2017 HSC Physics
Marking Guidelines

IMPORTANT:
This resource was developed to support a previous version of the syllabus.
It may contain content that differs from the current syllabus.

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21 (a)

Criteria	Marks
• Applies correct process to calculate the frequency	2
• Substitutes into a relevant formula	1

Sample answer:

$c = f\lambda$

$f = \dfrac{3\times10^{8}}{550\times10^{-9}}$

$f = 5.45\times10^{14}\,\text{Hz}$

Question 21 (b)

Criteria	Marks
• Provides a valid explanation supported by relevant calculations	3
• Provides a valid explanation AND/OR • Shows some relevant calculation	2
• Provides some relevant information	1

Sample answer:

For an electron to be ejected the energy of the incoming photons must be greater than $5\times10^{-19}\ J$.

Hence: $E_{photon} > 5\times10^{-19}$

$$\begin{aligned} E_{photon} &= hf \\ &= 6.62\times10^{-34}\times5.46\times10^{14} \\ &= 3.63\times10^{-19}\ J \end{aligned}$$

Therefore the electrons will not be ejected since hf $< 5\times10^{-19}\ J$.

Question 22 (a)

Criteria	Marks
• Provides TWO ways of increasing torque	2
• Provides ONE way of increasing torque	1

Sample answer:

The torque can be increased by increasing the applied force or by increasing the distance between the nut and the point of the applied force.

Question 22 (b)

Criteria	Marks
• Applies correct process to calculate torque and indicates the correct direction	3
• Applies correct process to calculate torque OR • Shows some relevant working for calculating the torque and indicates the correct direction	2
• Substitutes into a relevant formula OR • Indicates the correct direction	1

Sample answer:

Side BC: $F = BIl\sin\theta = 0.2 \times 7 \times 0.08 \times \sin 90° = 0.112$ N

For 15 turns, the total force = 0.112 N × 15 = 1.68 N.

$\tau = Fd$ = total force × total distance, where total distance is the distance from the axis of rotation to point B (0.03 m)

Therefore τ = 1.68 N × 0.03 m = 0.05 Nm into the page.

Question 23

Criteria	Marks
• Provides an explanation of how theories in science are validated in different ways using examples relating to the theory of special relativity	5
• Provides an explanation of how theories in science are validated using at least one relevant example	4
• Provides relevant example(s) and/or explains how theories in science are validated	3
• Identifies a relevant example or outlines how theories in science are validated	2
• Provides some relevant information	1

Sample answer:

A theory must be consistent with observations, be supported by valid experiments and be useful in making predictions.

Time dilation has been observed in experiments using atomic clocks in aircraft in relation to synchronised clocks observed on the surface of the Earth. The results from such experiments can be used to predict the relativistic effects on sub-atomic particles travelling at high velocity in linear accelerators.

Question 24 (a)

Criteria	Marks
• Correctly calculates the escape velocity	2
• Substitutes into a relevant formula	1

Sample answer:

$$v = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 6.39 \times 10^{23}}{3.39 \times 10^{6}}}$$

$$= 5014.5 \text{ ms}^{-1}$$

$$= 5010 \text{ ms}^{-1} \text{ (rounded)}$$

Question 24 (b)

Criteria	Marks
• Shows that the escape velocity is independent of mass using the law of conservation of energy	3
• Relates the conservation of energy to the escape velocity of an object	2
• Provides some relevant information	1

Sample answer:

Escape velocity is the minimum velocity required for an object to attain an E_p of 0.

Hence escape velocity is attained when $E_k + E_p = 0$.

$$\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$$

Rearranging:

$\cancel{m}v^2 = \dfrac{2GM\cancel{m}}{r}$ $\therefore$ the escape velocity is independent of the mass of the object.

Question 25 (a)

Criteria	Marks
• Outlines the contribution	2
• Provides some relevant information	1

Sample answer:

The Braggs aimed X-rays at materials and observed the diffraction patterns produced. This gave them information about arrangement and spacing of atoms, giving us clues about the crystal structure of materials.

Question 25 (b)

Criteria	Marks
• Explains how doping pure silicon with boron changes its electrical properties	2
• Provides some relevant information	1

Sample answer:

Boron from group 3 contributes a positive hole to the lattice of silicon. This increases the conductivity of silicon as holes are more easily able to move through the lattice.

Question 25 (c)

Criteria	Marks
• Outlines reasons for the use of superconductors on board maglev trains	3
• Outlines a reason OR • Identifies reasons	2
• Provides some relevant information	1

Sample answer:

Superconductors allow for the production of strong magnetic fields to cause the train to levitate above track magnets. The superconductors are light enough to be carried on board the train.

The refrigeration units required to produce the superconductive properties must be carried on the train, rather than cooling the whole rail track, in order to keep energy consumption within practical limits.

Question 26 (a)

Criteria	Marks
• Outlines consequences	2
• Outlines a consequence	1

Sample answer:

Upon entering Earth's atmosphere it will decelerate too rapidly for the astronauts to survive and the temperature reached will be dangerously high.

Question 26 (b)

Criteria	Marks
• Outlines the need to decrease E_p and/or E_k for a safe landing • Relates the information on the graph to the conversion of E_p and/or E_k	4
• Makes some relevant interpretation of the graph and/or recognizes the energy level desirable for a safe landing	2–3
• Provides some relevant information	1

Sample answer:

The graph shows that the gases around the shuttle, heated to 5000 K, radiate energy predominantly as light. The source of this energy is the conversion of the shuttle's potential and kinetic energy, reducing these so that the shuttle can make a safe landing.

Question 27 (a)

Criteria	Marks
• Applies correct process to calculate the maximum magnetic field strength	2
• Provides some relevant information	1

Sample answer:

B (flux density) is given by $\dfrac{flux}{area}\left(B = \dfrac{\Phi}{\pi r^2}\right)$

$$\text{Max } B = \frac{0.6}{\pi \times (0.3)^2}$$
$$= 2.1\,T$$

Question 27 (b)

Criteria	Marks
• Applies correct process to calculate the maximum voltage and identifies correct polarity of the terminals (*P* and *Q*)	3
• Applies correct process to calculate the maximum voltage OR • Shows some relevant calculations and identifies the polarity of the terminal(s)	2
• Provides some relevant information	1

Sample answer:

Voltage (*emf*) = time rate of change of flux. From the graph, this is maximum when the steepest gradient occurs, ie $t = 10 - 12$s.

$$emf = \frac{-d\Phi}{dt} = -\left(\frac{-0.6}{2}\right) = 0.3V$$

Terminal *P* is positive and terminal *Q* is negative (consistent with Lenz's Law).

Question 28

Criteria	Marks
• Contrasts the design of transformers and magnetic braking systems in terms of the effects that eddy currents have in each of these devices	6
• Contrasts the design of transformers and magnetic braking systems with some reference to the effects that eddy currents have in these devices	5
• Outlines design features of transformers and magnetic braking systems • Identifies at least one effect that eddy currents have in one of these devices	4
• Identifies features of transformers and/or magnetic braking systems and/or the effects of eddy currents	2–3
• Provides some relevant information	1

Sample answer:

A transformer uses changes in magnetic flux to induce current in a secondary coil. An iron core increases the flux but iron, being a conductor, will experience the induction of unwanted eddy currents, causing resistive heating losses. Laminating the iron core minimises the current pathway, thus minimising eddy currents and subsequent heating losses.

In contrast, magnetic braking systems need to maximise eddy currents since magnetic braking relies on converting kinetic energy to electrical current, and subsequently to heat. In order to maximise the current, magnetic braking systems need to provide substantial current pathway. This is done by providing large sheets or bulk volumes of conductive material, such as copper.

Question 29 (a)

Criteria	Marks
• Applies correct process to calculate the launch velocity with appropriate units	4
• Applies conservation of energy law to calculate the launch velocity with a minor error	3
• Shows some relevant calculation steps	2
• Substitutes into a relevant formula	1

Sample answer:

$$k = \frac{24}{0.08} = 300$$

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$$\frac{1}{2} \times 0.04 \times v^2 = \frac{1}{2} \times 300 \times 0.08^2$$

$$v^2 = 300 \times 0.08 \times 2$$

$$v = 6.9 \text{ m s}^{-1}$$

Answers could include:

Calculating the area under the curve for work done.

Question 29 (b)

Criteria	Marks
• Applies correct process to calculate the range	3
• Shows some relevant calculation steps	2
• Provides some relevant information	1

Sample answer:

The range is equal to the horizontal velocity component $\times$ the time of flight.

The time of flight is twice the time taken to reach the highest point.

Since $v = u + at$, at the highest point $v = 0 = 10 \sin 60° - 9.8\, t$

Hence time of flight $t = \dfrac{20 \sin 60°}{9.8} = 1.77 \text{ s}$.

Hence the range $= 10 \times \cos 60° \times 1.77 = 8.8 \text{ m}$.

Question 30

Criteria	Marks
• Provides an analysis of the motion of the proton	4
• Describes the path and/or direction of the proton	3
• Provides some characteristics of the path and/or direction of the proton	2
• Provides some relevant information	1

Sample answer:

The magnetic field will cause the proton to move in a circular path, initially moving out of the page, continuing in an anti-clockwise direction as viewed from the right. At the same time, the electric field will cause the proton to move to the left with increasing speed. The resultant motion of the proton is the vector sum of these two components, which will look like a helix that is getting stretched out towards the left. This helix will be decreasing in radius as the proton loses energy as it radiates electromagnetic radiation as it is an accelerating charge.

[Answers may include a labelled diagram.]

Section II

Question 31 (a) (i)

Criteria	Marks
• Gives TWO reasons	2
• Gives ONE reason	1

Sample answer:

Wegener's notion of drifting continents went against existing dogma and so there was reluctance to accept his new notions.

Wegener's explanations for continental drift were inadequate in accounting for the scale of the movements of the continents and alternative explanations could be provided for observations so there was no pressure to change.

Question 31 (a) (ii)

Criteria	Marks
• Relates features associated with the magnetic properties of the oceanic crust to the theory of plate tectonics	3
• Relates magnetism to plate tectonics and/or mid-ocean ridges and/or polar wandering	2
• Provides some relevant information	1

Sample answer:

Analysis of magnetic reversals in the crustal rocks showed a symmetry on either side of mid-ocean ridges that was consistent with seafloor spreading.

The increasing age of rocks associated with increasing distance from the mid-ocean ridges was consistent with seafloor spreading and plate tectonics.

Answers could include:

Relationship between magnetism and polar wandering.

Question 31 (b) (i)

Criteria	Marks
• Contrasts the movement of particles associated with the waves	2
• Identifies the movement of particles associated with one of the waves	1

Sample answer:

The particles transferring energy in the form of a *P* wave oscillate parallel to the direction of energy propagation whereas the particles transferring energy in the form of an *S* wave oscillate perpendicular to the direction of energy propagation.

Question 31 (b) (ii)

Criteria	Marks
• Describes the behaviour of the *P* waves and *S* waves	3
• Provides characteristics of the behaviour of the *P* waves and/or *S* waves	2
• Provides some relevant information	1

Sample answer:

At the boundary both *P* and *S* waves will be reflected at the same angle as the angle of incidence.

Only *P* waves will cross the boundary and travel into the liquid.

P waves will be refracted as they cross the solid–liquid boundary.

Question 31 (c)

Criteria	Marks
• Describes two methods • Refers to the relevant equations	4
• Outlines two methods	3
• Outlines a method or identifies two methods	2
• Provides some relevant information	1

Sample answer:

One method to calculate the mass of Earth is to use the relationship between the strength of the gravitational field and the radius of Earth and its mass. Gravitational field strength and the radius of Earth can be experimentally determined.

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

$$g = \frac{GM}{r^2}.$$

Hence

$$M = \frac{gr^2}{G}.$$

Another method is to apply Kepler's law using data – radius and period – from a satellite's orbit. Both the radius and period of a satellite can be experimentally determined.

$$\frac{r^3}{T^2} = \frac{GM}{r\pi^2}.$$

Hence

$$M = r\pi^2 \times \frac{r^3}{GT^2}.$$

Answers could include:

Pendulum.

Question 31 (d) (i)

Criteria	Marks
• Outlines how one type of gravimeter works	2
• Provides some relevant information	1

Sample answer:

One type of gravimeter uses the inertial properties of a mass confined by springs in a vacuum. The effect of gravity on the confined mass causes it to move independently of the surrounding housing. This movement is calibrated against variations in the strength of gravity so that the instrument can be used to directly measure the strength of gravity.

Question 31 (d) (ii)

Criteria	Marks
• Justifies why data reduction is necessary in the given scenario	3
• Shows some understanding of the effect of location on gravimeter measurements	2
• Provides some relevant information	1

Sample answer:

Data reduction removes the effects on the measurement of gravity which are caused by features associated with specific locations. This allows valid comparisons between these locations, independent of these features.

The effect on gravimeter readings of the rotation of Earth on its axis is greater at the equator (X) than at higher latitudes (Y), reducing the readings more at the equator.

At higher altitudes (Y) the reduction on the gravimeter readings is greater than at lower altitudes (X).

Question 31 (e)

Criteria	Marks
• Shows the similarities and/or differences between the information obtained from natural vibrations and vibrations caused by human activity • Refers to the processes used to obtain the data	6
• Outlines the information obtained from natural vibrations and vibrations caused by human activity • Refers to the process(es) used to obtain the data	4–5
• Shows some understanding of obtaining information from natural vibrations and/or vibrations caused by human activity	2–3
• Provides some relevant information	1

Sample answer:

The positions, sizes, shapes and types of material associated with structures into the Earth can be deduced from vibrations caused by human activity. These can be produced in different ways at or near Earth's surface using geophones or seismographs. The energy is reflected from relatively close to Earth's surface by layers or different materials.

Natural vibrations originate from seismic activity including earthquakes and volcanoes. The energy from these is generally much greater than vibrations caused by human activity and so can be detected by seismographs located at hundreds of locations on Earth's surface. Analysis of these, as well as knowledge about the behaviour of different types of waves, provides information about Earth's interior, including its layered structure, the presence of solids and liquids and variations in density.

Question 32 (a) (i)

Criteria	Marks
• Shows an understanding of how the arrangements differ	2
• Provides some relevant information	1

Sample answer:

In coherent bundles the position of individual fibres relative to each other is the same at each end. In incoherent bundles relative position is not maintained.

Question 32 (a) (ii)

Criteria	Marks
• Explains how light is used to create an endoscopic image	3
• Shows some understanding of endoscopy	2
• Provides some relevant information	1

Sample answer:

Endoscopy relies on the physical principle of total internal reflection. Light is reflected within each fibre and thereby manipulated. The incoherent bundles provide illumination to the site, which would otherwise be in darkness. This then permits the coherent bundles to transmit an image to a camera for external viewing.

Question 32 (b) (i)

Criteria	Marks
• Describes how ultrasound can be used to measure ONE property of bone	2
• Provides some relevant information	1

Sample answer:

Measurement of bone density can be made by directing ultrasound waves at a bone (eg heel bone) and measuring the amount of waves transmitted. The higher the bone density, the more ultrasound waves are absorbed and therefore fewer transmitted.

Question 32 (b) (ii)

Criteria	Marks
• Accounts for the different frequencies of the scans in terms of their purposes	3
• Outlines the purposes of the scans OR • Outlines the purpose of one scan and relates its purpose to the choice of frequency	2
• Provides some relevant information	1

Sample answer:

B scans are used to examine eyes and therefore have no need to penetrate tissue more than a few centimetres. Therefore a higher frequency can be used to obtain greater detail. Sector scans are used to examine tissues deep within the body eg pregnant uterus. By using a lower frequency, a greater depth of tissue can be examined, albeit with less detail.

Question 32 (c)

Criteria	Marks
• Explains how the application of a radio frequency wave changes the behaviour of nuclei in B_0	4
• Outlines behaviour of nuclei in B_0 and/or effects of radio frequency wave	2–3
• Provides some relevant information	1

Sample answer:

Nuclei with net spin line up with the external magnetic field, B_0. Their orientation may be in one of two ways – lower energy spin up or higher energy spin down – with slightly more in the lower energy state. At the same time, these nuclei precess around the direction on B_0 with a frequency (Larmor frequency) that is dependent on the magnitude of B_0, the type of nucleus and its immediate environment. When a radio frequency corresponding to the Larmor frequency is applied, the lower energy spin up nuclei absorb the energy and flip to spin down orientation, then precess in phase with each other. Nuclei which precess at different frequencies are unaffected.

Question 32 (d) (i)

Criteria	Marks
• Describes production of X-rays by one method	2
• Provides some relevant information	1

Sample answer:

Electrons are accelerated to high velocities by a high voltage. When they strike the tungsten target, their rapid deceleration produces EMR in the X-ray range of the spectrum.

Question 32 (d) (ii)

Criteria	Marks
• Shows an understanding of why a CAT scan image is superior to an X-ray image	3
• Identifies features of CAT scan image and/or X-ray image	2
• Provides some relevant information	1

Sample answer:

X-ray images are formed by the shadows cast on a film (or digital detector) in which each point on the image represents all of the tissue in front it, often several centimetres in depth. CAT scans use tomography to gather information on X-ray attenuation that can be organised into ‘slices’. This provides a clearer image as there is no superimposition of other layers.

Question 32 (e)

Criteria	Marks
• Relates the processes that produce functional medical images to benefits • Includes relevant examples	6
• Outlines how functional image(s) are produced • Outlines benefit(s) of functional imaging • Includes example(s)	4–5
• Outlines benefit(s) of functional imaging AND/OR • Outlines how functional image(s) are produced AND/OR • Includes example(s)	2–3
• Provides some relevant information	1

Sample answer:

PET scans and bone scans using gamma radiation are two functional imaging techniques. In both of these the uptake of radioisotopes used to produce the images is dependent on how the body is working.

In PET for example, the uptake of an injected radioactive isotope (FDG) is greater in, for example a brain tumour, than in healthy tissue and so tumours can be detected on the images produced from the radiation emitted from the concentrated radioisotope.

In a bone scan, molecules tagged with gamma-emitting Tc-99m accumulate in tumours in the bone and this is beneficial as the abnormal tissue can be detected clearly on the bone scan images.

Functional imaging techniques can make abnormal processes that cannot be detected using structural scans visible, thus allowing for earlier detection and more effective treatment.

Answers could include:

Doppler ultrasound or fMRI.

Question 33 (a) (i)

Criteria	Marks
• Shows an understanding of why space-based optical telescopes provide more information	2
• Provides some relevant information	1

Sample answer:

Space-based telescopes reduce both atmospheric absorption of specific frequencies (electromagnetic radiation) and atmospheric distortion of the light from stars due to turbulence.

Question 33 (a) (ii)

Criteria	Marks
• Correctly uses the brightness ratio to make a comparison	3
• Correctly applies the brightness ratio	2
• Provides some relevant information	1

Sample answer:

$$\frac{I_Q}{I_P} = 100^{\frac{\left(m_P - m_Q\right)}{5}}$$

$$= 100^{\frac{(10.3-8.5)}{5}}$$

$$= 100^{0.36}$$

$$= 5.25$$

Star Q is 5.25 times brighter than star P.

Question 33 (b) (i)

Criteria	Marks
• Outlines the differences	2
• Provides some relevant information	1

Sample answer:

Spectrum for Star X shows highest intensity in the blue part of the spectrum (short wavelength) with ionised He lines and strong UV component.

Spectrum for Star Y shows highest intensity in the red part of the spectrum (long wavelength) with dominant molecular lines and strong neutral metal lines.

Question 33 (b) (ii)

Criteria	Marks
• Describes a suitable process	3
• Outlines some features of a suitable process	2
• Provides some relevant information	1

Sample answer:

A diffraction grating is placed over the opening of a telescope. The resulting photographic image shows multiple spectra, one for each identified star in the field of view.

Answers could include:

Optic fibres are attached to a platen specifically where starlight falls for a particular field of view. The starlight is then passed to a spectroscope via the optic fibre for individual stars.

Question 33 (c)

Criteria	Marks
• Explains how the colour index is determined • Explains how the colour index can be used to deduce information about the star	4
• Shows some understanding of the colour index and/or the characteristics of the star	2–3
• Provides some relevant information	1

Sample answer:

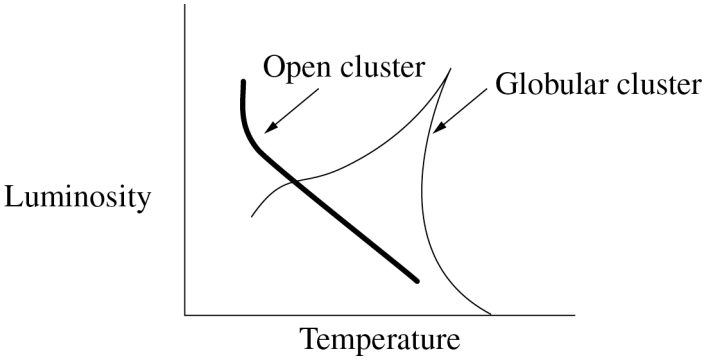
Colour index is calculated using CI = B – V* where B is the apparent magnitude measured when the star's light is passed through a blue filter and V is the visual apparent magnitude measured using a greenish-yellow filter (peak visual λ).

The more negative the CI, the hotter and hence more blue the star. Stars having CI < 0 have surface temperatures > 10 000 K.

Question 33 (d) (i)

Criteria	Marks
• Shows both clusters on a H–R diagram	2
• Shows one cluster on a H–R diagram	1

Sample answer:



Question 33 (d) (ii)

Criteria	Marks
• Outlines differences between stars from both cluster types	3
• Identifies features of the stars in an open cluster and/or a globular cluster	2
• Provides some relevant information	1

Sample answer:

Open clusters consist of relatively young, main-sequence stars where as globular clusters contain older stars at a post-main-sequence evolutionary stage.

Opens clusters generally contain stars that are hotter than those in globular clusters.

Question 33 (e)

Criteria	Marks
• Explains how gravitational forces affect star deaths for a range of solar masses	6
• Outlines the effects of gravitational forces on star deaths for a range of solar masses	4–5
• Recognises the relationship between a star's death and its mass AND/OR • Identifies the effects of gravitational forces on star deaths	2–3
• Provides some relevant information	1

Sample answer:

Gravity causes stars having a mass of less than 1.4 solar masses to collapse to form a white dwarf when nuclear fusion ceases.

Stars having initial masses of from 1.4 to 8 solar masses expel some of their mass into space during their evolution to star death, ultimately leaving a type of star dependent on the mass and hence gravitational forces.

For stars having a final mass of 1.4 to 3 solar masses, once fusion ceases, gravity causes the protons and electrons to form neutrons and a neutron star/pulsar is formed.

For stars having final masses greater than 3 solar masses, gravitational forces are stronger causing the star to ultimately collapse and form a black hole.

Question 34 (a) (i)

Criteria	Marks
• Identifies type and number of nucleons and number of quarks	2
• Provides some relevant information	1

Sample answer:

Helium 3 nucleus consists of:

- $1 \times$ neutron
- $2 \times$ protons

which themselves are made up of three quarks.

Question 34 (a) (ii)

Criteria	Marks
• Outlines features of the strong nuclear force	3
• Identifies features of the strong nuclear force or outlines a feature	2
• Identifies a feature of fundamental forces	1

Sample answer:

The strong nuclear force is much stronger than the coulomb repulsion and acts over only very small distances.

The strong nuclear force is extremely attractive between nucleons about 1fm apart but decreases rapidly at distances greater than about 2.5fm. This force becomes repulsive at distances less than 0.7fm.

Question 34 (b) (i)

Criteria	Marks
• Distinguishes between fission and transmutation	2
• Identifies a feature of fission or transmutation	1

Sample answer:

A transmutation involves an atomic nucleus turning into that of another element by radioactive decay or nuclear bombardment. Fission involves the splitting of an atom into smaller, similar sized fragments due to the capturing of a neutron. This process releases energy.

Question 34 (b) (ii)

Criteria	Marks
• Explains how the labelled components are used to produce a controlled nuclear reaction	3
• Outlines how some of the labelled components are used to produce a controlled nuclear reaction	2
• Identifies the role of a labelled component	1

Sample answer:

Fuel elements are a fissile material that releases energy and high-speed neutrons when atoms are split. The moderator slows the neutrons down so that they can be captured by more fissile atoms, which then split. The control rods absorb neutrons to limit the number of atoms undergoing fission, thereby controlling the release of energy.

Question 34 (c)

Criteria	Marks
• Explains the production of the line with reference to Bohr's postulates • Supports answer with calculations	4
• Relates the production of the line to Bohr's postulates • Includes some relevant calculations	3
• Shows some understanding of Bohr's postulates AND/OR • Provides some relevant calculations	2
• Provides some relevant information	1

Sample answer:

Bohr's postulates state that an electron orbits in fixed energy levels. Only when an electron jumps from a higher energy level to a lower energy level, it emits an exact amount of energy in the form of a photon. The specific wavelength of the photon can be determined according to the Rydberg equation. The blue light is part of the visible Balmer series and therefore $n_f = 2$.

The wavelength in this case is 434.0 nm. According to the equation, this corresponds to a jump from the 5th energy level to the 2nd energy level.

For Balmer series $n_f = 2$

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n_i^2}\right)$$

$$n_i^2 = \frac{1}{\left(\frac{1}{4} - \frac{1}{1.097 \times 10^7 \times 434 \times 10^9}\right)}$$

$$n_i = 5$$

Answers could include:

Taking clues from the diagram of the Balmer series, student could put $n_f = 2$ and $n_f = 5$ into the equation to obtain $\lambda = 434.0$ nm.

Question 34 (d) (i)

Criteria	Marks
• Accounts for the failure of classical physics in explaining stable electron orbits in the Bohr model of the atom	2
• Provides some relevant information	1

Sample answer:

The stable electron orbits necessary for the Bohr model to work assumed that the electron would be travelling in circular motion about the nucleus. This would mean that the electron is constantly accelerating. But since accelerating charges give out electromagnetic radiation, the electron would lose energy and spiral in towards the nucleus.

Question 34 (d) (ii)

Criteria	Marks
• Shows an understanding of how de Broglie's model explained the stable electron orbits • Outlines Davisson and Germer's role in validating de Broglie's model	3
• Shows an understanding of de Broglie's model AND/OR Davisson and Germer's role in validating this model	2
• Provides some relevant information	1

Sample answer:

Since classical physics could not explain the stable electron orbits in the Bohr model, de Broglie modelled the electrons existing as standing waves about the nucleus with each of Bohr's stationary states (energy levels) being associated with various wavelengths. Hence only integer multiples of the fundamental wavelength were possible.

This idea was then validated by Davisson and Germer through their electron scattering experiment which provided evidence that electrons were waves.

Question 34 (e)

Criteria	Marks
• Outlines properties of protons and neutrons • Outlines the uses of protons and neutrons as tools for investigating matter • Relates the properties to the uses of protons and neutrons as tools for investigating matter	6
• Outlines properties of protons and/or neutrons • Outlines the uses of protons and/or neutrons as tools for investigating matter • Provides some link between the properties	4–5
• Identifies some properties of protons and/or neutrons AND/OR • Identifies uses of protons and/or neutrons as tools for investigating matter	2–3
• Provides some relevant information	1

Sample answer:

Protons and neutrons have almost identical masses but the proton is positively charged and the neutron has no charge.

Having a positive charge allows protons to be accelerated to very high velocities in particle accelerators. The protons then collide head-on with other protons, transferring their energy to mass ($E = mc^2$) and producing other particles which can be detected through their interaction with large detectors. This allows us to discover new particles and study the fundamental nature of matter.

In studying normal matter, protons cannot get close enough since they are repelled by the positive nucleus. Instead, neutron beams can be fired at nuclei in a process known as neutron scattering. Since all matter has a dual particle/wave nature, neutrons, having a very small de Broglie wavelength can produce diffraction patterns giving us detailed models of atomic and molecular structures.

Question 35 (a) (i)

Criteria	Marks
• Draws the correct truth table	2
• Provides some relevant information	1

Sample answer:

Truth table shown for exclusive OR gate.

X	*Y*	*Z*
0	0	0
0	1	1
1	0	1
1	1	0

Question 35 (a) (ii)

Criteria	Marks
• Shows that the state of *Q* only changes when *S* is changed to a 0	3
• Shows some understanding of the operation of the circuit	2
• Provides some relevant information	1

Sample answer:

The *Q* state is input to gate H. The output of gate H is always 1 regardless of the state of R.

Q	*R*	*Output from* H
0	1	1
0	0	1

The output of gate H is fed into gate *G*.

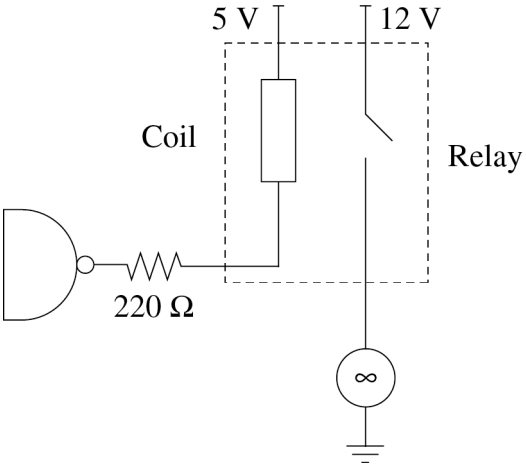
Output from H	*S*	*Q (output from G)*	
1	0	1	(Q changes from 0 to 1)
1	1	0	(no change to state)

So the state of *Q* will only change if the *S* input is changed to 0.

Question 35 (b) (i)

Criteria	Marks
• Draws a sketch showing a correct modification of the circuit	2
• Provides some relevant information	1

Sample answer:



Question 35 (b) (ii)

Criteria	Marks
• Determines the correct minimum illuminance	3
• Calculates the required resistance of the LDR	2
• Shows a basic understanding of the circuit OR • Substitutes into a relevant formula	1

Sample answer:

To switch the gate OFF so that it acts as a current sink the voltage across the 27 kΩ resistor must be greater than 2 V.

$$2\,\text{V} = 5\,\text{V} \times \frac{27\,\text{k}\Omega}{R_{LDR} + 27\,\text{k}\Omega}$$

R_{LDR} = 40.5 kΩ and from the graph the illumination threshold at which this occurs is about 12 lux.

Question 35 (c)

Criteria	Marks
• Contrasts the function and circuit construction of open-loop gain and closed-loop gain amplifiers	4
• Outlines the functions and/or circuit construction of open-loop gain and/or closed-loop gain amplifiers	2–3
• Provides some relevant information	1

Sample answer:

Open-loop gain refers to an operational amplifier when no feedback is provided. Typically, the open-loop gain is of the order of 200×10^3. Any difference in voltage between the inverting and non-inverting input will cause the output to swing to the supply rail voltage. Using an amplifier in this mode is useful if the amplifier is used as a switch or in a circuit that is comparing two voltages and a binary output is required. However, where the shape of the waveform is important then a closed-loop amplifier is required. This means that a portion of the output voltage is fed back to the input as negative feedback. The effect of negative feedback is to reduce the gain of the amplifier.

Question 35 (d) (i)

Criteria	Marks
• Correctly shows the mathematical relationship between V_{in} and V_{out} and identifies the circuit as a summing amplifier	2
• Provides some relevant information	1

Sample answer:

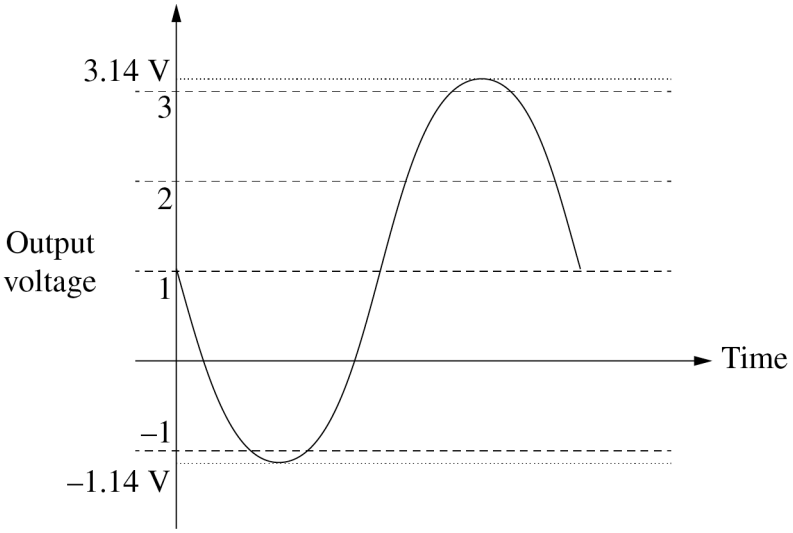
The circuit describes a summing inverting amplifier with the mathematical relationship between V_{in} and V_{out} equal to:

$$V_{out} = -R_3\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right).$$

Question 35 (d) (ii)

Criteria	Marks
• Draws a correct graph with all relevant voltages and signal inversion	3
• Provides a partially correct graph	2
• Provides some relevant information	1

Sample answer:



Question 35 (e)

Criteria	Marks
• Explains why both analogue and digital circuits are used in audio systems • Makes reference to the diagram	6
• Outlines why both analogue and digital circuits are used in audio systems • Refers to the diagram	5
• Outlines why both analogue and digital circuits are used in audio systems	4
• Shows some understanding of the use of analogue and/or digital circuits in audio systems OR • Outlines some components of the system shown	2–3
• Provides some relevant information	1

Sample answer:

Audio systems must involve analogue signals. The value of using analogue circuit components, such as microphones and loudspeakers, is that the input and outputs must be analogue for humans to hear it. Although analogue circuits can perform signal processing including recording, amplification and reproduction, the value of converting the signal to a digital form (analogue–digital converter) is that in digital form it can be stored, reproduced and transmitted without loss of information. Developments in integrated circuits technology (miniaturisation, increased functionality) have allowed audio systems to be incorporated into a wide variety of communication systems such as TV, phones and internet.

2017 HSC Physics
Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.3.3.3.3	H3
2	1	9.2.4.2.4	H6
3	1	9.4.1.2.4	H9
4	1	9.2.1.3.3	H6
5	1	9.4.3.2.3	H3
6	1	9.4.4.2.3	H1
7	1	9.2.4.2.2	H1
8	1	9.4.1.2.2	H9
9	1	9.4.1.2.2	H1
10	1	9.3.3.2.3	H3
11	1	9.3.4.3.2/9.4.1.3.3	H7
12	1	9.2.1.2.3	H7
13	1	9.3.1.2.5	H9
14	1	9.3.2.2.3	H7
15	1	9.2.2.3.4	H6
16	1	9.3.1.2.4	H9
17	1	9.3.1.3.3	H9
18	1	9.2.2.3.4/9.4.1.3.3	H9
19	1	9.3.1.2.1	H9
20	1	9.2.4.3.5	H6

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	2	9.4.2.3.4, 9.4.2.2.6	H8
21 (b)	3	9.4.2.3.4, 9.4.2.2.6, 9.4.2.2.5	H7
22 (a)	2	9.3.1.2.3	H6
22 (b)	3	9.3.1.2.3,.9.3.1.2.4, 9.3.1.2.5, 9.3.1.3.3	H9
23	5	9.2.4.3.4	H2
24 (a)	2	9.2.2.2.3	H9
24 (b)	3	9.2.2.2.3, 9.2.1.2.2, 9.2.1.2.3	H7
25 (a)	2	9.4.4.2.1, 9.4.4.1.1	H1
25 (b)	2	9.4.3.2.6, 9.4.3.2.7	H3
25 (c)	3	9.4.4.3.4	H3
26 (a)	2	9.2.2.2.2.13	H6, H7
26 (b)	4	9.2.2.2.12, 9.4.2.1.1	H7

Question	Marks	Content	Syllabus outcomes
27 (a)	2	9.3.2.2.2, 9.3.2.2.3	H7, H9
27 (b)	3	9.3.2.2.4	H9
28	6	9.3.2.3.4, 9.3.4.3.3	H7
29 (a)	4	9.2.1.2.2, 9.2.2.3.2	H7, H13
29 (b)	3	9.2.2.3.1, 9.4.1.2.5, 9.4.1.3.3	H7, H9
30	4	9.4.1.2.5, 9.4.1.3.3, 9.4.1.2.3	H9

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Geophysics**	
(a) (i)	2	9.5.4.2.4	H1
(a) (ii)	3	9.5.4.2.2/3, 9.5.4.3.2	H1
(b) (i)	2	9.5.3.2.2	H7
(b) (ii)	3	9.5.3.2.2/3, 9.5.3.3.1	H8
(c)	4	9.5.2.3.3/4	H14
(d) (i)	2	9.5.2.2.6	H7
(d) (ii)	3	9.5.2.2.7/8, 9.5.2.3.5	H14
(e)	6	9.5.3.2.5/6/7, 9.5.3.3.2/3	H14
Question 32		**Medical Physics**	
(a) (i)	2	9.6.2.2.6	H8
(a) (ii)	3	9.6.2.2.5/6	H8
(b) (i)	2	9.6.1.3.4	H7
(b) (ii)	3	9.6.1.2.7	H7
(c)	4	9.6.4.2.1/3/4/5/6	H9
(d) (i)	2	9.6.2.2.1	H8
(d) (ii)	3	9.6.2.2.3, 9.6.2.2.4, 9.6.2.3.2	H8
(e)	6	9.6.3.2.2/3/4/5	H4, H7, H8

Question 33		**Astrophysics**	
(a) (i)	2	9.7.1.2.4	H4
(a) (ii)	3	9.7.4.3.1	H12
(b) (i)	2	9.7.6.3.2	H14
(b) (ii)	3	9.7.3.2.2	H3
(c)	4	9.7.4.2.4	H3
(d) (i)	2	9.7.6.3.1	H14
(d) (ii)	3	9.7.6.3.2	H14
(e)	6	9.7.6.2.6	H13
Question 34		**From Quanta to Quarks**	
(a) (i)	2	9.8.4.2.5, 9.8.3.2.1	H10
(a) (ii)	3	9.8.3.2.8, 9.8.4.2.5	H10
(b) (i)	2	9.8.3.2.3, 9.8.3.3.2	H10
(b) (ii)	3	9.8.3.2.11	H3
(c)	4	9.8.1.2.5, 9.8.1.3.2, 9.8.1.3.3	H7, H10
(d) (i)	2	9.8.2.2.4	H1
(d) (ii)	3	9.8.2.2.3, 9.8.2.2.4, 9.8.2.2.1, 9.8.4.2.4	H2
(e)	6	9.8.4.2.3	H3
Question 35		**The Age of Silicon**	
(a) (i)	2	9.9.5.2.1, 9.9.5.3.1	H3, H13
(a) (ii)	3	9.9.5.3.2	H3, H13
(b) (i)	2	9.9.4.2.1, 9.9.4.3.1, 9.9.4.3.2	H7, H11, H14
(b) (ii)	3	9.9.2.2.4, 9.9.2.2.5, 9.9.2.3.3	H4, H12
(c)	4	9.9.6.2.1, 9.9.6.2.5, 9.9.6.2.9	H13, H14
(d) (i)	2	9.9.6.2.8, 9.9.6.2.11, 9.9.6.3.3	H12, H13, H14
(d) (ii)	3	9.9.6.2.8, 9.9.6.3.2, 9.9.7.3.4	H11, H12, H13
(e)	6	9.9.1.2.1, 9.9.1.2.4, 9.9.2.2.3	H1, H3, H7