Exam Choice

2008 Physics Trial HSC examination. Marking Guidelines and model Answers.

Section I A Multiple Choice

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	D	C	D	D	B	A	D	C	D	D	C	A	C	A

Part B

16

Marking Criteria	Marks
Appropriate technology identified and sound explanation provided	2
An appropriate technology identified	1

e.g. Photogates were used to measure the time taken for a projectile to fall as these are much more accurate than hand-held stopwatches.

17 a.

Marking Criteria	Marks
Full and correct explanation linking movement of object with force needed and therefore work done	2
Movement of object referred to OR force causing motion identified	1

To increase an object's gravitational potential energy, a force must act on the object to move it against the gravitational field it is within. A force moved through a distance equates to work done, therefore work has been done in increasing an object's E_P.

17 b.

Marking Criteria	Marks
Correct method used to calculate correct answer	2
An incorrect (GPE=mgh) method used OR error made in correct calculation	1

Work done = change in E_P:

$$\Delta E_P = E_{P \text{ at 300km}} - E_{P \text{ at surface}}$$

$$= -G\frac{m_{earth}m_{object}}{r_{\text{at 300km}}} - -G\frac{m_{earth}m_{object}}{r_{\text{at surface}}}$$

$$= -Gm_{earth}m_{object}\left(\frac{1}{r_{\text{at 300km}}} - \frac{1}{r_{\text{at surface}}}\right)$$

$$= -6.67\times10^{-11}\times6.0\times10^{24}\times5.0\times10^{2}\left(\frac{1}{6670\times10^{3}} - \frac{1}{6370\times10^{3}}\right)$$

$$= 1.4\times10^{9}\text{ J}$$

(Note: 1.5 x 10^9J is answer by simply doing GPE=mgh)

17 c.

Marking Criteria	Marks
Correct reasons given, i.e. satellite must have orbital velocity requiring more work to be done	2
A reason identified – e.g. satellite is in motion	1

When a satellite is launched, work is done to increase its gravitational potential energy AND its speed so that at its allotted altitude, it has sufficient speed to continue to orbit the Earth. Thus much more work is done than simply lifting it straight up.

18 a.

Marking Criteria	Marks
Correct data substituted into correct equation to arrive at correct answer	2
Correct data identified OR appropriate equation attempted with error(s)	1

$u_y = ?$ $\quad v_y^2 = u_y^2 + 2a_y\Delta y$

$a_y = -9.8\text{ m s}^{-2}$ $\quad 0 = u_y^2 - 2\times9.8\times50$

$v_y = 0$ (at max. height) $\quad u_y^2 = 980$

$\Delta y = 50.0\text{ m}$ $\quad u_y = 31.3\text{ m s}^{-1}$

18 b.

Marking Criteria	Marks
Correct values substituted correctly into appropriate equation	2
Correct values selected with errors in subsequent working	1

$u_y = 31.3 \text{ m s}^{-1}$ (or answer to Q18a)

$a_y = -9.8 \text{ m s}^{-2}$

$\Delta y = 0$ (over horizontal ground)

$$Use: \ \Delta y = u_y t + \frac{1}{2} a_y t^2$$

$$0 = 31.3t + \frac{1}{2} \times -9.8 \times t^2$$

$$4.9t = 31.3$$

$$t = 6.4s$$

18 c.

Marking Criteria	Marks
Full explanation is provided	2
Incomplete or partial explanation provided	1

The projectile's initial horizontal speed is first calculated. This remains constant throughout the motion of the projectile, so it is multiplied by the time of the flight. Distance = speed X time. This gives the range.

19

Marking Criteria	Marks
A thorough response inclusive of all aspects of the RoS, with a well-described/illustrated example given	4
Response inclusive of most aspects of the RoS, an example provided and referred to	3
Some extra points of information provided relevant to the RoS	2
A basic response with extra information is given	1

As the speed of light is always measured as being the same, two observers in different inertial frames of reference may observe the same events differently. For example: a train is moving at a constant speed past a platform at a relativistic speed. It is struck by lightning at the front and the back, observed to occur simultaneously by a person on the platform exactly half-way along the train. An observer sitting in the train, half-way along, will observe the front lightning striking the train before the back lightning. Each of the observations are valid as both are made in inertial frames of reference.

20 a.

Marking Criteria	Marks
Full description with appropriate observations relating to the motor effect given	3
Description of investigation OR observation provided	2
Basic outline or identification of an aspect of investigation provided	1

e.g. Place a straight wire between the poles of a strong horseshoe magnet. Connect the wire directly to a power pack DC outlet and momentarily turn the power pack on. The wire is seen to move. Using the right-hand palm rule to ensure the force on the wire is upwards results in the wire jumping up when the power is switched on. This is due to the motor effect.

20 b.

Marking Criteria	Marks
Correct definition provided	1

The motor effect is the production of a force on a current-carrying conductor when placed within a magnetic field.

21

Marking Criteria	Marks
Motion of magnet is linked to *changing flux* in order to produce an EMF	2
Only *changing* flux is identified	1

The movement of the magnet causes the strength of the magnetic field to vary → causing a change in magnetic flux (or cutting of field lines) which in turn produces on EMF which causes a current to flow.

22

Marking Criteria	Marks
One correct advantage and one correct disadvantage clearly provided	2
Only one advantage or disadvantage provided	1

DC generators can be made to produce a relatively smooth voltage output, suitable for use in battery charging and electronic applications, but AC generators require rectifying circuits to do this. AC generators can have their output voltage changed relatively easily by transformers for transmission over long distances.

23

Marking Criteria	Marks
Thorough discussion displaying evidence of deep and broad understanding of the issue – at least three individual points raised	**4-5**
Some discussion provided of some relevance – at least 2 individual points raised	**2-3**
At least one relevant point identified	**1**

Our society relies on electricity to be provided to consumers at a standard, safe voltage. Transformers are necessary to step-up the voltage at the source (power station) for efficient transmission to cities for distribution to the end users. The safe distribution again requires transformers to step-down the voltage. The large power stations can be sited near reserves of coal or hydro-electric dams which are often hundreds of kilometres from the cities.
Appliances within homes often need only small voltages (battery chargers, computers, phones) which rely on small transformers to decrease the supply voltage. Other appliances operate on higher voltages (cathode ray tube TVs, fluorescent lights) so small step-up transformers are required.

24

Marking Criteria	Marks
Thorough explanation including eddy current description and comparison of eddy current sizes	**3**
Some description of the existence of eddy currents in iron core	**2**
Basic identification of cause of heat provided	**1**

The changing magnetic field causes changing magnetic flux through the iron core. This in turn produces eddy currents which flow within the iron core in a plane perpendicular to the magnetic field lines. The laminated core has layers of insulation preventing large eddy currents forming. The smaller eddy currents cannot produce as much heat in the core. Less heat means less energy loss.

25 a.

Marking Criteria	Marks
Complete working using appropriate units arriving at correct answer	**3**
Partial or incomplete attempt at applying the appropriate equation	**2**
A qualitative identification of the change, i.e. year becomes longer	**1**

$$\frac{r_1^3}{T_1^2} = \frac{r_2^3}{T_2^2}$$

e.g. $T_2^2 = \dfrac{r_2^3 T_1^2}{r_1^3}$ (use of earth years and r_1=1 for time and distance units)

$$= \frac{(2r_1)^3 T_1^2}{r_1^3}$$

$$= 8 \times 1$$

$$T_2 = \sqrt{8}$$

$$= 2.82 \text{ old earth years}$$

25 b.

Marking Criteria	Marks
Identification of *one reason for* the change	**1**

e.g. Gravity is weaker further from the Sun causing a decrease in the orbital speed of the Earth.

26

Marking Criteria	Marks
All steps of required calculations performed with correct substitutions throughout	**3**
Equating of the two forces evident and some subsequent selection of appropriate equations for both forces	**2**
Equating of the two forces evident	**1**

$$F_B = F_C$$

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$

$$= \frac{9.1 \times 10^{-31} \times 6.0 \times 10^{6}}{1.6 \times 10^{-19} \times 4.0 \times 10^{-4}}$$

$$= 8.5 \times 10^{-2} \text{ m}$$

27a.

Marking Criteria	Marks
Full outline of problem with classical model	**2**
Problem with black body radiation identified	**1**

Classical physics, using a wave model for the radiation of energy, predicted that as the temperature of the body increased, a temperature would be reached when radiation in the UV wavelengths would have infinite energy/intensity – i.e. the "UV catastrophe". This violates the Law of Conservation of Energy, and was not what was observed.

27b.

Marking Criteria	Marks
Planck's hypothesis described fully in relation to black body radiation	**2**
Planck's hypothesis identified	**1**

Planck hypothesised that the radiation emitted by black bodies was not of a continuous wave nature, but was quantised – i.e. occurred as discrete packets of energy. This model fitted mathematically with observations made.

28a.

Marking Criteria	Marks
Correct substitution into correct equation *with two significant figures.*	**2**
Correct substitution into correct equation *without two sig figs* OR correct number of sig figs but error made in calculation	**1**

$$E_K = \frac{1}{2}mv^2$$
$$= \frac{1}{2} \times 9.1 \times 10^{-31} \times \left(3.7 \times 10^{7}\right)^2$$
$$= 6.2 \times 10^{-16}\,\text{J}$$

28 b.

Marking Criteria	Marks
Correct answer given *with correct units (Hz)*	**3**
Correct answer *without unit or with incorrect unit* OR error made in calculation but correct unit given	**2**
Appropriate selection of equation with subsequent error(s)	**1**

$$E = hf$$
$$f = \frac{E}{h}$$
$$= \frac{6.2 \times 10^{-16}\,(\text{or answer to pt (a)})}{6.626 \times 10^{-34}}$$
$$= 9.4 \times 10^{17}\,\text{Hz}$$

29

Marking Criteria	Marks
Thorough description of all relevant issues linked by logical thought/argument showing superior depth of knowledge, expressed clearly	**6**
Thorough description of relevant issues linked by logic, expressed well	**5**
Some description of most relevant issues	**3-4**
Identification of one or two relevant issues	**1-2**

Communication technology (radio) in the 1940s relied on thermionic devices – vacuum tubes. Throughout WWII, radio communication was vital for plane to plane, ground – plane and for troops in the field to communicate. Vacuum tubes are large, heavy, fragile and require relatively large amounts of power, making them unsuitable for portable radios and unreliable on planes due to the vibration and harsh conditions. Solid state devices – the transistor, could replace vacuum tubes and do the same job of amplification of signals. The earliest semiconductor material used was germanium as it could be obtained with the necessary purity. However, germanium's semiconductor properties break down as it gets hot. Silicon, a more abundant element but harder to purify was to replace germanium as it remains as a semiconductor when being used. In 1948, Bardeen, Brattain and Shockley developed/invented the first operating solid state transistor using a PNP configuration of semiconductors.

30

Marking Criteria	Marks
Thorough explanation linked by logical thought/argument showing superior depth of knowledge of the subject, expressed clearly Cooper pairs and lattice vibrations referred to.	**4**
An explanation provided showing sound knowledge of superconductivity	**3**
A number of factors linked showing some knowledge of the reasons for superconductivity	**2**
A relevant factor recognised	**1**

Type I superconductors, metals, have a lattice structure arrangement of their atoms. At normal temperatures, the lattice vibrations hinder the passage of electrons, causing resistance and loss of energy as heat. At a sufficiently cold temperature, the critical temperature, "X" on the graph, the lattice vibrations have decreased to such an extent that pairs of electrons, known as Cooper pairs, are able to move between the atoms of the lattice unimpeded. As the electrons can flow through the material in this way, the resistance decreases to zero for temperatures below "X".

Section 2 Options

31 – Geophysics

a. (i)

Marking Criteria	Marks
Correct identification of elasticity	**1**

a. **(ii)**

Marking Criteria	Marks
Correct description given	**2**
Partial or incomplete description or identification only of only one aspect	**1**

"Radiometric" applies to the method of dating rocks or measuring their age by studying the radioactivity levels remaining in the sample.

b.

Marking Criteria	Marks
All steps of calculation performed without error	**3**
Correct selection of equation with some correct substitution	**2**
One step of calculation performed correctly	**1**

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

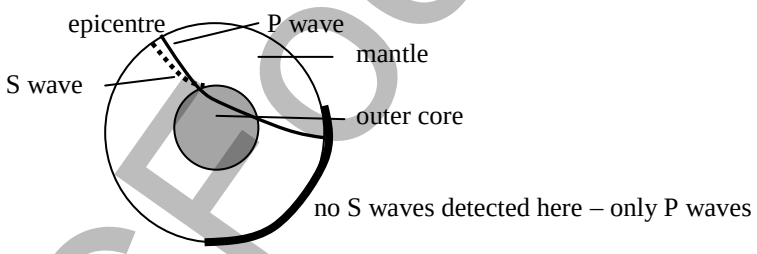
$$M = \frac{r^3 \times 4\pi^2}{GT^2}$$

$$= \frac{\left(2.5\times10^6\right)^3 \times 4\pi^2}{6.67\times10^{-11}\times\left(1.12\times10^4\right)^2}$$

$$= 7.37\times10^{22} \text{ kg}$$

c. (i)

Marking Criteria	Marks
Differences described clearly and well	**2**
Some difference identified	**1**



The liquid nature of the Earth's outer core prevents the propagation of S waves as they are shear waves, or transverse waves. S waves can only travel through solids. P waves are compression waves, or longitudinal waves. Such waves can travel through solid, liquid or gas.

c. (ii)

Marking Criteria	Marks
Thorough discussion of topic showing clear evidence of deep and broad understanding of the details, written in logical succinct style or point form	**5**
Good discussion of topic showing evidence of knowledge, linked in logical style or point form	**4**
A number of relevant points/facts raised and linked	**3**
One or two relevant facts identified	**1-2**

For details on the use of seismic methods used in oil and gas exploration, see, for example:

http://www.earthsci.unimelb.edu.au/ES304/MODULES/SEIS/NOTES/sintro.html
http://www.answers.com/topic/seismic-exploration-for-oil-and-gas?cat=technology
http://www.accessscience.com/abstract.aspx?id=612900&referURL=http%3a%2f%2fwww.accessscience.com%2fcontent.aspx%3fid%3d612900

d.

Marking Criteria	Marks
Current area of research described in depth with potential benefits to society well defined	**4**
Current area of research described adequately – some benefit(s) identified	**3**
Current area of research identified and some further information given	**2**
An area of research identified	**1**

[This question relates to PFA 5. As such, wide-ranging responses may be expected. A good response should show evidence of wide knowledge and reading in geophysics.]
Chosen topics could be: seismic research for oil and gas; remote sensing techniques for mineral exploration; remote sensing for climate/atmospheric measurements, etc.

e. (i)

Marking Criteria	Marks
Both types of variables correctly identified	2
One of the variables identified correctly	1

Independent variable: Latitude (or analogy thereof);
Dependent variable: Inclination of magnetic field

e. (ii)

Marking Criteria	Marks
Correct and appropriate identification made	1

e.g. altitude (or analogy thereof)

f.

Marking Criteria	Marks
Thorough description of the method given in a clear, logical style incorporating all relevant information	4
Description of method given either lacking clear logic or lacking some information	3
Outline of method given or partial description with error(s) or missing information	2
Identification of either sea floor spreading or magnetic polarity or magnetic anomaly profile showing further knowledge of topic.	1

e.g. A magnetic polarity time scale shows the time before present when Earth's magnetic field polarity was either as current polarity or reversed polarity. At mid-ocean ridges (e.g. running the full length of the mid-Atlantic), where the sea floor is spreading apart, Earth's current magnetic polarity is captured as remnant magnetism in the rocks forming either side of the mid-ocean ridges. This can be read with a magnetometer. The symmetrical pattern obtained either side of the ridge can be counted back to the present, and matched with the time scale. Using speed = distance/time, the speed (rate) at which sea floor spreading is occurring can be calculated.

32 Medical Physics

a. (i)

Marking Criteria	Marks
Identification of piezoelectric material	1

A piece of piezoelectric material that vibrates when an electrical pulse is applied.

a. (ii)

Marking Criteria	Marks
Description of material property given	2
Identification of property of material given	1

Acoustic impedance, a property of a material due to the speed of ultrasound through it and the material's density. Different materials have different acoustic impedances.

b. (i)

Marking Criteria	Marks
Correct substitution into correct equation	1

$Z = \rho v$
$= 952 \times 1.45 \times 10^3$
$= 1.38 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

b. (ii)

Marking Criteria	Marks
Correct substitution into correct equation with correct answer	2
Selection of appropriate equation	1

$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$
$$= \frac{[1.43 - 1.38]^2}{[1.43 + 1.38]^2}$$
$$= \frac{0.0025}{7.896}$$
$$= 3.166 \times 10^{-4}$$

c. (i)

Marking Criteria	Marks
Description of properties made thoroughly with clear comparisons	**3**
Some properties described; comparison attempted	**2**
A property identified	**1**

The desirable properties of radioisotopes are: short half-lives (so that the amount of radiation quickly decays after being injected into the body); and biological tagging (can be bound to another molecule which is taken up by specific organs). Unsuitable radioisotopes have long half-lives so that they continue to emit radiation long after the scan has been completed. Also, some radioisotopes are not capable of being bound to biologically active molecules so they do not accumulate in specific organs or may be expelled relatively quickly by the body.

c. (ii)

Marking Criteria	Marks
Thorough description of PET including why cancer cells can be resolved; logical and sequential with correct physics	**4-5**
Some points on the basis of PET given	**2-3**
Identification of a relevant fact to the operation of PET given	**1**

A source of positrons such as fluorine-18 in the form of 2-fluoro-2-deoxy-D-glucose (FDG) is injected into or inhaled by the patient. Such a radioisotope is produced in a cyclotron. It has a half-life of about 2 hours, so decays quickly after the scan is performed. When a positron collides with an electron, pair annihilation occurs and two gamma rays travelling in opposite directions with energies of 511 keV are detected in a gamma ray camera. The gamma ray camera feeds information into a computer which produces an image. Cancer cells or tumors usually have a higher water content than normal tissue. As water contains two hydrogen atoms per molecule, the gamma rays from tumors have a higher intensity so such areas are resolved on the scan.

d.

Marking Criteria	Marks
Current area of research described in depth with potential benefits to society well defined	**4**
Current area of research described adequately – some benefit(s) identified	**3**
Current area of research identified and some further information given	**2**
An area of research identified	**1**

[This question relates to PFA 5. As such, wide-ranging responses may be expected. A good response should show evidence of wide knowledge and reading in medical physics.]
e.g. Functional MRI – the imaging of the areas of the brain which blood flows to when different thought processes or stimuli or induced. This is possible due to the way in which advances in MRI have been made in recent years so that targeted areas of the organ (the brain) can be continuously scanned without harm to the patient. This may lead to information which increases our understanding of diseases like epilepsy, depression, memory loss, dementia etc. This knowledge may lead to better treatments or preventative medicines which increases patient's quality of life or prevents the disease from occurring.

e. (i)

Marking Criteria	Marks
Risks outlined well for both patient and operator	**2**
A risk identified	**1**

A bone scan is produced when a radioisotope (usually Technetium-99m) is injected into the patient. This is a gamma ray emitter. The patient will receive gamma ray radiation for a relatively short time, as Tc 99m has a half life of

e. (ii)

Marking Criteria	Marks
Appropriate response including benefit outweighing risk is provided	**1**

The medical benefits in being able to make an accurate diagnosis of the condition (e.g. cancer) outweighs the slight increased risk of contracting cancer from the radiation.

f. (i)

Marking Criteria	Marks
Complete explanation given	**2**
Description of diagram or partial explanation only	**1**

A very strong external magnetic field is applied causing the nuclei to have their spin align with it.

f. (ii)

Marking Criteria	Marks
Complete description given	**2**
Partial description only or identification of condition required for precession	**1**

Pulses of radio waves at a certain frequency are directed at these spinning nuclei which causes them to precess.

33 Astrophysics

a. (i)

Marking Criteria	Marks
Two distinct reasons outlined well	**2**
One reason outlined	**1**

Observatories in Earth orbit are above the atmosphere so that they are not affected by seeing (the blurring of images due to refraction effects) and are not subjected to the selective absorption of radiation by the atmosphere.

a. (ii)

Marking Criteria	Marks
One method identified	**1**

e.g. *One* of: adaptive optics; active optics or interferometry

b.

Marking Criteria	Marks
Parallax angle found correctly and subsequent distance calculation performed correctly	**3**
Angle given used incorrectly to find distance using correct equation correctly	**2**
Angle given used incorrectly and a further error made	**1**

The parallax angle to use is = ½ x 0.08" = 0.04".
Using d = 1/p'
= 1/0.04
= 25 p.c.

c. (i)

Marking Criteria	Marks
All types of spectra identified correctly	**3**
Three types of spectra correctly identified	**2**
One type of spectra attributed to source correctly in addition to emission nebula	**1**

Source	Type of spectra produced
Stars	absorption
Galaxies	continuous*
Emission nebula	emission
Quasars	emission

c. (ii)

Marking Criteria	Marks
Thorough account given with clear link between absorption and emission wavelengths	**4-5**
A response outlining process of absorption line production given	**3**
Some relevant information given identifying reason(s) for absorption	**1-2**

An absorption spectrum is produced when a background source of a continuous spectrum (such as the core of a star) passes through a heated gas containing molecules, ions and atoms. Electrons in the gas particles are able to absorb photons of set amounts of energy so they can jump up energy level(s), or orbitals. According to the relationship between the absorbed energy and frequency, E = hf, each set amount of energy absorbed has a certain frequency, f. When the excited electron "relaxes" and loses its absorbed energy, it falls back down to a lower energy level orbital and re-emits the photon with the original frequency of the absorbed light. The re-emission occurs in all directions so that to an observer, the overall effect is less intensity at that wavelength against the continuous background – an absorption spectrum. With emission spectra, the same frequencies for the same atoms/ions appear as bright lines as there is no continuous spectrum background source.

d.

Marking Criteria	Marks
Current area of research described in depth with potential benefits to society well defined	**4**
Current area of research described adequately – some benefit(s) identified	**3**
Current area of research identified and some further information given	**2**
An area of research identified	**1**

[This question relates to PFA 5. As such, wide-ranging responses may be expected. A good response should show evidence of wide knowledge and reading in astrophysics.]
e.g. In the field of deep space observation, the future Gaia observatory, the Hubble Space Telescope and other observatories in Earth orbit are making advances in observations of increasingly distant objects. The light originated from these objects only a few hundred million years after the Big Bang – the better the observation's resolution using interferometry etc, along with better sensitivity, the further back in time can the telescope "see". With such observations of the early universe, we may gain an increased understanding of how our universe formed.

e. (i)

Marking Criteria	Marks
Two risks clearly identified	**2**
One risk identified	**1**

e.g. 1. The risk of electric shock/electrocution from the high voltage source necessary to operate a discharge tube; 2. The risk of damage to the eyes by accidentally looking directly at the Sun through the spectroscope.

e. (ii)

Marking Criteria	Marks
Appropriate precaution described	**1**

e.g. Ensuring appropriate distance is kept between hands/body parts and the voltage source and wires when tube is operating

f.

Marking Criteria	Marks
Synthesis of elements well described and quote appropriately assessed	**4**
Synthesis of elements described	**3**
Several relevant pieces of information provided	**2**
One relevant aspect of element synthesis given	**1**

In the core of main sequence stars hydrogen nuclei are being fused into helium nuclei. The cores of red giant stars fuse heavier nuclei such as helium into carbon. More massive red giant stars are able to fuse and synthesise elements all the way to iron, as these processes are exothermic and sustain fusion in the star. Any nuclei heavier than iron forms in an endothermic process within the central core of a supernova explosion. The existence on Earth of these heavier elements is proof of the existence of stars which have ceased to exist. The left-over material has since re-formed into our solar system – and us.

34 From Quanta to Quarks

a. (i)

Marking Criteria	Marks
Correct identification of appropriate instrument	**1**

A spectroscope or spectral analyser

a. (ii)

Marking Criteria	Marks
Significance outlined clearly	**2**
Some link between Balmer series and Bohr model made	**1**

The Balmer series (the first hydrogen series observed) showed only discrete lines of emission at certain wavelengths – not a continuous spectrum. Bohr could account for this by allowing electrons to jump between set energy levels and emitting photons with frequencies proportional to the difference in the energies of the allowed levels.

b.

Marking Criteria	Marks
Wavelength calculated and its size recognised and related to our world	**3**
Wavelength calculated correctly	**2**
Wavelength stated as being too small to be noticed or identified but not calculated	**1**

$$\lambda = \frac{h}{mv}$$
$$= \frac{6.626\times10^{-34}}{57.0\times10^{-3}\times50.0}$$
$$= 2.32\times10^{-34}\,\text{m}$$

Such a wavelength is completely undetectable in our world – it is about a millionth millionth millionth millionth the diameter of a hydrogen atom.

c. (i)

Marking Criteria	Marks
Transmutation well described with at least one example shown by correct nuclear reaction	**3**
Transmutation described – lacking a nuclear reaction	**2**
Transmutation identified	**1**

Transmutation is the changing of a nucleus of one element into a nucleus of another element – i.e. the number of protons in the nucleus is changed, usually by alpha or beta decay or by fission into two smaller nuclei.

e.g. $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$ and $^{65}_{29}\text{Cu} \rightarrow {}^{65}_{30}\text{Zn} + {}^{0}_{-1}e$

(alpha decay and beta decay)

c. (ii)

Marking Criteria	Marks
Thorough description of mass defect with clear role in nucleus stability showing evidence of superior understanding of the topic	**5**
Mass defect identified and linked to nuclear stability	**3-4**
Identification of mass defect	**1-2**

The mass of a nucleus is less than the sum of the masses of the individual nucleons within the nucleus itself. The missing mass is known as mass defect. Using $E=mc^2$, the mass defect is equated to binding energy – the energy that is keeping the nucleus bound together to overcome the electrostatic repulsion between the protons in the nucleus. The strong nuclear force between nucleons only acts over very small distances found in a nucleus – this force must be overcome to split a nucleus or to remove nucleons. The greater the mass defect per nucleon in the nucleus, the more stable is the nucleus.

d.

Marking Criteria	Marks
Current area of research described in depth with potential benefits to our knowledge is well defined	**4**
Current area of research described adequately – some benefit(s) identified	**3**
Current area of research identified and some further information given	**2**
An area of research identified	**1**

[This question relates to PFA 5. As such, wide-ranging responses may be expected. A good response should show evidence of wide knowledge and reading in astrophysics.]
e.g. At CERN in Switzerland, the Large Hadron Collider will accelerate clumps of protons to speeds very close to c and smash them into each other. Such energetic collisions are required in order to break the protons into their constituent particles. One of these as yet undetected particles is the Higg's boson – the particle thought to be responsible for mass in all matter. The LHC has cost about AUS $6 billion – a huge investment of funds by most European and other Western nations. The results of the experiments, due to begin in July 2008, may assist scientists in their quest for a better understanding of what makes up matter and what the universe may have been like in the earliest few seconds after the Big Bang. (see, for example, *Cosmos*, April-May 2008)

e. (i)

Marking Criteria	Marks
Two appropriate precautions outlined clearly	**2**
One appropriate precaution outlined	**1**

e.g. 1. Always keep sources not being used wrapped inside lead casing; 2. Stand back from sources to reduce exposure to radiation – never place in a pocket!

e. (ii)

Marking Criteria	Marks
Identification correctly made	**1**

Smoke detectors use a source of alpha particles which only penetrate 6-7cm of air. Placed on the ceiling, no radiation is received by occupants in the room.

f.

Marking Criteria	Marks
Role of quark and leptons in the standard model is discussed thoroughly	**4**
Some knowledge of the standard model evident	**2-3**
A relevant point to the standard model is provided	**1**

In the standard model, quarks make up neutrons and protons, while leptons are fundamentals particles which include the electron. Quarks have charges of +2/3, -2/3, +1/3 and -1/3. Three quarks make up a proton or a neutron in combinations that result in the proton charge of +1 and the neutron charge of 0. There are other types of subatomic particles as well as quarks and leptons, but these two types together are responsible for the main forms of matter as we know it – protons, neutrons and electrons.

35 The Age of Silicon

a. (i)

Marking Criteria	Marks
One desirable property identified	**1**

e.g. optical density

a. (ii)

Marking Criteria	Marks
Role of silica outlined fully	**2**
role of silica identified	**1**

Optically pure silica allows the light (or infra-red light used in most fibre optic applications) to travel long distances through the fibre until requiring amplification. Its higher refractive index means total internal reflection keeps the light inside the fibre.

b.

Marking Criteria	Marks
Electronic circuits' advantages are discussed thoroughly showing clear evidence of deep understanding of the topic	**3**
Differences between the types of circuits are identified	**2**
Both types of circuits are identified	**1**

Electronic circuits can perform complex tasks. They contain diodes, transistors, integrated circuits and perhaps microprocessors to manipulate signals and perform mathematical tasks or to store data (memory) in digital form. Electric circuits have no semiconductors, and perform simple tasks such as light up brake lights using a switch, globe and wires (for example). These may be more robust, but are limited in their applications.

c.

Marking Criteria	Marks
Role explained clearly showing broad and deep understanding of the topic	**3**
Input transducer identified and role identified	**2**
Input transducer identified	**1**

CCDs – charge coupled devices contain many small individual solar cells that make up individual pixels. Light falling on the surface of the CCD when the shutter is opened is converted into electric charge held by the CCD and then transferred as digital information to the memory chip in the camera. This code can then be re-constituted into an image.

d. (i)

Marking Criteria	Marks
Appropriate explanation given showing evidence of clear understanding of the issue	**2**
A relevant reason identified	**1**

The increased density of transistors cannot continue as their extremely small size means that electrons can "tunnel" across the spaces separating conducting wires on the silicon chip. This leakage of current prevents the proper operation of the device and will prevent ever-increasing transistor densities.

d. (ii)

Marking Criteria	Marks
Outline of effect well defined	**2**
Statement of effect given	**1**

Computing power has approximately doubled every 18 months or so for the past few decades. This may begin to decline as computing power is related to the number of individual transistor connections on one chip. Unless alternative techniques such as quantum effects are employed, and the problem by-passed, computing power will plateau sometime in the next few decades.

e.

Marking Criteria	Marks
Current research identified and well described with potential benefits clearly given in a manner that shows wide knowledge of topic	**4-5**
Relevant research identified and benefits identified	**2-3**
Some relevant research identified	**1**

[This question relates to PFA 5. As such, wide-ranging responses may be expected. A good response should show evidence of wide knowledge and reading in astrophysics.]
e.g. Research into new ways of "etching in" transistors onto silicon chips or to entirely avoid the use of transistors by using quantum effects such as spin to hold data in binary code. The benefits of being able to hold more data in a smaller volume device needs to be emphasised

f. (i)

Marking Criteria	Marks
Correct expression given	**1**

C = (A and B)

f. (ii)

Marking Criteria	Marks
Precautions clearly described	**2**
A precaution identified	**1**

e.g. 1. Power supply of motherboard must be off when removing or inserting;
2. Handler should be earthed or connected to frame of computer to prevent electrostatic build-up and discharge between microprocessor and computer due to the very sensitive nature of circuitry on microprocessor.

g.

Marking Criteria	Marks
Clear assessment given showing evidence of wide knowledge of subject	**4**
Changes identified and described to a limited extent	**2-3**
A change identified	**1**

Solid state devices led to a rapid decrease in size, power consumption and heat production of computers. Solid state devices quickly became more complex leading to the rapid increase in computing power and memory capabilities. Computers soon became relatively portable devices and were far more reliable than previously, as thermionic devices were very prone to breaking down. Thus the changes were broad and far-reaching for the better, making the new solid state-based computers far better and more useful as well as more powerful within a few years of their invention.