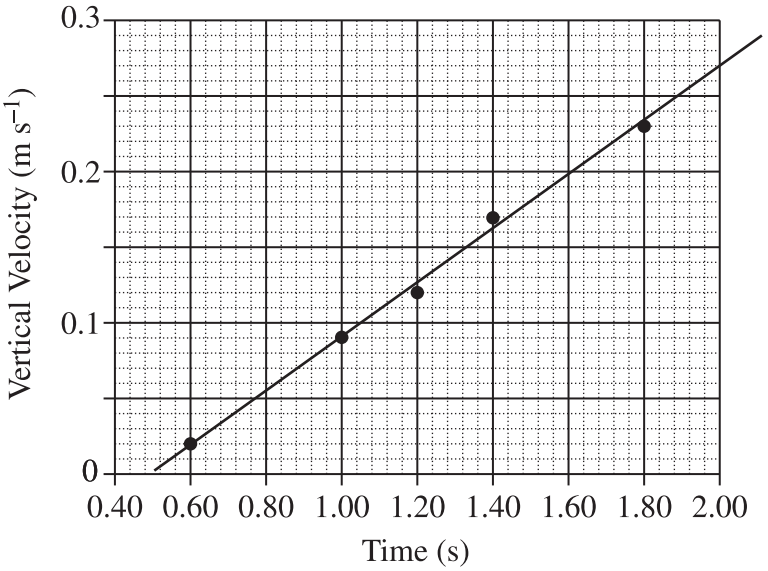
Sample answer:

A source could be cross-referenced with several other reputable sources. If the information is consistent it is deemed reliable.

Question 22

Criteria	Marks
• Correctly plots points and draws line of best fit • Correct substitution to determine the acceleration	3
• Correctly plots points and attempts to determine the acceleration OR • Correctly plots points and draws line of best fit	2
• Shows a basic understanding of graphing	1

Sample answer



Acceleration

$= \dfrac{0.235 - 0.02}{1.80 - 0.60}$

$= \dfrac{0.215}{1.20}$

$= 0.18 \text{ m s}^{-2}$

Question 23 (a)

Criteria	Marks
• Explains why the mass of the planet plays no role in determining its orbital speed	2
• Shows some understanding of the orbital speed of the planet	1

Sample answer:

The orbital velocity is determined by the planet's period and distance from the central mass, as described by Kepler's Laws. Therefore, the mass of the planet plays no role in determining its orbital speed around Pollux.

Question 23 (b)

Criteria	Marks
• Demonstrates correct process to calculate the distance required	3
• Relates period and radius of the 2 objects orbiting the central mass OR • Substitutes into correct equation to calculate constant	2
• Partial substitution into a relevant formula OR • Attempts to relate period and radius of the 2 objects orbiting the central mass	1

Sample answer:

$$\frac{r_x^3}{T_x^2} = \frac{r^3}{T^2} \qquad \frac{r^3}{365^2} = 1.27 \times 10^{-5}$$

$$\frac{1.64^3}{590^2} = \frac{r^3}{365^2} \qquad r^3 = \left(1.27 \times 10^{-5}\right) \times 365^2$$

$$r = \sqrt[3]{\left(1.27 \times 10^{-5}\right) \times 365^2}$$

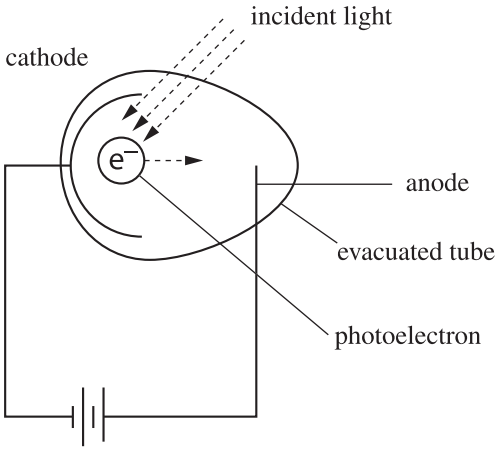
$$= 1.19\ AU$$

Question 24

Criteria	Marks
• Explains how a photocell works, using photoelectric effect • Includes an appropriate diagram	5
• Describes how a photocell works, using photoelectric effect	4
• Outlines how a photocell works, using photoelectric effect	3
• Outlines how a photocell works, without necessarily mentioning the photoelectric effect	2
• Identifies ONE feature of a cell that uses light OR • Identifies that a photocell uses the photoelectric effect	1

Sample answer:

A photocell detects light and transforms the energy into electricity using the photoelectric effect. When light of frequency greater than the threshold frequency of the cathode material falls on the cathode, photoelectrons are emitted because the electrons have enough energy to leave the surface of the metal. This is the photoelectric effect. These electrons are collected by the anode and an electric current starts flowing in the external circuit. The current would stop if the light does not fall on the cathode or the frequency of the light was less than the threshold frequency.



Question 25 (a)

Criteria	Marks
• Identifies correct direction	1

Sample answer:

To the left
OR
Towards the conductor P

Question 25 (b)

Criteria	Marks
• Demonstrates correct process to calculate the force experienced by Q	3
• Demonstrates logical process to calculate force P or force R on Q	2
• Partial substitution into a relevant equation	1

Sample answer:

$$\frac{F}{l} = \frac{kI_1I_2}{d}$$

Force P on Q

$$F = \frac{2\times10^{-7}\times6\times2}{5\times10^{-3}}$$

$$F = 4.8\times10^{-4}\ \text{N}$$

Force R on Q

$$F = \frac{2\times10^{-7}\times2\times2}{2.5\times10^{-3}}$$

$$F = 3.2\times10^{-4}\ \text{N}$$

Total force $= 4.8\times10^{-4}\,\text{N} + 3.2\times10^{-4}\,\text{N}$

Total force $= 8\times10^{-4}$ Newtons

Question 26 (a)

Criteria	Marks
• Substitutes into correct equation to calculate the potential difference between the plates	2
• Partial substitution into a relevant equation	1

Sample answer:

$$E = \frac{V}{d}$$

$$\therefore V = Ed = 15 \times 1.0 \times 10^{-2} = 0.15 \ V$$

Question 26 (b)

Criteria	Marks
• Demonstrates correct process to determine the magnitude of the electric field AND • Identifies the correct direction of the electric field	3
• Demonstrates correct process to determine the magnitude of the electric field OR • Correctly substitutes into a relevant equation and identifies the correct direction of the electric field	2
• Identifies ONE relevant piece of data	1

Sample answer:

$$F = qvB = qE$$

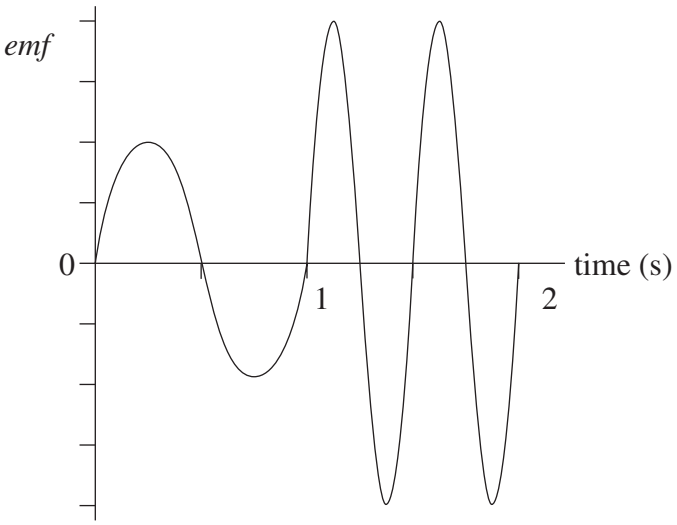
$$\therefore E = vB = 1 \times 10^4 \times 0.5$$

$$= 5000 \ V \ m^{-1} \text{ from } M \text{ to } N$$

Question 27 (a)

Criteria	Marks
• Starting from zero, produces a single period AC curve for 0–1 seconds, followed by an AC curve of twice the frequency and amplitude for 1–2 seconds	3
• Produces a correct curve for 0–1 seconds OR 1–2 seconds AND • Includes a correct feature for the other second	2
• Identifies ONE correct feature	1

Sample answer:



Question 27 (b)

Criteria	Marks
• Demonstrates a sound understanding of the physics principles involved in a motor and a generator • Considers the energy changes and relates these to the motion of the vehicle both in propulsion and in braking • Clearly explains the physics principles involved in the propelling and braking of the vehicle	4
• Demonstrates an understanding of the physics principles involved in a motor and a generator • Describes relevant energy changes	3
• Demonstrates an understanding of the physics principles involved in a motor or generator OR • Shows some understanding of how a motor can act as a generator	2
• Identifies some relevant information	1

Sample answer:

A motor consists of a rotating coil in a magnetic field. When power is cut, this rotation causes an emf to be produced due to a change in magnetic flux. This allows the motor to act as a generator, which has essentially the same parts as a motor.

When acting as a motor, the vehicle converts electrical energy to kinetic energy due to the motor effect, thus propelling the vehicle. When it acts as a generator, kinetic energy is converted to electrical energy, and so by Lenz's law, the motion of the rotor is opposed. This acts to slow the vehicle.

Question 28

Criteria	Marks
• Demonstrates a thorough understanding of the contribution of Einstein to quantum theory • Makes an informed judgement implicitly or explicitly about Einstein's contribution to quantum theory	6
• Demonstrates a thorough understanding of the contribution of Einstein to quantum theory OR • Demonstrates a good understanding of the contribution of Einstein to quantum theory AND • Makes an informed judgement implicitly or explicitly about Einstein's contribution to quantum theory	5
• Demonstrates a good understanding of the contribution of Einstein to quantum theory OR • Demonstrates a sound understanding of the contribution of Einstein to quantum theory AND • Makes an informed judgement implicitly or explicitly about Einstein's contribution to quantum theory	4
• Demonstrates a sound understanding of the contribution of Einstein to quantum theory • OR • Demonstrates some understanding of the contribution of Einstein to quantum theory AND • Makes an informed judgment implicitly or explicitly about Einstein's contribution to quantum theory	3
• Demonstrates some understanding of the contribution of Einstein to quantum theory	2
• Identifies a contribution of Einstein to modern physics	1

Sample answer:

Einstein contributed a great deal to Quantum Theory. Until this time in history, classical theory was the prevailing theory and it was the physics of the large scale. Quantum theory deals with the physics of the small. Planck had proposed that light energy came in packets or quanta when he was investigating black body radiation. The energy of the photon is given by E = hf. Einstein was able to use Planck's ideas and apply them to both black body radiation and the photoelectric effect to formulate explanations for how and why they work. Einstein stated that light comes in quanta called photons, which have an energy (E = hf), and when this photon interacts with electrons in a metal surface, it gives all or none of its energy to the electron.

Question 29 (a)

Criteria	Marks
• Correct substitution into relevant equation to calculate the force required	2
• Identifies one correct step in calculating the force required	1

Sample answer:

$F = mg = 0.05 \times 9.8 = 0.49$ N

Question 29 (b)

Criteria	Marks
• Equates two torque equations AND • Shows correct substitution into both equations to calculate the current required	3
• Equates two torque equations OR • Shows correct substitution into ONE torque equation	2
• Identifies a correct step in calculating the current required	1

Sample answer:

$\tau = \text{Fd} = nBIA\cos\theta$

$mgd = nBIA\cos 0°$

$0.05 \times 9.8 \times 0.004 = 100 \times 0.1 \times I \times 0.0012 \times 1$

$1.96 \times 10^{-3} = 0.012\ I$

$I = 0.16$ A

Question 30 (a)

Criteria	Marks
• Provides a correct explanation • Identifies centripetal force towards centre and relates this force to simulation of gravity	2
• Identifies a force is acting on the astronaut	1

Sample answer:

The rotating wheel provides a centripetal force (acceleration) towards the centre. The astronaut reacts against this force according to Newton's 3rd Law, thus providing a simulated gravity.

Question 30 (b)

Criteria	Marks
• Demonstrates correct process to determine the rotational speed	2
• Shows an understanding in deriving the orbital velocity formula	1

Sample answer:

$$F = \frac{mv^2}{r} = mg$$

$$g = \frac{v^2}{r}$$

$$v^2 = gr$$

$$v = \sqrt{gr}$$

$$= \sqrt{9.8 \times \frac{550}{2}}$$

$$= 51.9 \ m \ s^{-1}$$

Question 31

Criteria	Marks
• Shows thorough understanding of the changes that occur to the electrical properties of materials • Clearly relates changes in electrical properties of materials to the development of new technologies • Shows good understanding of the benefits of these technologies to society • Explains in a coherent and logical manner	7
• Shows good understanding of the changes that occur to the electrical properties of materials • Relates changes in electrical properties of materials to the development of new technologies • Shows good understanding of the benefits of these technologies to society	6
• Shows good understanding of changing electrical properties of materials • Relates the change(s) to the development of a new technology • Shows sound understanding of the benefits of this technology to society OR • Shows sound understanding of electrical properties of materials • Links these electrical properties to relevant new technologies • Shows some understanding of the benefits of these technologies to society	5
• Shows a sound understanding of electrical properties of materials • Links the electrical properties/property to the development of a relevant new technology • Shows sound understanding of the benefits of this technology to society OR • Shows some understanding of electrical properties of materials • Identifies relevant new technologies • Shows some understanding of the benefits of these technologies to society	4
• Describes a relevant new technology and identifies a benefit of this technology to society OR • Links electrical properties of materials to the development of technologies/benefits to society OR • Shows sound understanding of electrical properties of materials	3
• Shows some understanding of electrical properties and/or relevant new technologies and/or relevant benefits to society	2
• Identifies a relevant piece of information on electrical properties / new technologies / benefits to society	1

Sample Answer:

Changes in the electrical properties of materials can produce semi-conduction materials or superconductors.

P and N type semi conductors can then be used to make components such as transistors and solar cells.

Transistors have led to the development of miniaturised computers, phones etc rather than those possible with thermionic devices. These items have benefited society by making an information rich society that has efficient communication.

Mobile phones benefit society because people can now communicate from most places. This can save lives allowing a rapid response in car accidents.

Solar cells allow for electricity to be produced and delivered in remote areas and is a clean form of energy which reduces carbon emissions and ultimately improve society's health.

Super conductors allow a much better way to detect small magnetic fields, which can be used in SQUIDS for medical applications to improve diagnosis and hence the health of the population.

Superconductors can be used in sending and making electricity, reducing energy losses and hence reducing carbon emissions and greenhouse effect.

Answers could include:

- Mentions multiple electrical properties – eg conductors, semiconductors and superconductors
- Mentions multiple technologies – eg transistors, microprocessors, Maglev trains, MRI, electricity supply
- Mentions multiple benefits to society – eg reduced costs, reduction of electricity use, increase in portability (miniaturisation), employment, communications, globalisation, processing computer speed, delocalised workforce, improved health, improved medical diagnosis, etc.

Section II

Question 32 – Geophysics

Question 32 (a)

Criteria	Marks
• Correctly describes how a relevant piece of equipment detects seismic waves	3
• Provides a general description of a relevant piece of equipment	2
• Names a piece of relevant equipment OR • Identifies a relevant feature	1

Sample answer:

The seismometer works on the principle of inertia of one component of the device measuring movement of another component of the device that is attached to Earth. A freely suspended inertia mass is attached to a base on the Earth. As the Earth shakes the mass remains stationary. This is connected to a needle which imparts a graphical representation onto a drum.

Question 32 (b) (i)

Criteria	Marks
• Describes a plausible investigation procedure including apparatus	3
• Outlines the main steps of a suitable procedure which may not include apparatus	2
• Lists relevant equipment OR • Identifies some steps	1

Answers could include:

Procedure

1. Measure mass of rock sample using balance
2. Partially fill measuring cylinder with water. Record volume
3. Tie string to rock, immerse completely in water in measuring cylinder
4. Record new volume
5. Difference between the two volumes equals the volume of the rock
6. Use $D = \frac{M}{V}$ to calculate density of rock
7. Repeat for each different rock type

Question 32 (b) (ii)

Criteria	Marks
• Explains how the reliability of results could be determined	2
• Shows a basic understanding of the results of the procedure	1

Sample answer:

The reliability of the results can be determined by comparing density of rocks obtained from repetitions of the experiment to see if they are consistent.

Question 32 (c) (i)

Criteria	Marks
• Explains by relating activity to hot spot and to how the hot spot is formed	2
• Shows a basic understanding of the volcanic activity	1

Sample answer:

The volcanic activity on the island of Hawaii is associated with a hot spot on the ocean floor where hot solid material is rising in narrow cylindrical jets from deep within the mantle.

Question 32 (c) (ii)

Criteria	Marks
• Provides an explanation by relating the position of the islands to moving plates and relating this to theory of plate tectonics	3
• Shows some understanding of plate tectonics and/or the formation of the island chain	2
• Provides one piece of relevant information	1

Sample answer:

Although the Hawaiian Islands are in the middle of the Pacific plate they do provide evidence of plate movement. The plate moved to the NW but the hot spot remained stationary. Therefore the further NW of Hawaii the older and more stable the islands, eg Kauai was on the hot spot 3.8 to 5.6 million years ago and as the plate moved NW it moved off the hot spot and stopped volcanic activity. The next island formed over the hot spot was Oahu 2.2 to 3.4 million years ago. Therefore the island chain provides evidence that the plate moves not just at the boundaries.

Question 32 (d)

Criteria	Marks
• Explains the significance of the shape of the gravity anomaly line by relating the density of rock and the gravity anomaly to the topographic map	3
• Relates gravity anomaly to density of underlying rock OR to topographic map	2
• States an understanding of gravity anomaly	1

Sample answer:

The gravity anomaly (Bauger Anomaly) shows density variations due to differing density of rocks below the datum without the effects of topology or latitude.

Large gravity lows (troughs) are associated with accumulation of lighter, less dense material near trenches and long gravity high (crest) due to cold dense slabs of lithosphere descending from beneath the volcanic zone.

Question 32 (e)

Criteria	Marks
• Shows correct process to determine the acceleration	3
• Derives correct equation for determining acceleration OR • Equates two relevant equations	2
• Partial substitution into a relevant equation	1

Sample answer:

$$F_g = \frac{gm_o m_E}{r_E^2} \qquad F_g = m_o g$$

$$\cancel{m}_o g = \frac{G\cancel{m}_o m_E}{r_E^2}$$

$$g = \frac{Gm_E}{r_E^2}$$

$$g = \frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{\left(6357 \times 10^3\right)^2}$$

$$g = 9.9 ms^{-2}$$

Question 32 (f)

Criteria	Marks
• Identifies major issues and provides points for and/or against the effectiveness of using geophysical methods in mineral exploration AND environmental monitoring • Shows thorough understanding of geophysical methods • Uses clear and scientifically correct language	6
• Identifies issues and provides points for and/or against the effectiveness of using geophysical methods in mineral exploration AND environmental monitoring • Shows good understanding of geophysical methods	5
• Outlines issues in relation to the effectiveness of using geophysical methods in mineral exploration and/or environmental monitoring • Shows sound understanding of geophysical methods	4
• Outlines issues in relation to the use of geophysical method(s) in mineral exploration and/or environmental monitoring	3
• Shows some understanding of geophysical method(s) and/or mineral exploration and/or environmental monitoring	2
• Shows a basic understanding of geophysical method/mineral exploration/ environmental monitoring	1

Sample Answer:

Geophysical methods have proven to be very beneficial in both mineral exploration and environmental monitoring. The main geophysical methods employed include gravity methods, seismic methods, magnetic methods, electrical methods, radiometric methods and geothermal methods.

Seismic methods are capable of looking into the earth without the need for removal of the surface rocks. By using artificially generated sound waves and their reflection from subsurface layers they are able to detect the gross geological features of an area.

The use of seismic methods have enabled the presence and boundaries of water, gas and oil deposits to be accurately determined, reducing the large scale need for drilling and excavation of the landscape in search of the deposits.

Seismographic stations all over the world can detect earthquakes. The use of this network of stations for early detection of earthquake wake could reduce the fatalities that occur as a result of earthquakes.

Magnetic methods used in geophysics work on the magnetic susceptibility of minerals. The magnetic susceptibility depends on the amount of ferromagnetic minerals present in the rock. Magnetic prospecting can be done using high-resolution airborne magnetic surveys where a magnometer is towed behind an airplane detecting the magnetic field from the terrain below. Satellites are also used for that purpose. This process is often non-invasive, hence causes no damage to the vegetation. The extent and location of large ferromagnetic ore deposits can be detected and planning of mining infrastructure and management can be done without adverse impact on the environment. Magnetic methods have enabled the monitoring of the earth's

magnetic field as well as monitoring of magnetic anomalies associated with the spreading of the ocean floor.

Answers could include:

Environmental monitoring can vary from the local to regional and even national scale with instruments ranging from hand held to high tech satellites. The data collected can be stored in digital format so it can be reprocessed so that comparisons can be made and environmental monitoring can be continuous.

Question 33 — Medical Physics

Question 33 (a)

Criteria	Marks
• Shows a comprehensive understanding of differences between X-ray images and CAT scans	3
• Clearly shows the differences between X-ray images and CAT scans	2
• Identifies a feature of X-ray images or CAT scans	1

Sample answer:

X-ray images	*CAT scans*
• Fewer shades of grey in image (30 shades) • One 2D plane image formed at a time • X-ray images show bone early	• More shades of grey in image (256 shades) • Helical scanning forms multiple images in all 3 planes (x, y and z) which can be formed in 3D image • CT images show soft tissue and bone structure clearly

Question 33 (b)

Criteria	Marks
• Outlines a first-hand investigation to demonstrate the transfer of light by optical fibres	2
• Identifies ONE relevant feature of the process	1

Sample answer:

A light beam, either single ray or laser pointer, is sent into a glass rod at an angle to the surface. The light beam can be seen in a zig zag pattern down the rod. This is called total internal reflection, as shown in the diagram below.

Question 33 (c)

Criteria	Marks
• Correctly explains how tissue samples of internal organs can be obtained using an endoscope	3
• Shows some understanding of the use of an endoscope to obtain tissue samples	2
• Identifies a piece of relevant equipment or a step in the process	1

Sample answer:

Tissue samples can be taken through keyhole surgery using an endoscope. Along with optical fibres to illuminate and view inside the body, endoscopes have attachments that can cut or snip small tissue samples and an extract that can remove the sample from the patient.

Question 33 (d) (i)

Criteria	Marks
• Identifies changes in orientation of nuclei magnetic axis due to the application of strong magnetic field	2
• Identifies orientation of nuclei magnetic axis due to the strong magnetic field	1

Sample answer:

Nuclei with net spin have a magnetic moment that has a random orientation when no external magnetic field is applied. After a strong magnetic field is applied, the magnetic moment of the nuclei line up either parallel or anti-parallel to the external magnetic field.

Question 33 (d) (ii)

Criteria	Marks
• Correctly explains the difference in the relaxation times between hydrogen in water and hydrogen in other molecules	3
• Shows an understanding of the relaxation time of hydrogen in water and that of hydrogen in other molecules	2
• Identifies some relevant information	1

Sample answer:

Hydrogen in water has a longer relaxation time because the interaction with its surroundings (water) is small. The relaxation time of hydrogen in other molecules is shorter because it has greater interactions with its surroundings.

Question 33 (e) (i)

Criteria	Marks
• Describes how the Doppler effect is used in ultrasonics to investigate blood flow characteristics	3
• Outlines how the Doppler effect is used in ultrasonics	2
• Shows a basic understanding of the Doppler effect	1

Sample answer:

The Doppler Effect is the apparent change in frequency of a sound wave that is observed when there is relative movement between the source of the sound and the observer. In ultrasonics, the ultrasound waves are sent out from the transducer towards the moving blood cells and the reflected ultrasound waves are detected by the transducer. The change in the frequency of the ultrasound waves observed is used to determine the direction and speed of the blood cells. This can assist in diagnosis of blockages or leakages in blood vessels, especially in the heart.

Question 33 (e) (ii)

Criteria	Marks
• Outlines TWO technologies required for an ultrasound scan	3
• Outlines ONE technology required for an ultrasound scan	2
• Identifies TWO technologies required for an ultrasound scan	1

Sample answer:

For Doppler ultrasound to be used in an ultrasound scan, both the cathode ray tube monitor and the computer needed to be developed. The processing speed of computers has enabled the formation of an ultrasound image and calculation of direction and speed of blood flow to happen in a relatively short period of time.

Question 33 (f)

Criteria	Marks
• Identifies both gamma scans and PET as diagnostic tools using radioactive isotopes • Identifies radioactive isotopes for gamma scans and PET from list provided • Fully justifies the suitability of the identified radioactive isotopes for use in diagnostic imaging techniques • Shows a thorough understanding of both gamma scans and PET and their use as a diagnostic tool with the radioactive isotopes • Uses clear and scientifically correct language	6
• Identifies both gamma scans and PET as diagnostic tools using radioactive isotopes • Identifies radioactive isotopes for gamma scans and PET from list provided • Provides a good justification for the suitability of the identified radioactive isotopes for use in diagnostic imaging techniques • Shows a good understanding of both gamma scans and PET and their use as a diagnostic tool	5
• Identifies both gamma scans and PET as diagnostic tools using radioactive isotopes • Identifies radioactive isotopes for gamma scans and PET from list provided • Provides some justification for the suitability of the identified radioactive isotopes for use in diagnostic imaging techniques • Shows a sound understanding of either gamma scans or PET and their use as a diagnostic tool	4
• Identifies either gamma scans or PET as diagnostic tools using radioactive isotopes • Identifies a radioactive isotope for either gamma scans or PET from list provided • Gives reason(s) for the suitability of the identified radioactive isotope for use in diagnostic tools • Shows some understanding of either gamma scans or PET and their use as a diagnostic tool	3
• Shows some understanding of diagnostic tool(s) and/or radioactive isotope(s)	2
• Shows a basic understanding of diagnostic tool/radioactive isotope	1

Sample answer:

Radioactive isotopes are used to show functioning of areas of interest in the body. Radioactive isotopes are attached to pharmaceuticals that roam the body and position themselves in certain areas. Their radioactive decay products are detected with diagnostic imaging tools such as Gamma scan and PET devices.

Radioactive isotopes used for diagnostics are short-lived so that they can decay fast and don't harm the body, yet radiate long enough to be transported and given to the patient. Fluorine-18 and Technetium-99m are such isotopes. T-99m is a gamma emitter and thus suitable for gamma scans. F-18 is a $ß^+$ or positron emitter and thus suitable for PET scans.

The gamma rays emitted by T-99m pass through the body without harming it. The uptake of T-99m is determined by metabolism of the organ and hence different concentration of gamma rays can be detected outside the body by gamma cameras. A computer is used to further process gamma ray locations and concentration.

The F-18 emitted positron combines with a nearby electron, together they annihilate to produce 2 gamma rays which are emitted in opposite direction out of the body. This allows a gamma detector to locate the emission region with high accuracy and hence high-resolution location specific images can be produced for diagnostic purpose.

Question 34 — Astrophysics

Question 34 (a)

Criteria	Marks
• Outlines a suitable method • Outlines the results • Links the results to desirability in terms of sensitivity	3
• Gives features of a suitable method	2
• Identifies a feature of a suitable method	1

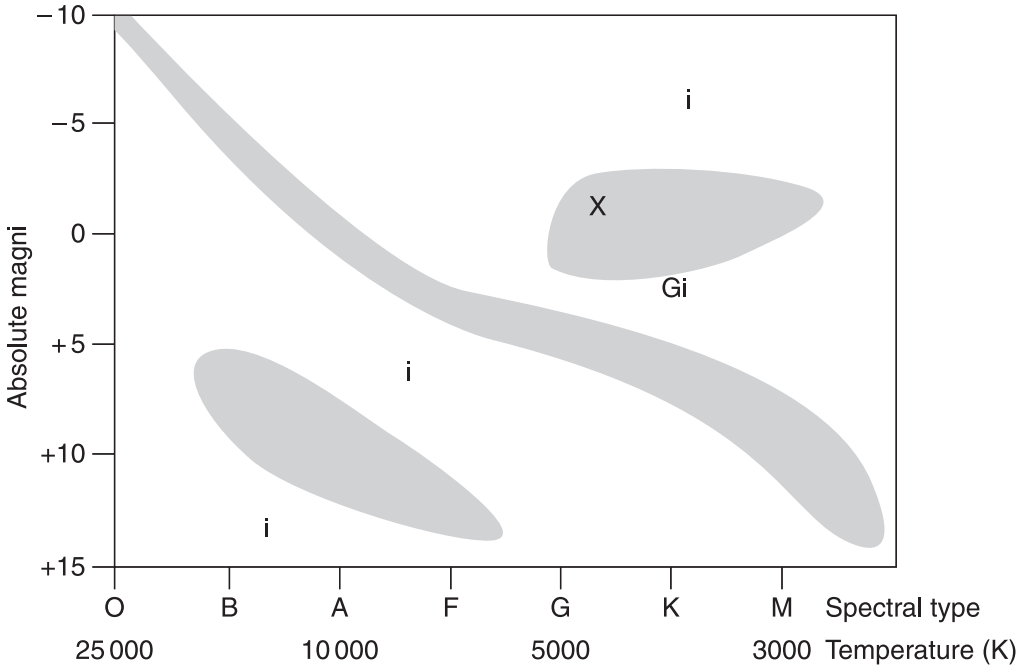
Sample answer:

An investigation can be performed where light is collected by a photo meter through different sized lenses. The source of light is the sun. The investigation should show that the larger the diameter of the lens the more light is collected due to the larger surface area. The telescope becomes more sensitive as more light is collected. Hence, it is desirable in terms of sensitivity for a telescope to have a larger diameter lens.

Question 34 (b) (i)

Criteria	Marks
• Correctly places and labels Matar on the HR diagram • Draws and labels an HR diagram showing the main star groupings	3
• Correctly places Matar on the HR diagram • Draws an HR diagram	2
• Shows some understanding of an HR diagram	1

Sample answer:



Question 34 (b) (ii)

Criteria	Marks
• Shows a good understanding of the differences between the two stars	2
• Identifies one difference between the stars other than mass	1

Sample answer:

Matar is more luminous and larger in radius than the sun. It is a giant and hence is less dense than the sun.

Question 34 (c)

Criteria	Marks
• Describes in detail the CNO Cycle	3
• Provides some features of the CNO cycle	2
• Identifies a feature of the nuclear fusion reaction	1

Sample answer:

In an A2 main sequence star the CNO cycle will be the dominant fusion reaction in the core of the star. This reaction takes place at higher temperatures than the p p reaction and as it uses carbon nitrogen and oxygen as a nuclear catalyst the reaction is faster than the p p reaction. In the overall reaction 4 hydrogens are converted into helium releasing two positrons and a neutrino in a multi-step reaction. Carbon, oxygen and nitrogen are intermediary products.

Question 34 (d)

Criteria	Marks
• Describes key physical processes and nuclear reactions during the evolution	3
• Outlines the transition process OR • Shows some understanding of the features of the transition process	2
• Identifies features of the transition process	1

Sample answer:

When a main sequence star such as our sun reaches the end of its life hydrogen in the core is depleted. The nuclear reaction is no longer sustained and the core collapses heating up the surrounding shell and the core. Hydrogen in the shell will eventually begin to fuse to helium. The surrounding shell expands due to the increased radiation pressure and as it does it cools becoming more red in colour. The helium fusion reaction in the core will start suddenly and produce a ‘helium flash’ the radius of the star will decrease and the star could become unstable and pulsate as a periodic variable.

Question 34 (e) (i)

Criteria	Marks
• Correct substitution to determine the distance and compares to the stated value	3
• Correct substitution to determine the distance OR • Partially substitutes into distance modulus formula and compares the distance calculated to the stated value	2
• Finds the absolute magnitude OR • Shows an understanding that the distance modulus needs to be used	1

Sample answer:

Absolute magnitude M = – 4
The distance modulus is m – M = 6.5 – (–4) = 10.5, using the distance modulus formula this corresponds to a distance of 1260 pc which is the claimed value.

$$M = m - 5\log\left[\frac{d}{10}\right]$$

$$m - M = 5\log\left[\frac{1260}{10}\right]$$
$$= 10.5$$

Question 34 (e) (ii)

Criteria	Marks
• States one advantage and one disadvantage	2
• States one advantage or one disadvantage	1

Sample answer:

Disadvantage: The method is not that accurate

Advantage: It can be done to predict the distance to a cluster containing a Cepheid variable

Question 34 (f)

Criteria	Marks
• Demonstrates coherence and logical progression and includes correct use of scientific ideas and principles • Describes methods and relates the methods to the physics principles behind the determination of standard properties • Uses information in the table to express their answer • Uses clear and scientifically correct language	6
• Describes methods and physics principles behind the determination of standard properties • Refers to information in the table	5
• Describes methods and physics principles behind the determination of some standard properties OR • Outlines methods and physics principles behind the determination of standard properties	4
• Outlines method(s) and/or physics principle(s) for determining standard properties	3
• Shows some understanding of physics principle(s) and/or method(s) for determining standard property	2
• Shows a basic understanding of a physics principle/method for determining standard property	1

Sample answer:

To determine the characteristics of a star the visible light can be broken up with a spectrograph and then examined. The spectrum is compared to known spectra of other stars. Stars of the A class will have absorption lines showing strong hydrogen lines and ionised metal lines in the spectra. By comparing radiation emitted by the star to a black body radiation curve the colour of the star can also be determined as the combination of wavelengths emitted will be white. The temperature of the star can also be determined in this way as stars act as black body radiators and will produce a specific radiation curve at a specific temperature in this case between 7500–10000 K. The mass of a star can be determined by assuming that stars of the same spectral class and same luminosity class will be the same mass. The standard is produced by determining the mass of a binary star using Kepler's law. The separation of the stars can be determined and by collecting the light a CCD/computer or similar device analyses the amount of light to determine the period of the variation in light which will be the period of orbit as the stars rotate about a common point from an eclipsing binary. $m_1 + m_2 = 4\pi^2 r^3 / GT^2$. The luminosity or absolute magnitude can be determined by using photometry eg taking a photo and measuring the magnitude to determine the apparent magnitude and if the distance to the star is determined then the distance modulus formula can be used to determine the absolute magnitude or luminosity. Distances can be determined by spectroscopic parallax or trigonometric parallax depending on the distance to the star. Both mass and luminosity are compared to that of the Sun.

Question 35 — From Quanta to Quarks

Question 35 (a) (i)

Criteria	Marks
• Outlines key features of the Rutherford model	2
• States a feature of the Rutherford model	1

Sample answer:

A small, dense, positively charged nucleus, with electrons orbiting around it at a distance. The atom is mostly empty space.

Question 35 (a) (ii)

Criteria	Marks
• Identifies one limitation of the Rutherford model and explains the relevant Bohr's postulate to account for the limitation	3
• Identifies one limitation of the Rutherford model or identifies relevant Bohr's postulate to account for a limitation	2
• Identifies a feature of the Bohr model	1

Sample answer:

Rutherford's model could not explain the hydrogen emission lines.

Bohr's model placed electrons into quantised energy shells. When electrons moved from a higher to a lower shell, they released energy. This energy corresponded to the frequencies in the emission spectra.

Question 35 (b) (i)

Criteria	Marks
• Shows the correct process to determine the energy released	3
• Shows some understanding of calculating the energy released	2
• Identifies that there is a mass difference in reactants and products	1

Sample answer:

$$U + n = 235.0439 + 1.008665$$

$$\textit{Reactants} = 236.0526\ \textit{amu}$$

$$Ba + Kr + (3 \times n) = 140.9144 + 91.9263 + (3 \times 1.008665)$$

$$\textit{Products} = 235.8433\ \textit{amu}$$

$$\textit{Mass defect} = 236.0526 - 235.8433$$

$$\textit{Mass defect} = 0.2093\ \textit{amu}$$

$$\textit{Energy} = 0.2093 \times 931$$

$$\underline{\textit{Energy} = 194.8583\ \textit{MeV}}$$

Question 35 (b) (ii)

Criteria	Marks
• Explains the production of energy by applying Einstein's mass/energy equivalence	2
• Identifies that the mass has been converted into energy	1

Sample answer:

Because there is a mass difference between the products and the reactants, this mass is converted into the released energy, as mass and energy are equivalent as stated by Einstein.

Question 35 (c)

Criteria	Marks
• Identifies the features of a neutrino AND explains why it was suggested AND why Pauli did not 'discover' the particle	4
• Identifies the features of a neutrino AND • Shows some understanding of why it was 'suggested' but not discovered by Pauli	3
• Identifies the features of a neutrino OR • Shows some understanding of why it was 'suggested' but not discovered by Pauli	2
• Identifies a feature of the neutrino	1

Sample answer:

Pauli is said to have suggested the new particle to explain why there were varying energies in the emitted electrons during β decay. This appeared to break the conservation laws. Pauli suggested the neutrino carried the 'missing energy' but was massless and therefore undetectable. His suggested particle solved the problem of the conservation laws, but he had no evidence that it existed, hence why it was suggested but not discovered by Pauli.

Question 35 (d) (i)

Criteria	Marks
• Identifies all the forces proposed by the standard model of the atom	2
• Identifies TWO forces proposed by the standard model of the atom	1

Sample answer:

Forces	
Electromagnetic	Gravity
Strong Force	Weak Force

Question 35 (d) (ii)

Criteria	Marks
• Explains how the stability of atomic nuclei is maintained	3
• Provides some relevant features	2
• Provides a relevant feature	1

Sample answer:

The nuclei of atoms are stable due to the presence of the strong nuclear force. This force is an attractive force that holds the nucleons together. It is stronger than the repulsive electrostatic force that exists between the protons.

Question 35 (e)

Criteria	Marks
• Shows a thorough understanding of the contributions made by de Broglie • Describes how de Broglie used existing concepts and ideas to come up with new interpretations • Uses clear and scientifically correct language	6
• Shows a good understanding of the contributions made by de Broglie • Outlines how de Broglie used existing concepts/ideas to come up with new interpretations	5
• Shows a sound understanding of the contributions made by de Broglie • Identifies existing concepts/ideas de Broglie used to come up with new interpretations in our understanding of the structure of the matter	4
• Shows some understanding of the contributions made by de Broglie	3
• Identifies some contribution(s) made by de Broglie and/or existing concept(s) and/or idea(s)	2
• Identifies a contribution made by de Broglie or existing concept or idea	1

Sample answer:

De Broglie was able to utilise the current understanding of matter to further develop our understanding of the structure of matter. At the time there was an understanding of the nature of light, which was energy, displaying particle-like properties. Also, a model of the atom was established displaying quantised electron energy levels, but this was yet to be explained. De Broglie utilised the ideas about light being a particle and applied this to electrons, stating that it could behave as a wave. By establishing that electrons exist in stationary states that correspond to the wavelength of the electron, and that they could only move between energy levels that correspond to this wavelength, de Broglie was able to provide an explanation for the stability and quantised nature of the electrons in the atom. De Broglie was then able to describe the wave particle duality of matter. In this way de Broglie increased our understanding of the nature and structure of matter.

Question 36 — The Age of Silicon

Question 36 (a)

Criteria	Marks
• Shows correct process to determine the voltage	3
• Determines that the LDR resistance at 20 *lux* is 30 kΩ OR • Partial substitution into relevant equation	2
• Shows a basic understanding of interpreting the graph OR • Identifies some relevant data and formula	1

Sample answer:

From graph 20 *lux* $\rightarrow$ 30 kΩ

$$\frac{5V \times 30k\Omega}{\left(30k\Omega + 10k\Omega\right)} = 3.75V$$

Question 36 (b)

Criteria	Marks
• Describes how output voltage produced by a LDR in a circuit relates to light level and can be used by a camera's electronics • Identifies that this setup would be used for light metering to produce correct exposure	3
• Identifies relevant features	2
• Identifies a relevant feature	1

Sample answer:

The light level falling on the LDR is converted to a voltage. This voltage is then sent to the camera's electronics systems to control the exposure via shutter speed/aperture. This allows for the right amount of light to fall on the film (or CCD) to produce a correct exposure. Thus the LDR circuit acts as a light meter.

Question 36 (c)

Criteria	Marks
• Explains how relevant input and output transducers interact to control the temperature in a room	4
• Shows some understanding of how relevant input and output transducers can be used OR • Shows some understanding of how a relevant transducer can be used • Demonstrates an understanding of the difference between electronic and electric circuits	3
• Shows some understanding of how a relevant transducer can be used	2
• Identifies one relevant feature	1

Sample answer:

A thermistor placed in a room acts as an input transducer to monitor temperature by converting temperature to a voltage in a voltage divider. Through an electronic circuit, an output voltage would be used to switch on and off the heating lamp, but since the output voltage is too small to operate a heating lamp, a relay must be used. The relay's input is the low voltage from the electronic circuit, and the output switches the heating lamp on or off.

Question 36 (d)

Criteria	Marks
• Draws a correct truth table	3
• Draws a partially correct truth table	2
• Shows some understanding of a truth table	1

Sample answer:

A	B	C	Output
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Question 36 (e) (i)

Criteria	Marks
• Correctly describes an ideal operational amplifier	2
• Identifies a feature of an ideal operational amplifier	1

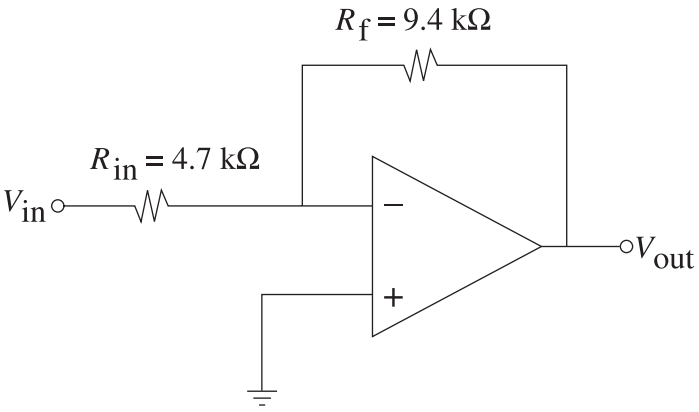
Sample answer:

An ideal operational amplifier outputs a reproduction of its input signal, only larger in voltage. It has infinite input impedance, zero output impedance, infinite open-loop gain and infinite bandwidth.

Question 36 (e) (ii)

Criteria	Marks
• A substantially correct diagram with the 9.4 kΩ resistor drawn in correct location	2
• Either correct location OR correct value resistor drawn	1

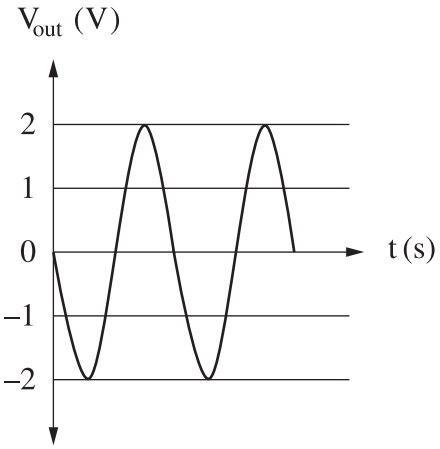
Sample answer:



Question 36 (e) (iii)

Criteria	Marks
• Correct shape, inverted and correct amplitude	2
• Correct shape, inverted or correct amplitude	1

Sample answer:



Question 36 (f)

Criteria	Marks
• Demonstrates thorough knowledge and understanding of the development of electronics, including past developments and future limitations • Clearly relates the above to society's increasing computer needs • Makes an informed judgement implicitly or explicitly about how the development of electronics has met the increasing computing needs of society • Uses clear and scientifically correct language	6
• Demonstrates good knowledge and understanding of the development of electronics, including past developments and limitations • Some relation of the above to society's increasing computer needs	5
• Demonstrates sound knowledge and understanding of the development of electronics, including past developments or limitations • Some relation of the above to society's increasing computer needs	4
• Demonstrates some knowledge and understanding of the development of electronics, including past developments or limitations	3
• Demonstrates an understanding of the development of electronics or increasing computer needs	2
• Identifies a relevant fact	1

Sample answer:

Early computers each employed hundreds of thousands of single transistors. However, as the need for faster, more powerful and lightweight computers arose, scientists had to work out a way of packing more transistors into a small space. This led to the integrated circuit, which contained millions of transistors on a single chip. This uses far less power and takes up far less space for a given processing ability.

As computing needs increase, more and more transistors are placed onto a single chip. This means they become closer and closer to physical limits due to the size of atoms and so quantum effects become significant. This is where electrons tunnel across the transistors and interfere with one another. As a result, computers have had to be designed differently to overcome these effects as this limit has been reached. Portable computers now make use of multiple core processors working in parallel to increase computing power rather than further miniaturisation of the chip.

From these developments, society has access to smaller and more powerful computers, increasing productivity and communication between individuals and businesses worldwide. It has also led to changes in the way people are entertained by music and video through the use of mp3 players and videos on their portable devices. Portable GPS devices have made it possible to navigate easily in your car without stopping to look at a map. There have also been negative impacts as people tend to rely so much on the technology, that when technology fails for one reason or another, communication breaks down.

Physics

2013 HSC Examination Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.1.11.2a, 9.3.2.3.2	H11
2	1	9.2.3.2.4	H7, H9
3	1	9.3.1.2.4, 9.3.1.2.5	H9, H6
4	1	9.1.11.3b, 9.2.2.3.2	H11
5	1	9.4.2.2.2	H2
6	1	9.2.2.2.2, 9.2.2.2.1	H6, H9
7	1	9.3.4.3.3	H7, H9
8	1	9.2.4.2.4	H6
9	1	9.2.2.2.12	H6, H7, H9
10	1	9.3.4.3.4	H9
11	1	9.4.4.2.1	H11
12	1	9.4.4.3.3	H9
13	1	9.3.2.2.3	H9
14	1	9.4.1.2.7	H9
15	1	9.3.1.3.3, 9.3.1.3.4	H7, H9, H10
16	1	9.4.3.2.2, 9.4.3.2.1	H7, H9, H10
17	1	9.3.1.3.4, 9.3.2.2.5	H9
18	1	9.1.14.1c, 9.2.4.2.2	H14
19	1	9.2.4.3.5	H6
20	1	9.4.2.2.5, 9.4.2.2.6	H10

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	2	9.2.2.3.3	H1
21 (b)	2	9.1.12.4e, 9.2.2.3.3	H12.4e
22	3	9.2.1.3.2	H6, H13.1e, f, g, H14.1a
23 (a)	2	9.2.2.2.10	H6
23 (b)	3	9.2.2.3.5	H6
24	5	9.4.2.3.3	H3
25 (a)	1	9.3.1.2.2	H9
25 (b)	3	9.3.1.3.1	H9
26 (a)	2	9.4.1.3.3	H9
26 (b)	3	9.4.1.2.7, 9.4.1.3.3	H9
27 (a)	3	9.3.2.2.4	H7
27 (b)	4	9.3.3.2.2, 9.3.5.3.2	H7

Question	Marks	Content	Syllabus outcomes
28	6	9.4.2.3.2	H1, H2, H10
29 (a)	2	9.2.1.3.3	H9
29 (b)	3	9.3.1.3.4, 9.3.1.2.3	H9
30 (a)	2	9.2.2.2.8	H6, H9
30 (b)	2	9.2.2.2.5, 9.2.2.3.4	H6, H9
31	7	9.4.3.2.6, 9.4.3.3.2., 9.4.3.3.3, 9.4.3.2.8, 9.4.4.3.4, 9.4.4.3.5	H3, H4, H9

Section II

Question	Marks	Content	Syllabus outcomes
Question 32		**Geophysics**	
(a)	3	9.5.3.2.4	H2, H3, H8
(b) (i)	3	9.5.1.3.1	H11, H12, H13, H14
(b) (ii)	2	9.5.1.3.1	H11, H12, H13, H14
(c) (i)	2	9.5.4.2.3	H7
(c) (ii)	3	9.5.4.2.3	H1, H2, H4, H7
(d)	3	9.5.2.1.4, 9.5.2.1	H9
(e)	3	9.5.2.3.3	H6, H9
(f)	6	9.5.1.3.1, 9.5.5.1.2	H13, H14
Question 33		**Medical Physics**	
(a)	3	9.6.2.3.2	H8, H10
(b)	2	9.6.2.3.3, 9.6.2.2.5	H12
(c)	3	9.6.2.3.3, 9.6.2.2.7	H14
(d) (i)	2	9.6.4.2.4	H7, H9, H10
(d) (ii)	3	9.6.4.2.8	H7, H9, H10
(e) (i)	3	9.6.1.2.8	H6, H7
(e) (ii)	3	9.6.1.2.4, 9.6.1.2.8	H3, H7, H9, H10
(f)	6	9.6.3.2.1, 9.6.3.2.2, 9.6.3.2.3, 9.6.3.2.4, 9.6.3.2.5	H3, H7, H8, H9, H10, H14

Question 34		**Astrophysics**	
(a)	3	9.7.1.3.1	H3, H8
(b) (i)	3	9.7.6.3.2	H10
(b) (ii)	2	9.7.6.3.2, 9.7.3.2.4	H8
(c)	3	9.7.6.3.2, 9.7.6.3.3, 9.7.6.3.4	H7
(d)	3	9.7.6.2.2, 9.7.6.3.3, 9.7.6.2.6	H7, H9
(e) (i)	3	9.7.4.3.1, 9.7.5.2.4	H8, H10
(e) (ii)	2	9.7.5.2.4	H10
(f)	6	9.7.5.2.2, 9.7.5.3.2, 9.7.4.2.5, 9.7.3.2.2, 9.7.3.2.4, 9.7.3.2.5, 9.7.3.2.1	H8, H10
Question 35		**From Quanta to Quarks**	
(a) (i)	2	9.8.1.2.1	H1, H10
(a) (ii)	3	9.8.1.2.3	H2, H10
(b) (i)	3	9.8.3.2.9	H6
(b) (ii)	2	9.8.3.3.2	H10
(c)	4	9.8.3.2.6	H1, H6
(d) (i)	2	9.8.4.2.5	H9, H10
(d) (ii)	3	9.8.4.2.5	H10
(e)	6	9.8.2.2.1, 9.8.2.2.4, 9.8.2.2.3	H2, H10
Question 36		**The Age of Silicon**	
(a)	3	9.9.2.3.3	H13
(b)	3	9.9.3.2.3	H3
(c)	4	9.9.4.2.1, 9.9.3.2.6	H7
(d)	3	9.9.5.2.1, 9.9.5.3.2	H9
(e)(i)	2	9.9.6.2.1	H3
(e)(ii)	2	9.9.6.2.7, 9.9.6.2.8, 9.9.6.3.3	H13
(e)(iii)	2	9.9.6.3.2	H13
(f)	6	9.9.1.2.1, 9.9.1.2.2, 9.9.1.2.3, 9.9.1.3.1, 9.9.7.2.1, 9.9.7.2.2, 9.9.7.2.3	H1, H3, H4