2018 HSC Physics
Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21 (a)

Criteria	Marks
• Identifies both equal force AND opposite directions	2
• Provides some relevant information	1

Sample answer:

The force of Earth on the moon is equal in magnitude to the force of the moon on Earth, but in the opposite direction.

Question 21 (b)

Criteria	Marks
• Correctly compares the mass and weight of the person on the moon and on Earth quantitatively	2
• Provides some relevant information	1

Sample answer:

Mass does not change due to gravity so the mass will be 70 kg on Earth and on the moon.

$W = mg$

$W_m = 70 \times 1.6 = 112$

Weight on moon = 112 N

$W_E = 70 \times 9.8 = 686$

Weight on Earth is 686 N

Question 22 (a)

Criteria	Marks
• Relates the movement of the disc to the effect of the rotating magnet	3
• Outlines the movement of the disc and/or the effect of the magnet	2
• Provides some relevant information	1

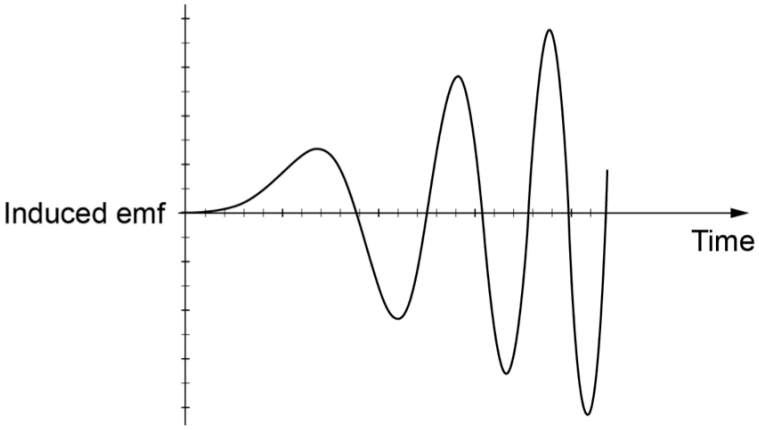
Sample answer:

As the magnet spins there is a change in magnetic flux in the metal disc, inducing eddy currents which, by Lenz's law and conservation of energy, will tend to create magnetic fields that will oppose the change. This will have the effect of the disc trying to keep up with the magnet and it will therefore spin in the same direction.

Question 22 (b)

Criteria	Marks
• Draws a graph showing all correct features	3
• Draws a graph showing some correct features	2
• Draws a graph with a correct feature	1

Sample answer:



[The graph should show a curve that is increasing in both amplitude and frequency.]

Question 23 (a)

Criteria	Marks
• Outlines energy changes in the electron gun and the screen	2
• Identifies an energy change	1

Sample answer:

The electron gains kinetic energy as it passes through the electron gun. At the screen the electron's kinetic energy is converted to light energy.

Question 23 (b)

Criteria	Marks
• Relates features of the components to forming an image on the screen	3
• Outlines some features of the components	2
• Provides some relevant information	1

Sample answer:

The components labelled *Y* provide a force on moving electrons, causing them to deflect. By varying the strength of the magnetic field, the force on the electron can be controlled to steer the electron beam to different parts of the screen.

Question 24 (a)

Criteria	Marks
• Outlines TWO safety features	2
• Provides a safety feature	1

Sample answer:

Earth line above the high-voltage transmission lines to protect them from lightning strikes and insulating discs used to attach transmission lines to power poles to prevent short-circuiting.

Question 24 (b)

Criteria	Marks
• Provides correct calculation of magnitude and direction of current	3
• Provides some steps to calculate the magnitude of the current OR • Substitutes into a relevant equation and shows direction of current	2
• Substitutes into a relevant equation OR • Shows direction of current	1

Sample answer:

$I_1 = 20$ A, $I_2 = 20$ A, $I_3 = ?$

$d_1 = 0.3$, $d_2 = 0.75$

$\frac{F_1}{l} = \frac{F_2}{l}$, therefore $\frac{kI_1I_2}{d_1} = \frac{kI_2I_3}{d_2}$

So $\frac{20 \times 20}{0.3} = \frac{20I_3}{0.75}$, thus $I_3 = 50$ A travelling in the same direction as Y.

Question 25 (a)

Criteria	Marks
• States ONE benefit and ONE limitation	2
• States a benefit or a limitation	1

Sample answer:

Benefit – no energy loss in transmission
Limitation – energy required to keep the transmission lines cold

Question 25 (b)

Criteria	Marks
• Contrasts features of electrical conduction in the two types of materials	4
• Outlines features of electrical conduction in one material and identifies a feature of conduction in the other material	3
• Outlines a feature of electrical conduction in either material OR • Identifies a feature of electrical conduction in each material	2
• Provides some relevant information	1

Sample answer:

In a room temperature metal, electrons move independently of each other, whereas in a superconductor electrons move in pairs.

In a room temperature metal, interaction between electrons moving through a lattice and the thermal lattice vibrations gives rise to resistance, whereas in a superconductor the electrons move without resistance through the crystal lattice which is distorted only by the electron pairs.

Question 26

Criteria	Marks
• Outlines similarities and differences between the effects of electric and gravitational fields • Refers to definitions of the fields	4
• Outlines similarities and/or differences between the effects of electric and gravitational fields	3
• Shows some understanding of the effects of electric fields and/or gravitational fields	2
• Provides some relevant information	1

Sample answer:

An electric field is a region in space where a force acts on a charged particle. A gravitational field is a region in space where an object with mass affects other objects with mass.

Electric field strength is given by $E = F/q$ (force per unit charge), whereas gravitational field strength is given by $g = F/m$ (force per unit mass).

Both fields produce forces of attraction, but only electric fields repel (due to like charges). Electric and gravitational fields vary in strength due to magnitudes of the charge or mass respectively.

Both fields decrease in strength with the square of the separation distance from a point charge or mass.

Answers could include

Gravity is a very weak fundamental force compared to the forces dependent on charge.

Question 27 (a)

Criteria	Marks
• Identifies an error • Describes the effect	3
• Identifies an error • Identifies the effect	2
• Identifies an error or and effect	1

Sample answer:

Error: The camera is off centre

Effect: When the object is closer to the camera, it will appear to be moving faster than when it is further away, therefore it will give an incorrect measurement of velocity.

Answers could include:

Error: Ruler closer to the camera than the trajectory

Effect: Distance calculated on the trajectory using the ruler will be greater than the true distance and hence the calculated velocity will be greater than the true value.

Others: Camera too close/non-linearity of distances etc; ruler off centre/non-linearity of distances etc.

Question 27 (b)

Criteria	Marks
• Describes quantitatively and qualitatively the velocity and acceleration related to the graphs	3
• Describes the velocity and acceleration related to the graphs	2
• Identifies features of the motion related to the graph(s) OR • Describes the velocity or acceleration related to the graph(s)	1

Sample answer:

The first graph shows that the ball is moving horizontally at a constant speed of 1.6 m s^{-1}. The second graph shows that the ball is accelerating at a constant rate in the vertically downward direction.

Answers could include:

$$\text{velocity} = \frac{-1.1-\left(-0.3\right)}{0.5} = \frac{-0.8}{0.5} = -1.6 \text{ m s}^{-1}$$

$$\text{acceleration} = \frac{-2.4-2.4}{0.5} = -9.6 \text{ m s}^{-2}$$

Question 28 (a)

Criteria	Marks
• Shows that the change in potential energy is 1.26×10^7 J	2
• Substitutes some information into a relevant equation	1

Sample answer:

Initial potential energy of mass

$$E_{\text{pi}} = -\frac{GMm}{r} = \frac{-6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 20}{1.74 \times 10^6}$$

$$= -5.64 \times 10^7 \text{ J}$$

Final potential energy of mass

$$E_{\text{pf}} = \frac{-6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 20}{2.24 \times 10^6}$$

$$= -4.38 \times 10^7 \text{ J}$$

$$\triangle E_{\text{p}} = E_{\text{pf}} - E_{\text{pi}} = 1.26 \times 10^7 \text{ J}$$

Question 28 (b)

Criteria	Marks
• Applies a correct process to calculate the velocity	3
• Applies the law of conservation of energy	2
• Substitutes some information into a relevant equation	1

Sample answer:

Initial $E_{\text{ki}} = \frac{1}{2}mu^2 = \frac{1}{2} \times 20 \times 1200^2$

$$= 1.44 \times 10^7 \text{ J}$$

Final $E_{\text{kf}} = E_{\text{ki}} - \triangle E_{\text{p}}$

$$= 1.44 \times 10^7 - 1.26 \times 10^7$$

$$= 1.8 \times 10^6 \text{ J}$$

$$E_{\text{kf}} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2E_{\text{kf}}}{M}} = \sqrt{\frac{2 \times 1.8 \times 10^6}{20}}$$

$$= 424 \text{ m s}^{-1}$$

Question 29 (a)

Criteria	Marks
• Shows how light contributes to the flow of current in each of the cells	4
• Shows how light contributes to the flow of current in one of the cells and links light to the flow of current in the other cell	3
• Links light to the flow of current in each of the cells OR • Shows how light contributes to the flow of current in one of the cells	2
• Provides some relevant information	1

Sample answer:

In a vacuum photocell, incoming photons strike a photocathode *A*, knocking electrons out of its surface, which are attracted to an anode *B*, due to the potential difference applied by the battery, thus producing a current.

In a solar cell, a potential difference is set up by the *p* and *n* junction. When incoming photons of light hit the electrons the *n*-type semiconductor electrons are pushed through the external circuit, thus creating a current, which is electricity for the load.

Question 29 (b)

Criteria	Marks
• Explains how one advance in scientific understanding and one advance in technology have led to the use of semiconductors	4
• Describes an advance in either understanding or technology that have led to the use of semiconductors AND • Identifies an advance in the other	3
• Shows some understanding of advance in scientific understanding and/or technology in relation to the use of semiconductors	2
• Provides some relevant information	1

Sample answer:

Our increased understanding of the band structure model has led to the doping of materials. Advances in technology have allowed silicon to be easily purified to make an intrinsic semiconductor ready for doping. Doping is used to produce different types of semiconductors: *n*-type, and *p*-type. Layering these together allows us to make diodes and transistors which have many uses.

Answers could include:

Scientific understanding	Band structure	Effects of doping
Technology	Purification	Fabrication

Question 30

Criteria	Marks
• Explains the effects of the increased demand on the components of the system • Refers to voltage, current and energy	6
• Explains the effects of the increased demand on components of the system • Refers to voltage, current and/or energy	5
• Describes an effect of the increased demand on a component of the system • Makes reference to voltage, current OR energy	4
• Outlines an effect of the increased demand on the system OR • Outlines how components of the system work together to transmit power	3
• Identifies effects of the increased demand on the system OR • Outlines the operation of a component of the system	2
• Provides some relevant information	1

Sample answer:

The increased demand for energy can be analysed in terms of the effect on voltages, current and energy losses.

Voltages: The output voltage from the power station, the transmission line voltage and the supply voltage to the houses remains approximately constant.

Current: An increase in the total current being drawn from T2 by the houses produces an increase in the transmission line current and the output current from the power station. If the former doubles, then the transmission line current and the current output of the power station approximately double.

Energy losses: Heat is produced in the transmission line wires and other wires due to their resistance. As the current increases the heat produced in the wires increases. Heat is also produced by eddy currents in the transformer cores, and this increases as the current increases.

Because of the resistance of the wires, relatively small voltage drops occur along these conductors and these increase as more appliances are turned on in the houses. This results in slight decreases in the voltage inputs and outputs at each of the transformers.

Answers could include:

Reference to parallel circuits in the houses

Section II

Question 31 (a) (i)

Criteria	Marks
• Provides TWO methods	2
• Provides ONE method	1

Sample answer:

Radiometric and gravitational methods

Answers could include:

Magnetic, palaeomagnetic or geothermal

Question 31 (a) (ii)

Criteria	Marks
• Shows a sound understanding of how a suitable geophysical method provides information about Earth's physical properties	3
• Outlines how a suitable geophysical method provides information about Earth's physical properties	2
• Provides some relevant information	1

Sample answer:

Radiometric methods are used for dating specimens. The radioactive decay of elements in a rock or mineral is measured and compared to determine its age. By using radioactive elements with differing half-lives, ages can be determined for specimens from a few thousand years to billions of years of age.

Answers could include:

Other answers could describe information about:
Magnetic, gravitational, palaeomagnetic or geothermal methods

Question 31 (b) (i)

Criteria	Marks
• Explains a relevant feature	2
• Provides some relevant information	1

Sample answer:

The altitude of NOAA-20 is much less than that of geostationary satellites, hence photographs will provide more detail about storms and cloud systems.

Answers could include:

Due to NOAA-20's short period polar orbit, it regularly passes over the entire surface of Earth to photograph changes in the atmosphere.

Question 31 (b) (ii)

Criteria	Marks
• Applies a correct process to calculate the mass of Earth	3
• Shows some appropriate calculations	2
• Provides some relevant information	1

Sample answer:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$M = \frac{r^3 4\pi^2}{GT^2}$$

$$= \left(r_{\text{E}} + \text{altitude}\right)^3 \times \frac{4\pi^2}{GT}$$

$$= \frac{\left(6.37 \times 10^6 + 8.7 \times 10^5\right)^3 \times 39.48}{6.67 \times 10^{-11} \times \left(100 \times 60\right)^2}$$

$$= 6.24 \times 10^{24}$$

The mass of Earth is calculated to be 6.24×10^{24} kg

Question 31 (c)

Criteria	Marks
• Shows an understanding of both Richer's and Newton's use of data obtained from experiments involving pendulums • Explains how both independently used the data to determine the shape of Earth	4
• Shows an understanding of both Richer's and Newton's use of data obtained from experiments involving pendulums • Explains how one of them used the data to determine the shape of Earth	3
• Shows some understanding of Richer's and/or Newton's use of data obtained from experiments involving pendulums	2
• Provides some relevant information	1

Sample answer:

Richer found that the rate of swing of a pendulum at the Equator was slightly slower than the rate of swing of a similar pendulum in Paris. Since the rate of swing of a pendulum is directly related to the acceleration due to gravity, this suggested that the acceleration due to gravity was less at the Equator than in Paris. Newton used this information to explain that the Earth was flattened at the poles and bulged at the Equator.

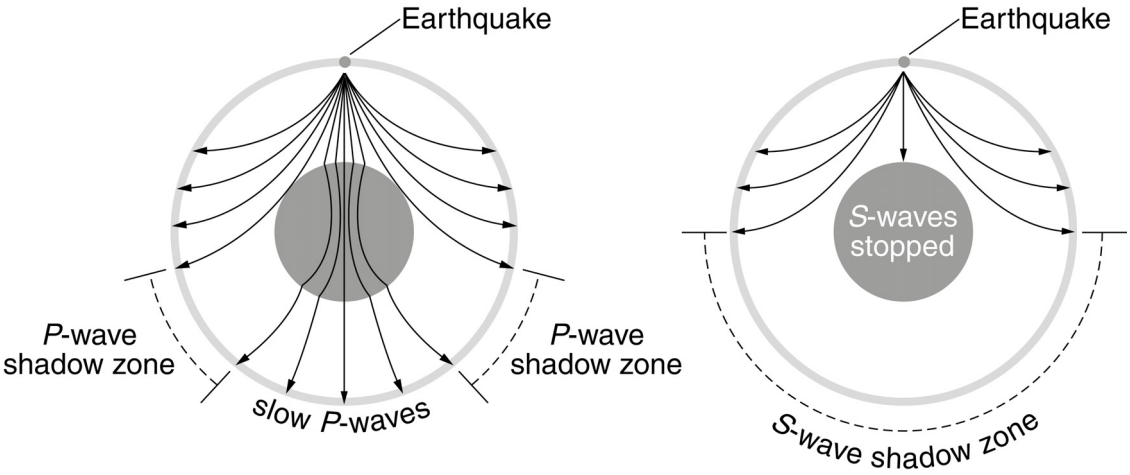
Question 31 (d)

Criteria	Marks
• Shows how seismic data are used to provide a model of Earth's core • Supports answer with a diagram	4
• Shows how seismic data are used to provide a model of Earth's core	3
• Shows some understanding of Earth's core and/or the use of seismic data	2
• Provides some relevant information	1

Sample answer:

Seismic waves may reflect (bounce) or refract (bend and change speed) depending on the materials they pass through. *P*-waves (compression waves) and *S*-waves (shear waves) both travel through solids, but *S*-waves cannot travel through liquids.

Seismic waves can be detected around Earth's surface, as shown in the diagrams.



Scientists have used this seismic data to produce a model of Earth's core: a liquid outer core around a solid inner core.

Question 31 (e)

Criteria	Marks
• Explains the role of palaeomagnetic data in providing evidence that supports the theory of plate tectonics	7
• Describes the role of palaeomagnetic data in relation to the theory of plate tectonics	6
• Outlines the role of palaeomagnetic data in relation to the theory of plate tectonics	4–5
• Shows some understanding of palaeomagnetic data and/or the theory of plate tectonics	2–3
• Provides some relevant information	1

Sample answer:

Certain minerals in rocks lock in a record of the direction and intensity of Earth's magnetic field when they form. Palaeomagnetism is the study of this record in ancient rocks.

Mirror image patterns of magnetic reversal in the sea floor on either side of mid-ocean ridges provided strong evidence for sea-floor spreading when correlated with data from which the ages of the rocks can be determined.

Apparent polar wander paths determined from palaeomagnetic data provided evidence for continental drift.

Together, continental drift and sea-floor spreading formed the basis of the theory of plate tectonics which describes the Earth's surface as a series of major and minor plates which move around the surface of the Earth due to convection currents in the mantle.

Answers may include:

Use of such data to explain earthquake and volcanic activity, mountain building and oceanic trench formation.

Question 32 (a) (i)

Criteria	Marks
• Identifies two specific uses of MRI	2
• Identifies one specific use of MRI OR • Outlines a general use of MRI	1

Sample answer:

MRI is used to detect cancerous tissues and to distinguish between grey and white matter in the brain.

Question 32 (a) (ii)

Criteria	Marks
• Describes effects of the external field on the protons	3
• Identifies effects of the external field on the protons OR • Describes an effect of the external field on the protons	2
• Identifies an effect of the external field on the protons	1

Sample answer:

Hydrogen nuclei in water molecules tend to align their spins with the field. The axes of rotation are not exactly parallel to the external field direction and the spins of these protons precess around the direction of the applied external field at a rate that is dependent on the strength of the field. The hydrogen nuclei align parallel or antiparallel to the field with a small minority in the parallel direction.

Question 32 (b) (i)

Criteria	Marks
• Shows how the behaviour of waves *A* and *B* are similar and/or different	2
• Shows some understanding of the behaviour of waves *A* or *B*	1

Sample answer:

The proportion of the ultrasound that is transmitted (or reflected) at the boundary is the same for both *A* and *B*.

Both waves have some of their energy reflected at the boundary and some of their energy transferred across the boundary.

Question 32 (b) (ii)

Criteria	Marks
• Applies a correct process to calculate the acoustic impedance of fat tissue	3
• Provides some main steps to calculate the acoustic impedance of fat tissue	2
• Substitutes some information into a relevant formula	1

Sample answer:

$Z_{\text{kidney}} = rv = 1050 \times 1560 = 1.64 \times 10^6$ Rayls

$$\frac{I_r}{I_o} = \frac{\left(Z_2 - Z_1\right)^2}{\left(Z_2 + Z_1\right)^2}$$

$$0.01 = \frac{\left(1.64 \times 10^6 - Z_1\right)^2}{\left(1.64 \times 10^6 + Z_1\right)^2}$$

$$0.1 = \frac{1.64 \times 10^6 - Z_1}{1.64 \times 10^6 + Z_1}$$

$0.1 \times 1.64 \times 10^6 + 0.1 \times Z_1 = 1.64 \times 10^6 - Z_1$

$1.1 \times Z_1 = 1.64 \times 10^6 - 1.64 \times 10^5 = 1.476 \times 10^6$

Hence $Z_1 = 1.34 \times 10^6$ Rayls

Question 32 (c)

Criteria	Marks
• Justifies the use of I-124 as a PET medical diagnostic tool • Supports answer quantitatively	4
• Outlines reason(s) for using I-124 as a medical diagnostic tool • Links its use quantitatively to its half-life	3
• Shows some understanding of the use of I-124 as a medical diagnostic tool	2
• Provides some relevant information	1

Sample answer:

Iodine-124 is a positron emitter and hence could be used for PET scans. Each positron emitted by this isotope in the body undergoes annihilation with an electron, producing two gamma photons which can be detected outside the body. Gamma rays are not strongly ionising, making them safe for diagnostic use.

The gamma radiation can be detected once it has left the body, providing information about the parts of the body where it was produced.

The half-life of approximately 100 hours makes it suitable for use in the body because the potentially damaging radiation does not persist in the body long enough to be dangerous.

Question 32 (d)

Criteria	Marks
• Explains how the Doppler effect is used for medical imaging	4
• Describes the use of the Doppler effect in medical imaging	3
• Outlines features of the Doppler effect OR • Outlines features of ultrasound imaging	2
• Provides some relevant information	1

Sample answer:

When ultrasound waves are reflected from a moving surface, the frequency of the reflected wave is higher if the surface is moving towards the incident wave and lower if it is moving away. The greater the velocity of the reflecting surface, the greater the change in frequency. This is the Doppler effect.

Information about the angle between the directions of the velocities of the ultrasound and the reflecting surface can be determined to produce more accurate images.

The position of the reflecting tissue can be calculated knowing the velocity of the ultrasound in the tissues and the time for the reflected signal to be detected.

Doppler ultrasound is therefore used to analyse movement of tissues such as heart valves and the flow of blood.

Question 32 (e)

Criteria	Marks
• Compares the production of the longitudinal CAT image with an X-ray image of the same area • Compares the benefits of the CAT image provided with an X-ray image of the same area	7
• Describes the production and benefits of CAT and X-ray images including some comparisons	6
• Outlines production and benefits of CAT and X-ray images	4–5
• Shows some understanding of CAT images and/or X-ray images	2–3
• Provides some relevant information	1

Sample answer:

The production of both types of scans is dependent on differences in the absorption of X-rays passed through the body by different types and depths of tissue. Conventional X-rays are cheaper.

A conventional X-ray image of the neck is made by passing X-rays in a wide beam transversely through the neck producing a longitudinal image of the neck in a single plane, which is the result of the absorption of the X-rays by all the intervening tissues. The image can be ambiguous.

In contrast to this, a CAT scan is produced by a narrow beam of X-rays that are passed through the person from a source that rotates in the transverse plane around the person's body, and which are detected by a sensor that also moves so that it is always opposite the X-ray source. This data is processed by a computer to produce an image that is a cross-section of the body. The benefit is that the CAT image is clearer and less ambiguous than the conventional X-ray image. The CAT scan also produces better soft tissue differentiation.

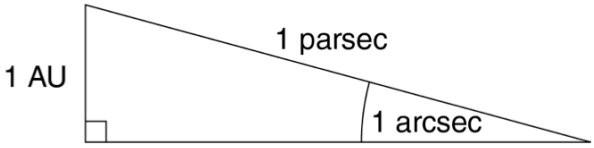
In the case of the CAT scan shown, it shows structures in the longitudinal plane, as would be the case with a conventional X-ray. This is achieved by combining multiple transverse images allowing computer software to produce an image in a single plane through the body at any angle.

Question 33 (a) (i)

Criteria	Marks
• Uses a diagram to define the parsec	2
• Provides some relevant information	1

Sample answer:

One parsec is the distance from Earth to a point that has an annual parallax of one arcsec.



Question 33 (a) (ii)

Criteria	Marks
• Outlines TWO limitations	3
• Identifies TWO limitations OR • Outlines ONE limitation	2
• Provides some relevant information	1

Sample answer:

As Earth's atmosphere causes distortion of incoming light, light waves are refracted by the gas particles and as a result resolution of ground-based telescopes can be low. Only large angles of parallax can be measured accurately, which means only very small distances in space can be measured.

Question 33 (b) (i)

Criteria	Marks
• Contrasts the reasons for the variation in brightness of these two stars	2
• Provides some relevant information	1

Sample answer:

Eclipsing binary stars' brightness varies due to the relative motion between the two stars whereas Cepheid's varying brightness is due to the star's core activity.

Question 33 (b) (ii)

Criteria	Marks
• Applies correct procedure to calculate distance	3
• Provides some main steps to calculate distance	2
• Substitutes some information into a relevant formula	1

Sample answer:

From graph, period $= 6$ days, therefore $M = -3.2$ and $m = 16.3$.

$$M = m - 5\log_{10}\left(\frac{d}{10}\right)$$

$$\log_{10}\left(\frac{d}{10}\right) = \frac{16.3 - \left(-3.2\right)}{5}$$

$$\log_{10}\left(\frac{d}{10}\right) = 3.9$$

$$d = 10^{3.9} \times 10$$

$$d = 79\,432.8 = 79 \text{ kpc}$$

Question 33 (c)

Criteria	Marks
• Describes physical and chemical changes through the remaining stages of the star's life	4
• Identifies some physical and chemical changes through the remaining stages of the star's life • Describes at least one of the changes	3
• Shows some understanding of how star *X* evolves	2
• Provides some relevant information	1

Sample answer:

The next stage of its evolutionary path would be a red supergiant where its size will increase dramatically but the luminosity would stay the same. Helium burning starts in the core and changes to fusion between helium and carbon to form oxygen. As the temperature rises carbon fuses to form heavier elements and iron which causes the core to collapse forming a supernova explosion which results in an increase in its luminosity leading to a gravitational collapse into a black hole.

Question 33 (d)

Criteria	Marks
• Describes differences between photoelectric and photographic methods • Relates differences to the increased understanding provided	4
• Describes differences between photoelectric and photographic methods OR • Describes a difference between photoelectric and photographic methods and relates the difference to the increased understanding provided	3
• Shows some understanding of photographic and/or photoelectric methods	2
• Provides some relevant information	1

Sample answer:

With photographic methods each image contains many stars whereas photoelectric technologies using charged-coupled devices (CCD) can isolate the light from a single star and thoroughly analyse it.

CCD images show fainter objects, collect more effectively across the entire spectrum (including infrared) and can be collected and processed more rapidly than photographic methods. Due to its digitisation, computers can be used to enhance, enlarge, add or subtract selected colours to assist in enhancing specific features.

This gives a greater understanding of the star in terms of its surface temperature, chemical composition, mass, density, rotational and translational velocity.

Question 33 (e)

Criteria	Marks
• Explains how the three spectra are used to analyse surface temperature and chemical composition of stars • Refers to observations that can be made in a school laboratory	7
• Explains how at least two of the spectra are used to analyse surface temperature and chemical composition of stars with reference to observations that can be made in a school laboratory OR • Explains how the three spectra are used to analyse surface temperature and/or chemical composition of stars with reference to observations that can be made in a school laboratory	6
• Outlines how black body spectra and/or emission spectra and/or absorption spectra are used to analyse surface temperature and/or chemical composition of stars • Better responses should refer to observations that can be made in a school laboratory	4–5
• Shows some understanding of the use of black body spectra and/or emission spectra and/or absorption spectra to analyse stars AND/OR • Refers to observations that can be made in a school laboratory	2–3
• Provides some relevant information	1

Sample answer:

A black body produces a radiation curve that is dependent on the temperature of the body. A star acts as a black body and the characteristic peak of the curve reflects the temperature of the surface of the star.

A black body produces a continuous spectrum, so the spectrum of stars is continuous. Absorption lines are seen in the spectrum due to cooler gas particles in the atmosphere around the stars absorbing certain wavelengths of energy resulting in an absorption spectrum which identifies the atoms in the gas clouds.

Using different gas discharge tubes (hydrogen, helium, neon) and a spectroscope, unique spectra can be observed in a school laboratory. This can be used to compare with spectral lines produced by stars to identify their chemical composition. Incandescent bulbs can demonstrate a continuous spectrum curve.

Question 34 (a) (i)

Criteria	Marks
• Identifies TWO limitations of the Bohr model of the atom	2
• Identifies a limitation of the Bohr model of the atom	1

Sample answer:

- Only works for hydrogen
- Doesn't account for variation in spectral line intensity

Answers could include:

- Doesn't account for hyperfine spectral lines
- Doesn't account for the Zeeman effect.

Question 34 (a) (ii)

Criteria	Marks
• Shows how the Bohr model accounts for the emission spectrum of hydrogen	3
• Relates a feature of the Bohr model to the production of the emission spectrum	2
• Provides some relevant information	1

Sample answer:

The Bohr model consists of an electron occupying only very specific energy levels in orbiting the positive nucleus. According to this model, the emission spectrum of hydrogen is created when an excited electron falls from a higher energy level to a lower energy level with a corresponding release of a photon with energy a multiple of **hf**.

Answers could include:

Reference to a well-labelled diagram

Question 34 (b) (i)

Criteria	Marks
• Shows an understanding of how the law of conservation of momentum or energy was used to estimate the mass or energy of the particle	2
• Provides some relevant information	1

Sample answer:

When calculating the momentums of the three particles, alpha, *X* and proton, the law of conservation of momentum indicates that the mass of *X* is similar to the mass of a proton. This is how Chadwick discovered the neutron.

Question 34 (b) (ii)

Criteria	Marks
• Applies a correct procedure to calculate energy in joules	3
• Provides some main steps to calculate energy	2
• Substitutes some information into a relevant formula	1

Sample answer:

Initial mass $= 4.0012 + 9.0122 = 13.0134u$

Final mass $= 12.000 + 1.0087 = 13.0087u$

Mass difference $= 13.0087 - 13.0134 = -0.0047u$

Mass in kg $= 0.0047 \times 1.661 \times 10^{-27} = 7.8067 \times 10^{-30}$ kg

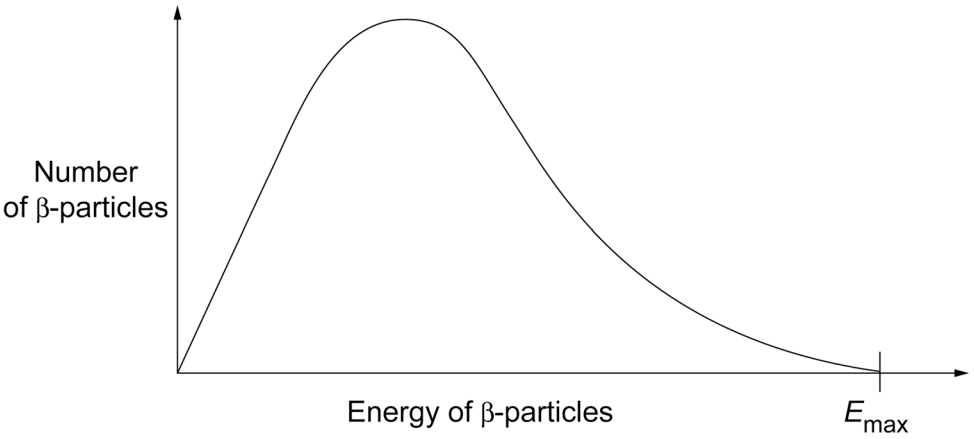
$E = mc^2 = 7.8067 \times 10^{-30} \times \left(3.00 \times 10^8\right)^2 = 7.0 \times 10^{-13}$ J

Question 34 (c)

Criteria	Marks
• Shows how Pauli inferred the existence and properties of a new particle • Supports answer with a graph	4
• Shows an understanding of how Pauli inferred the existence and properties of a new particle	3
• Shows some understanding of how Pauli inferred the existence and/or properties of a new particle	2
• Provides some relevant information	1

Sample answer:

The graph below represents the measured energies of emitted beta particles from a nuclear reaction.



The law of conservation of energy states that any nuclear reaction would release a fixed amount of energy.

The graph shows β-particles are emitted with a range of energy implying that some other particle must exist that carries the difference in energy.

Pauli inferred a new particle, neutrino, which must be chargeless and have negligible mass.

Question 34 (d)

Criteria	Marks
• Describes changes in the nuclei of *X* and *Y*	4
• Identifies a change in the nucleus of *X* and nucleus of *Y* • Describes one of the changes	3
• Identifies a change in the nucleus of *X* and the nucleus of *Y* OR • Outlines a change in the nucleus of *X* or *Y* OR • Relates the trails to the emission of particles from *X* and *Y*	2
• Provides some relevant information	1

Sample answer:

Source *X* emits an alpha particle (He nucleus), hence atomic number decreases by 2 and mass decreases by 4.

Source *Y* emits a beta particle (electron) from the nucleus, hence mass change is insignificant, but atomic number increases by 1.

Question 34 (e)

Criteria	Marks
• Analyses the roles of both forces and particles using the standard model • Relates these to the current understanding of the atom	7
• Analyses the roles of forces and/or particles using the standard model • Relates these to the current understanding of the atom	6
• Describes the roles of forces and/or particles in relation to the standard model • Links these to the current understanding of the atom	4–5
• Shows some understanding of the standard model	2–3
• Provides some relevant information	1

Sample answer:

In the standard model, fundamental particles – quarks and leptons – interact through four fundamental forces. The constituents of protons and neutrons are three quarks. The strong force holds nucleons together in the nucleus, overcoming the electrostatic repulsion between protons. An electron is a lepton which has no constituents. The force of gravity attracts protons and neutrons within the nucleus but this force is negligible.

The electrostatic force results in a mutual repulsion of protons and an attraction for the electrons toward the nucleus. Electrons orbit the nucleus. The strong nuclear force counteracts the electrostatic force, but only within a limited range of subatomic distances. The weak force is involved in the process of radioactive decay.

Question 35 (a) (i)

Criteria	Marks
• Outlines TWO differences between an electric circuit and an electronic circuit	2
• Outlines a difference between an electric circuit and an electronic circuit	1

Sample answer:

Electric circuits are designed for transmitting power and therefore operate with higher voltages and currents than electronic circuits in which voltages and currents represent information or signals.

Question 35 (a) (ii)

Criteria	Marks
• Relates properties of silica to its use in electronic communication	3
• Relates a property of silica to its use in electronic communication	2
• Provides some relevant information	1

Sample answer:

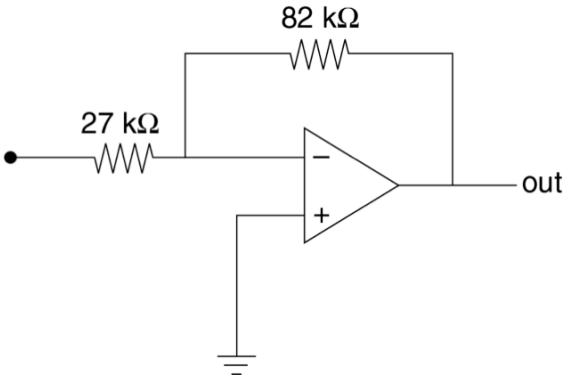
Silica can be easily drawn into fibres at high temperatures to produce optic fibres. Silica is optically transparent and can be made very pure, so that very little attenuation occurs over a long distance.

Silica has a refractive index of about 1.5, but it can vary such that the core of the fibre can be made to have a greater refractive index than the surrounding cladding, allowing total internal reflection to occur.

Question 35 (b) (i)

Criteria	Marks
• Draws the inverting amp with resistors connected in the correct place	2
• Provides some relevant information	1

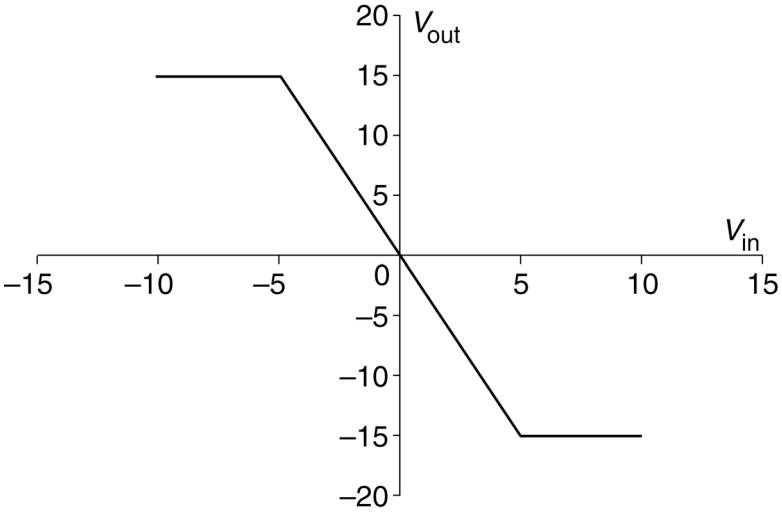
Sample answer:



Question 35 (b) (ii)

Criteria	Marks
• Draws a graph showing the correct features	3
• Draws a graph with some correct features	2
• Draws a graph with a correct feature OR calculates the correct gradient	1

Sample answer:



Question 35 (c)

Criteria	Marks
• Relates information in the graph to the evolution of computer technology • Refers to both the history and forward prediction of the graph	4
• Shows an understanding of the graph and the evolution of computer technology • Links the graph to the evolution of computer technology	3
• Shows some understanding of the graph and/or the evolution of computer technology	2
• Provides some relevant information	1

Sample answer:

Individual resistors have been replaced by integrated circuits containing many transistors. The graph shows that since 1970 the transistor count has increased at an exponential rate (by a factor of 10 roughly every 7–8 years). With this continued trend there has been an associated increase in computing power and portability of computers. Computers have gone from specialised devices in military, research and businesses to becoming ubiquitous devices in everyone's homes and in the palm of their hand. Today, small handheld devices have exponentially more computing power than early supercomputers that filled entire rooms. The graph also shows a predicted trend into the future. However, one has to be careful how far we extrapolate due to physical limits on transistor sizes, where components become so small that quantum effects become significant.

Question 35 (d)

Criteria	Marks
• Explains how an electronic circuit can use a relay to switch high-power devices • Refer to the roles of the components of the relay	4
• Describes how an electronic circuit can use a relay to switch high-power devices	3
• Shows some understanding of relays	2
• Provides some relevant information	1

Sample answer:

An electronic circuit cannot handle high voltages or currents without damaging components. Relatively small power is required to operate an electromagnet which forms the input of the relay. This electromagnet pulls a lever which, via a pivot, pushes a switch contact closed. The switch contacts are electrically insulated from the lever in order to isolate the output from the input. Since it is a mechanical switch, it can be manufactured to handle much higher voltages and currents.

Answers may include:

A well-labelled diagram

Question 35 (e)

Criteria	Marks
• Explains the operation of the circuit • Supports explanation with a truth table and data from the thermistor characteristic curve	7
• Describes the operation of the circuit • Includes a truth table and/or data from the thermistor characteristic curve	6
• Outlines the operation of the circuit • Includes a truth table and/or data from the thermistor characteristic curve	4–5
• Shows some understanding of the operation of the circuit and/or provides a truth table	2–3
• Provides some relevant information	1

Sample answer:

For the temperature sensor to produce a high output, the input voltage must be greater than the reference voltage provided by the two fixed resistors. As the temp rises, R_t will decrease, increasing the input voltage.

$$\frac{R_t}{5.6} = \frac{10}{20}$$

$$R_t = 2.8 \text{ k}\Omega$$

On the graph this corresponds to 60°C

Inputs			Output
Smoke	*Temp*	*Switch*	
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

The alarm will be activated only if the switch is open and either or both the outputs (T_{out}, S_{out}) are high.

The alarm will be activated under the following conditions: The switch must be open and either the temp is above 60° or the smoke detector output is high.

2018 HSC Physics
Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.2.3.2.1/3	H9
2	1	9.4.2.2.3	H2, H10
3	1	9.2.2.2.11	H6, H7
4	1	9.3.2.2.6	H7, H9
5	1	9.3.1.3.3	H9
6	1	9.3.2.3.3	H9
7	1	9.2.1.3.3/9.2.3.3.2	H9
8	1	9.4.3.2.2/3/7	H3, H7, H10
9	1	9.2.4.2.9/10	H6
10	1	9.3.1.2.3/5/6	H9
11	1	9.2.2.2.5/7	H9
12	1	9.4.1.3.3	H9
13	1	9.4.1.2.5, 9.4.1.2.8	H9
14	1	9.2.1.3.1/2	H9
15	1	9.4.4.2.2	H6
16	1	9.2.4.2.9	H6
17	1	9.4.2.2.5	H10
18	1	9.2.4.2.2, 9.2.4.3.1, 9.3.2.2.5/7	H7, H9
19	1	9.2.4.2.4	H6, H9
20	1	9.3.1.3.5/9.3.2.2.4	H7, H9

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	2	9.2.3.2.1	H6, H9
21 (b)	2	9.2.1.3.3	H6, H9, H14
22 (a)	3	9.3.5.3.1	H7, H9
22 (b)	3	9.3.2.2.4, 9.3.2.3.2	H7, H9, H13
23 (a)	2	9.4.1.2.9	H7, H9
23 (b)	3	9.4.1.2/2/3/5/9	H9
24 (a)	2	9.3.3.3.4	H7, H9
24 (b)	3	9.3.1.2.2, 9.3.1.3.1	H9, H14
25 (a)	2	9.4.4.3.5	H4, H7
25 (b)	4	9.2.3.2.1, 9.4.1.2.6/7, 9.2.1.2.1	H9
26	4	9.4.4.2.3/4/5/6	H7, H9
27 (a)	3	9.2.2.3.1/2	H9, H11
27 (b)	3	9.2.2.3.1/2	H9, H14

Question	Marks	Content	Syllabus outcomes
28 (a)	2	9.2.1.2.3	H7, H9, H14
28 (b)	3	9.2.2.3.3	H7, H9
29 (a)	4	9.4.2.3.3, 9.4.3.3.4	H7, H10
29 (b)	4	9.4.3.2.2/5/6/8, 9.4.3.3.3	H3, H7
30	6	9.3.3.2.4, 9.3.4.2.4, 9.3.4.3.4	H7, H9

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Geophysics**	
(a) (i)	2	9.5.1.2.2	H7
(a) (ii)	3	9.5.1.2.2	H3
(b) (i)	2	9.5.2.2.2	H4
(b) (ii)	3	9.5.2.3.4	H14
(c)	4	9.5.2.3.2, 9.5.1.3.1	H7, H9
(d)	4	9.5.3.2.1/2/5	H7, H8
(e)	7	9.5.4.2.3, 9.5.4.3.2	H9
Question 32		**Medical Physics**	
(a) (i)	2	9.6.4.3.2	H4
(a) (ii)	3	9.6.4.2.4/5	H7, H9
(b) (i)	2	9.6.1.2.4, 9.6.1.2.6	H7, H14
(b) (ii)	3	9.6.1.2.5	H7, H8
(c)	4	9.6.3.2.1/4	H7
(d)	4	9.6.2.2.3/4, 9.6.2.3.2	H7, H8
(e)	7	9.6.2.2.3/4, 9.6.2.3.2	H7, H8
Question 33		**Astrophysics**	
(a) (i)	2	9.7.2.2.1	H8, H10, H13
(a) (ii)	3	9.7.1.2.4, 9.7.2.2.3	H8, H10
(b) (i)	2	9.7.5.2.1/3, 9.7.5.3.1	H8
(b) (ii)	3	9.7.4.3.1, 9.7.5.2.4	H8, H13, H14
(c)	4	9.7.6.2.3, 9.7.6.3.2	H7, H10
(d)	4	9.7.4.2.4	H3, H8, H10
(e)	7	9.7.3.2.1/5, 9.7.3.3.1	H8, H10, H11, H14
Question 34		**From Quanta to Quarks**	
(a) (i)	2	9.8.1.2.6	H2, H10
(a) (ii)	3	9.8.1.2.2	H1, H10
(b) (i)	2	9.8.3.2.2	H1, H6, H10
(b) (ii)	3	9.8.3.3.2	H7, H10
(c)	4	9.8.3.2.6	H1, H7, H10
(d)	4	9.8.3.3.1	H10

Question	Marks	Content	Syllabus outcomes
(e)	7	9.8.3.2.1/7/8, 9.8.4.2.5	H1, H9, H10
Question 35		**The Age of Silicon**	
(a) (i)	2	9.9.2.2.1	H3, H7
(a) (ii)	3	9.9.1.3.2	H3
(b) (i)	2	9.9.6.2.3/7/9	H13
(b) (ii)	3	9.9.6.2.2/6/8, 9.9.6.3.1/2	H7
(c)	4	9.9.7.2.1/2, 9.9.7.3.1	H3
(d)	4	9.9.4.2.1/2, 9.9.4.3.1	H7
(e)	7	9.9.2.5/6, 9.9.2.3.3, 9.9.3.2.5/6, 9.9.3.3.1/2, 9.9.5.2.1/2, 9.9.6.2.5	H9, H3