Trial Higher School Certificate Examination 2001

Physics

Suggested Answers and Marking Schemes

by S Robinson, B Sc, Dip Ed, Cert Gifted Ed

Please Note: These are only suggested answers. In some cases, there are alternative, correct answers. Check with your teacher or tutor. We cannot cover every conceivable situation. However, we have tried to give an indication of the sort of approach that scores full marks in those questions where there is a lot of scope in the answers.

Section I, Part A

Each answer in Part A is worth **1 mark**.

1. (D). The two spheres have the same vertical acceleration (g) and so will hit the ground at the same time. Since they have the same horizontal velocity for the same time, they will cover the same horizontal distance.

2. (D) Anything moving at constant speed in circular motion has a net force towards the centre of the circle.

3. (B) The constant thrust force will produce a constant acceleration in the direction that the rocket is pointing. The rocket, however, still has a constant velocity component in its original direction of travel. These two effects combine to give a parabolic path.

4. (D) Each would see the other's clock as running slower, and the other's ruler as being shorter.

5. (C) The two separate coils wound onto an iron core make a simple transformer. The multimeter can be used to measure the a.c. output voltage.

6. (A) the magnetic flux represents the number of magnetic field lines going through the area in question. In (B) and (D) no field lines go through the area. (A) has a bigger area and more field lines per unit area than (C).

7. (C) a commutator forms part of a d.c. motor or a d.c. generator.

8. (B) the laminations are insulated from each other, stopping energy-wasting induced eddy currents from flowing from one lamination to the next.

9. (D)

10. (D) The formula linking E, V and d is E=V/d. Plotting E against d will produce the final graph.

11. (A) de Broglie proposed that moving particles also have an associated wave nature, and used this idea to try to explain stable orbitals in atoms

12. (D) the electroscope did not discharge because the frequency of light used was below the freshold frequency. A higher frequency is needed.

13. (A)

14. (A)

15. (C) The independent variable is the one directly altered by the experimenter (net force here), the dependent variable is the one that alters in response to [depends on] changes in the independent variable (acceleration), and a controlled variable is one that is held constant (mass).

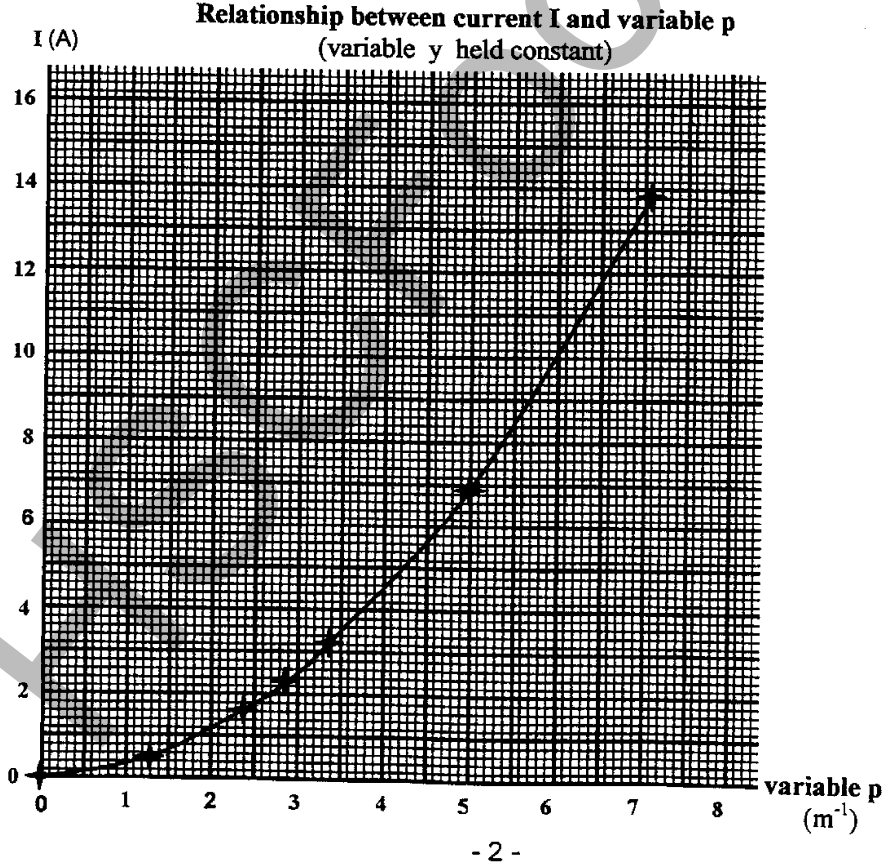
Section I, Part B

Question 16

(a) *So that any variation in I is known to be caused by variable "p" alone, allowing a relationship between "p" and I to be established.* **1 mark**

("p" and "q" are the only two variables affecting I - see question)

(b)



4 marks for an appropriate graph, correctly plotted and neatly drawn, with appropriate scales and labels, and with independent and dependent variables on the horizontal and vertical axes respectively.
* 3 marks for basically correct graph with one minor error, or for a graph with no technical errors, but roughly drawn
*0, 1 or 2 marks for a graph with more than one error, perhaps roughly drawn.

Question 16 answers, continued

(c) *The graph appears parabolic in shape.* **1 mark**

(d) *The curve may be a shape looking somewhat similar to a parabola, but not truly parabolic.* **1 mark**

(d) *To test if* I *is proportional to* p^2*, they should draw a graph plotting* I *against* p^2
1 mark *(or* $\sqrt{I}$ *against* p*). This graph will be a straight line through the origin*
1 mark *if* I *is proportional to* p^2*.*

Question 17

On earth	*On moon*
$F = mg$	$F = mg$
$686 = m \times 9.8$	$112 = 70g$
$m = 70kg$	$g = 1.6\ ms^{-2}$

therefore the acceleration due to gravity on the moon is $1.6\ ms^{-2}$ *downwards.*

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

Question 18

(a) *Looking at the vertical component of motion, and taking up as positive,*

$u_y = U \sin 65^\circ = ?$
$\Delta y = -260\ m$
$a_y = -9.8\ ms^{-2}$
$t = 12\ s$

$$\Delta y = u_y + \tfrac{1}{2} a_y t^2$$
$$-260 = U \sin 65^\circ \times 12 + \tfrac{1}{2}(-9.8) \times 12^2$$
$$-260 = 10.876U - 705.6$$
$$U = 40.97 ms^{-1}$$

therefore <u>*speed of rocket when it ran out of fuel = 41* ms^{-1}</u>

(Note that data are only given to 2 significant figures, so your answer should be also)

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(b) *Looking at the horizontal motion,*

$u_x = U \cos 65^\circ = 40.97 \cos 65^\circ = 17.32\ ms^{-1}$
$t = 12\ s$
$\Delta x = ?$

$$\Delta x = u_x t$$
$$= 17.32 \times 12$$
$$= 208\ m$$

but the distance required includes the extra 52 m while firing,

therefore <u>$X = 260\ m$</u>

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

Question 18 answers, continued

(c) *The equations used in part (b) are equations of uniformly accelerated motion. As you go higher above the earth's surface, the acceleration due to gravity decreases, so the acceleration of the rocket in "free fall" would not be uniform. It would therefore be wrong to use these equations.* **1 mark**

(d) *The earth is rotating from west to east at a high speed. This means that at launch a rocket going "vertically" up already has this horizontal component of velocity towards the east, so less fuel is needed to reach the necessary horizontal speed to attain a stable circular orbit.* **1 mark**

Question 19

(a)

r = ?
T = 27.3 days = 27.3 x 24 x 60 x 60 s = 2 358 720 s
M_E = 6.0×10^{24} kg (from data sheet)
G = 6.67×10^{-11} N m^2 kg^{-2}

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

$$\frac{(r)^3}{2358720^2} = \frac{6.67\times10^{-11}\times6.0\times10^{24}}{4\pi^2}$$

$$r = 3.835\times10^8\ m$$

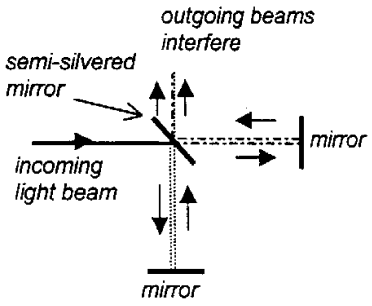
Therefore radius of orbit = 3.8×10^8 m

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(b) *The value given for the mass of the earth (6.0×10^{24} kg) is only to two significant figures, so the answer would be no more accurate than two significant figures.* **1 mark** **OR** *The value of T (the period = 27.3 days) is not exact (3 significant figures). When squared, this produces a larger error.* **1 mark** OR a combination of both of these.

Question 20

(a) *The Michelson-Morley experiment split a beam of light into two beams at right angles sending each out to a mirror and back, then recombining them to create interference. By rotating the whole apparatus, at some stage due to the earth's motion one beam should be going "up aether and back", while the other would go "across and back". The up and back beam should have a longer travel time than the other. Rotating the equipment a further 90° should change the interference, by an amount well within the sensitivity of the interferometer*



Note how the diagram could have replaced a lot of the description above. **Use diagrams where helpful!**

2 marks for a clear explanation of the experiment including the idea of interfering light beams and paths across and with the earth's direction of travel. Note that an explanation is often aided by a diagram
* 1 mark for a disorganised explanation that includes these two concepts, or for an explanation that omits one

Question 20 answers, continued

(b) *The null result (within experimental error) of the experiment is important because it was experimental evidence that suggested that the velocity of light is independent of the velocity of the observer. This was one of the fundamental assumptions of Einstein's Special Theory of Relativity. Although Einstein based his theory on what he regarded as logical necessity, the Michelson-Morley result probably produced more rapid acceptance of Einstein's Theory with its conclusions that seemed to defy "common sense".*

2 marks for a clearly expressed answer that describes the result in some way and evaluates its importance. Note that evaluate means that you have to gather evidence then come to a conclusion.
* 1 mark for a disorganised answer that tries to describe and evaluate, or for an answer that describes but does not come to a conclusion.

Question 21

As a charged particle moving towards the earth enters the earth's magnetic field, it experiences a force at right angles to its direction of travel (hand rule), which deflects it into a circular or spiral path, trapping it in the Van Allen belt

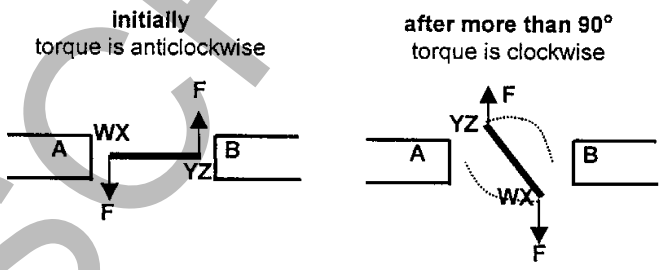
2 marks for a clearly expressed answer involving the earth's magnetic field producing a force that gives circular (or spiral) motion.
* 1 mark for a disorganised answer involving these ideas, or for where one of these two points is missing.

Question 22

(a) *A is a magnetic north pole* (use hand rule) **1 mark**

(b) *The force on side WX is down the page. Once the coil has rotated more than quarter of a turn from the position drawn, this downwards force produces a torque on the coil in a clockwise direction. The upwards force on YZ similarly produces a clockwise torque after quarter of a turn. These clockwise torques will slow the (anticlockwise rotating) coil to a stop.*

2 marks for a clearly expressed answer involving the magnetic forces staying in the same direction, but the torque reversing in direction
* 1 mark for a disorganised answer, or one that is incomplete



Note how effective a diagram is compared to lots of words. Add relevant diagrams to your answers, and reduce the explanation!

(c) *When the coil rotates to the vertical position, the commutator reverses the current in the coil, so the force on WX is then up and on YZ down. The torque is then anticlockwise, so the coil keeps rotating anticlockwise. This reversal happens every time the coil passes through the vertical position to the magnetic field, so the torque is always in the same direction.*

2 marks for a clear explanation involving current reversal (possibly with diagram)
* 1 mark for a disorganised explanation of current reversal.

Question 22 answers, continued

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(d) $F = 6.0\ N$
$d = 2.0\ cm = 2 \times 10^{-2}\ m$

$$\tau = Fd$$
$$= 6 \times 2 \times 10^{-2}$$
$$= 0.12\ Nm$$

therefore torque on coil due to spring balance = 0.12 Nm clockwise

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(e) $\tau = 0.12\ Nm$
$n = 200$ turns
$B = ?$
$I = 2.0\ A$
$A = 4.0\ cm \times 4.0\ cm = 1.6 \times 10^{-3}\ m^2$
$\cos\theta = 1.0$

$$\tau = nBIA\cos\theta$$
$$0.12 = 200 \times B \times 2 \times 1.6 \times 10^{-3}$$
$$B = 0.1875\ T$$

therefore magnetic field strength = 0.19 T

Question 23

There is many possible answers to this question. One would be:-

4 marks for a clearly expressed and organised assessment involving evidence from examples (a couple of examples with lots of detail, or more examples), and a conclusion.
* 2 or 3 marks for the above but not well organised, or insufficient supporting evidence, or no conclusion
* 0 or 1 mark for some relevant facts

Faraday's discovery had many technological spin offs. These include
** Development of efficient electric generators, which allowed the large scale production and distribution of electrical energy (batteries were not capable of this). This permitted use of electrical energy for trains, trams, electric lighting, heating, stoves and eventually the huge number of electrical appliances that we use today.*
** Development of the transformer, which greatly improved the efficiency of electric distribution systems (the power grid) and allowed devices which required different p.d.s to obtain energy from the mains (e.g. most computer chips need 5V or 12V. Transformers allow them to obtain this from a 240V mains supply).*
From this it can be seen that Faraday's discovery of electromagnetic induction had a great effect on the development of technologies.

Note:-
1. the need for **evidence** from **examples** in "assess" questions.
2. that you must come to a **conclusion** in "assess" questions.
3. how use of point form, underlining etc. makes answers clearer. Use these where appropriate!
4. electromagnetic braking, induction motors and other induced current effects would be other examples
5. d.c. electric motors and other non-induction motors cannot be used as examples, as they work using the motor effect, not electromagnetic induction.

Question 24

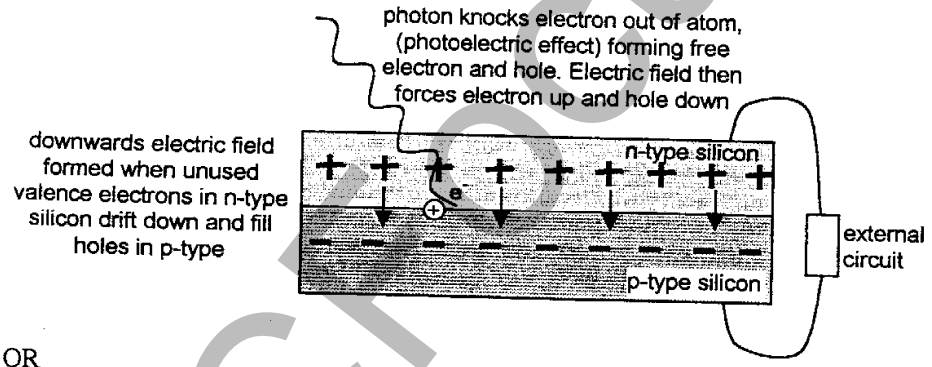
(a) *Most generators produce an emf by rotating a coil in a magnetic field, or rotating a magnetic field past a coil. In both cases alternating current is produced in the coil as the magnetic flux through the coil increases in one direction, then decays, then increases in the opposite direction, etc. To produce d.c., extra parts have to be added, increasing complexity and cost, so a.c. generators are simpler, cheaper and more reliable.* **1 mark**
(This answer is too long for 1 mark - a couple of these ideas would gain the mark)

(b) *For long distance transmission of electrical energy through power lines, losses are least when the current transmitted is as low as possible (since power loss = I^2R). To transfer significant amounts of power with low current, the voltage must be as high as possible. But high voltages are dangerous. Transformers allow the voltage to be stepped up for power transmission, then reduced back to safer levels for use in the home and industry. Transformers operate on a.c. and not d.c., so a.c. is better for electrical power distribution. It is very much more difficult to change voltages up and down with d.c.*

2 marks for a clear, organised answer including energy losses minimised at high voltages so transformers needed so a.c. needed
* 1 mark for a disorganised answer with correct concepts, or some logical steps missing

Question 25

(a)



OR

A solar cell has a layer of n-type silicon overlaying a layer of p-type silicon. Some conduction electrons in the n-type material will be attracted to the positive holes in the p-type, setting up an electric field over the junction. Now, if a photon of light of suitable energy strikes an atom in the junction region, it might knock an electron from the atom by the photoelectric effect. This produces an extra free electron and a positive hole. The electric field will sweep the electron to the n-type side, and the hole to the p-type side. The only way they can recombine (because of the electric field across the junction) is for the electron to go through an external circuit around to p-type side, i.e. the cell has generated an external electric current.

3 marks for a clear explanation of a solar cell, how the photoelectric effect produces free electrons and holes, and how the field across the p-n junction separates these
* 2 marks for a disorganised explanation involving these ideas, or for most of these ideas
* 0 or 1 mark for some relevant facts

Note how much clearer the diagram is than lots of text. Use diagrams in answers!

Question 25 answers, continued

(b)

$\lambda = 5.0 \times 10^{-7}\ m$
$c = 3.0 \times 10^{8}\ ms^{-1}$
$f = ?$

1 mark for correct approach and numerically correct answer

$$c = f\lambda$$
$$3.0\times10^{8} = f \times 5.0\times10^{-7}$$
$$f = 6.0\times10^{14}\ Hz$$

therefore frequency of photon = 6.0 x 10 ^{14} Hz

Question 26

(a) *To produce p-type silicon, a small amount of an atom with valence 3 (usually boron or gallium) is added as an impurity to pure silicon. When the mix crystallises, "holes" are formed where a silicon electron has nothing to bond to when next to a valence 3 atom.*

2 marks for clear description including the valence 3 impurity and the formation of a hole at an unused bonding site
* 1 mark for a disorganised or incomplete description

(b) *Holes can move under the influence of an electric field by accepting an electron from a neighbouring atom, moving the hole over one space. Each electron that falls into a hole moves only one atom from negative towards positive, but the hole moves in a series of steps from positive towards negative. Thus a hole behaves like a positive charge moving through the material.*

2 marks for a clear description involving an electron falling into a hole, moving the hole, and that holes keep moving, electrons only move one step
* 1 mark for a disorganised or incomplete description

Question 27

(a) There are many possible answers to this question, depending on the method that you used in this investigation. Make sure that you give a clear description of your method so that it is clear how you did the experiment. List the equipment used, how it was connected up and how you controlled variables. Indicate the sorts of results that you found, and any major sources of uncertainty. Don't forget to use diagrams, point form etc. where appropriate

5 marks for a well organised and expressed answer that involves the equipment used and how it was set up (diagram excellent), how variables were controlled, the sorts of results obtained, a conclusion and an indication of major sources of uncertainty
* 3 or 4 marks for most of the above
* 1 or 2 marks for a few relevant facts with little or no organisation

(b) Evaluation questions require you to look at points **for** and **against**, each with **evidence** (usually in the form of examples), then come to a **conclusion**.

Some possible applications of superconductors might include very powerful electromagnets in research applications and medical scanners, computers, generators, motors, and the power grid.
In all of these, superconductors would greatly reduce energy losses from heating, and so reduce costs from heat losses [point in favour], *but at present all superconductors require very expensive cooling to low temperatures* [point against]. (continued:)

Where size is not a problem so thick copper wires can be used, (e.g. most motors and generators), or where the conductors are very spread out and so difficult to cool (e.g. the power grid) at present it is generally cheaper to accept the heating losses than use superconductors. [examples against]
In compact specialist applications (e.g. supercomputers), especially where extremely strong magnetic fields are required (e.g. particle accelerators and some medical scanners) the use of superconductors becomes economic, or perhaps the only way to achieve the performance required [examples for].
The use of present day superconductors is only justified in very specialised applications. This may change in the future if higher temperature superconductors are developed [conclusion].

5 marks for a clearly expressed and well structured answer that looks at points for and against, each with evidence, then comes to a clear conclusion based on that evidence.
* 3 or 4 marks for much of the above
* 0, 1 or 2 marks for some disorganised but relevant facts

Section II Options

28 Geophysics

(a) *a **free air correction** is needed to account for the fact that the earth's gravitational field weakens as you get higher. By Newton's Law of Universal Gravitation ($F = GmM/r^2$) and $F = mg$, then $g = GM/r^2$. At higher altitude, r is greater so "g" is less.*

*a **latitude correction** to account for the fact that the earth is not a true sphere, but an oblate spheroid. The equatorial diameter is greater than the polar diameter because the earth is spinning, so "r" decreases at higher latitudes, increasing "g" as shown above.*

4 marks for 3 correct reductions, each with a clear explanation of why it is necessary
* 3 marks for 3 correct reductions and 3 explanations, which while not wrong, are not clearly expressed
* a mark lost for each wrong explanation

*a **Bouguer correction** to take account of the density and distribution of the material surrounding the gravity meter and between it and the elevation datum. All this material has mass which affects the local gravitational field.* (Applying the Bouguer corrections in all but flat areas can be very difficult.)

(Other corrections, such as tidal corrections, could be correctly included, but the three above are specifically mentioned in the syllabus.)

(b) $T = 13673.4\ s$
$r = 12265km = 1.2265 \times 10^7\ m$

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

$$\frac{(1.2265\times10^7)^3}{(13673.4)^2} = \frac{6.67\times10^{-11}\times M}{4\pi^2}$$

$$M = 5.8410\times10^{24}\,kg$$

therefore <u>mass of earth = 5.8410 x 10^{24} kg</u>

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(c) (i) *There have been 4 periods of reversal in the last 3.3 million years.* (3.3 Ma is the approximate junction between the Gauss and Gilbert Epochs. There are 4 white bands (reversals) between the centre of the ridge and this point. **1 mark**

Question 28 answers, continued

(ii) *The middle of the longest reversal was about 1.4 million years ago.* (Allow between 1.2 and 1.6 Ma) **1 mark**

(c) (iii) *Looking at the Gilbert - Gauss boundary,*

distance = 150 km approx.

time = 3.3 Ma approx

$$Av.\ speed = \frac{distance}{time}$$

$$= \frac{150}{3.3}$$

$$= 45\ km/Ma$$

therefore average speed of seafloor spreading = 45 km / million years

= 45 mm/year

(Between 35 and 55 mm/year would gain the mark)

3 marks for a well set out correct answer with correct units, having used the Gilbert-Gauss boundary for distance and time
* 2 marks for a correct answer which uses a different point for distance and time, as this will have reduced accuracy OR correct distance and time, but minor arith. error or units error
* 0 or 1 mark for part solution

(d) *P waves from an earthquake are compression waves, and can travel through solids and liquids. S waves are transverse, and can travel through solids but not liquids.* **1 mark** *A substantial part of the earth opposite the earthquake's focus receives no S waves, no matter where the earthquake is, meaning that a substantial part of the interior of the earth must be liquid - the outer core* **1 mark**

(e) In an "evaluate" question you must look at **evidence for** and **against**, then come to a **conclusion.**

You are asked to look at four geophysical techniques. These could be four of

seismic
gravity
magnetic
palaeomagnetic
electrical
electromagnetic
radiometric
geothermal

For each one that you choose, you should briefly indicate what the technique is and how it works, what sort of information it gives and what its limitations are. Do not look at more than four - you could lose marks for that, and only waste time.

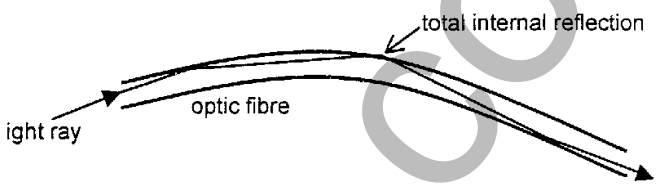
You should then come to a conclusion. A possible conclusion could be *"Each geophysical technique reveals some information about possible underground structures, but none gives a complete picture. By using several techniques together, a more detailed and reliable idea of the extent of a possible ore body can be produced before embarking on expensive drilling."*

12 or 11 marks for a clearly expressed and well structured answer that explains at four techniques, with detailed points for and against each, then comes to a clear conclusion based on that evidence.
* 10, 9, 8 or 7 marks for a less structured answer, but which has explanations of four techniques, with detailed points for and against each, OR a well structured answer with four techniques, but with only general statements about each, OR less structure and less detail
* 6, 5 or 4 marks for a less well structured answer with some vague general statements about four or fewer techniques
* 1, 2 or 3 marks for some disorganised but relevant facts

29 Medical Physics

(a) (i) *In a coherent bundle of optic fibres, each fibre is in exactly the same position in relation to the neighbouring fibres at each end of the bundle. In an incoherent bundle this is not so.* **1 mark** *A coherent bundle is used to transmit an image, focussed onto one end of the bundle, to the other end, where it can be viewed with an eyepiece or camera.* **1 mark** *An incoherent bundle is used to transmit light from a light source at the "outside" end of the endoscope to the "inside" end, to illuminate the organ being examined inside the patient's body.* **1 mark.**

(ii) *An endoscope can "see around corners" because of <u>total internal reflection</u> within each optic fibre.* **1 mark** *Because the fibre is very long and thin, a ray of light entering at one end will always meet the side of the fibre at greater than the critical angle, and so will reflect inside the fibre repeatedly until it emerges at the opposite end.* **1 mark**



(b) (i)

$Z_1 = 1.64 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

$Z_2 = 7.68 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

$\frac{I_r}{I_0} = ?$

$$\frac{I_r}{I_0} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

$$= \frac{[7.68\times10^6 - 1.64\times10^6]^2}{[7.68\times10^6 + 1.64\times10^6]^2}$$

$$= \frac{6.04^2}{9.32^2}$$

$$= 0.4120$$

therefore <u>percentage returned in echo = 41.2 %</u>

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(ii) $v = 1540 \text{ ms}^{-1}$

$Z = 1.64 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

$\rho = ?$

$$Z = \rho v$$

$$1.64\times10^6 = \rho \times 1540$$

$$\rho = 1064.9$$

therefore <u>density of muscle = 1060 kg m^{-3}</u>

2 marks for correct approach and right answer with units
* 1 mark for basically correct approach but wrong answer or no units

(c) (i) *Oxygen-15-water is a water molecule, H_2O, which has the oxygen-15 isotope as the oxygen atom.* **1 mark**

Question 29 answers (medical physics), continued

(ii) *Cancerous tumours are very fast growing,* **1 mark** *and so will take up large amounts of the carbon-11-methionine as the cells make new tissue, producing a high density PET image at that point.* **1 mark**

(iii) *All the isotopes used in PET scans have very short half-lives. Unless the PET scanner is very close to the cyclotron, the material containing the required isotope will have lost most of its activity by the time it is transported to the scanner.* **1 mark**

(d) In an "evaluate" question you must look at **evidence for** and **against**, then come to a **conclusion.**

You are asked to look at four imaging techniques. These could be four of

ultrasound
X rays
computed axial tomography
endoscopy
positron emission tomography
magnetic resonance imaging

For each one that you choose, you should briefly indicate what the technique is and how it works, what sort of information it gives and what its limitations are in terms of what it can sense, risks to the patient and cost. Do not look at more than four - you could lose marks for that, and only waste time.

You should then come to a conclusion. A possible conclusion could be *"Each imaging technique reveals some information about internal structures or processes but none gives a complete picture. Different ones are chosen by doctors to investigate different conditions, after weighing up the risk to the patient, the benefit of the information obtained and the cost of the procedure. There is no doubt, however, that these imaging techniques have greatly extended the ability of doctors to treat a wide range of medical problems successfully."*

12 or 11 marks for a clearly expressed and well structured answer that details four techniques, with clear points for and against each, then comes to a clear conclusion based on that evidence.
* 10, 9, 8 or 7 marks for a less structured answer, but which has four techniques, with detailed points for and against each, OR a well structured answer with four techniques, but with only general statements about each, OR less structure and less detail
* 6, 5 or 4 marks for a less well structured answer with some vague general statements about four or fewer techniques
* 1, 2 or 3 marks for some disorganised but relevant facts

30 Astrophysics

(a) (i) *While resolution is primarily determined by the diameter of the telescope mirror (or lens), turbulence in the earth's atmosphere* **1 mark** *finally provides a limit to resolution for ground based telescopes no matter how big the mirror*

(ii) *Mainly only visible, radio (and short wavelength infra-red at high altitude observatories) can be carried out from ground based observatories because other wavelengths are strongly absorbed by the atmosphere.* **1 mark**

Question 30 answers continue on next page

(iii) *In order to study the universe at other wavelengths, rockets and satellites (for X rays and ultra-violet), and balloons, rockets and satellites (for gamma rays and infra red) are used to lift observing instruments above the radiation-absorbing atmosphere.* **1 mark** (Satellites etc are also used for optical astronomy to remove problems caused by atmospheric turbulance.)

(b) (i) *Vega is brighter.* (It has a lower apparent magnitude)

(ii) *Vega*

$$M = m - 5\log\left(\frac{d}{10}\right)$$
$$= 0.03 - 5\log\left(\frac{7.7}{10}\right)$$
$$= 0.03 - (-0.57)$$
$$= 0.60$$

therefore absolute magnitude of Vega = 0.60

Achenar

$$M = m - 5\log\left(\frac{d}{10}\right)$$
$$= 0.46 - 5\log\left(\frac{21.2}{10}\right)$$
$$= -1.2$$

therefore absolute magnitude of Achenar = -1.2

3 marks for correct approach and right answer with units for both stars
* 2 mark for correct approach but wrong answer or no units for one star, and correct answer for the other, OR correct approach but the same minor error for both stars
* 1 mark for correct approach but two different minor errors, OR a correct approach but a major error for both stars

(iii) *Achenar is more luminous.* (It has the lower absolute magnitude) **1 mark**

(iv) *the brightness of a star (what we see from Earth) depends on how much luminous energy it produces (its luminosity) and how far away it is. Because of the inverse square law, increases in distance mean large decreases in brightness (Intensity $\propto 1/d^2$). So a luminous star at a great distance can appear less bright than a less luminous star that is closer*

2 marks for a clear explanation involving the meaning of luminosity and the reduction of brightness with increasing distance
* 0 or 1 mark for a partial explanation

(c) (i) *The light curve is from an eclipsing binary star system.* **1 mark**

(ii) *the dips in the curve occur when one star passes in front of the other, blocking its light.* **1 mark** *The deeper dip occurs when the less bright star passes in front of the brighter star.* **1 mark**

Question 30 answers continue on next page

Question 30 answers (astrophysics), continued

(d) In an "assess" question you must look at **evidence**, then come to a **conclusion.**

You are asked to look at four different types of evidence obtained from spectroscopy. These could be four of

classification
surface temperature
rotational velocity
translational velocity
density
chemical composition
resolution of spectroscopic binaries
spectroscopic parallax

For each one that you choose, you should briefly indicate what the type of evidence is, how it is obtained, why the information is useful and what its limitations are (if any). Do not look at more than four - you could lose marks for that, and only waste time.

You should then come to a conclusion. A possible conclusion could be *"Each spectroscopic technique gives us more important information about the universe, and so increases our understanding. There is no doubt that the various aspects of spectroscopy have been of huge importance in the progress of astronomy."*

12 or 11 marks for a clearly expressed and well structured answer that looks at four different types of evidence, with detailed discussion of each, then comes to a clear conclusion based on that evidence.
* 10, 9, 8 or 7 marks for a less structured answer, but which has four different types of evidence, with detailed discussion of each, OR a well structured answer with four types, but with only general statements about each, OR less structure and less detail
* 6, 5 or 4 marks for a less well structured answer with some vague general statements about four or fewer types
* 1, 2 or 3 marks for some disorganised but relevant facts

31 Quantum to Quarks

(a) (i) *Using de Broglie's idea of the wave nature of moving electrons, stable orbits are those in which an electron can form a standing wave around the nucleus* **1 mark**

(ii) $\lambda = 9.1 \times 10^{-10}\ m$
$m = 9.109 \times 10^{-31}\ kg$ *(data sheet)*
$h = 6.626 \times 10^{-34}\ Js$ *(data sheet)*

$$\lambda = \frac{h}{mv}$$

$$9.1\times10^{-10} = \frac{6.626\times10^{-34}}{9.109\times10^{-31}\times v}$$

$$v = 8.0\times10^{5}\ ms^{-1}$$

therefore speed of electron = 8.0 x 10^5 ms^{-1}

2 marks for correct method and correct answer with units
* 1 mark for correct method but minor mistake

(iii) *Because the spacing of atoms was about the same as the wavelength of a moving electron of suitable speed, they were able to produce interference patterns as electrons scattered off Nickel, thus confirming de Broglie's hypothesis that moving particles had an associated wave nature.* **1 mark**

Question 31 answers continue on next page

Question 31 answers (quantum to quarks), continued

(b) $\lambda = 4.862 \times 10^{-7}\ m$
$R_H = 1.097 \times 10^{7}\ m^{-1}$
$n_i = ?$
$n_f = 2$

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

$$\frac{1}{4.862\times10^{-7}} = 1.097\times10^{7}\left(\frac{1}{2^2} - \frac{1}{n_i^2}\right)$$

$$\left(\frac{1}{4} - \frac{1}{n_i^2}\right) = 0.18749$$

$$\frac{1}{n_i^2} = 0.25 - 0.18749$$

$$n_i^2 = 15.997$$

$$n_i = 4.00$$

therefore the electron dropped from the 4th energy level

3 marks for correct approach and right answer with units
* 2 mark for basically correct approach but wrong answer due to a minor error, or no units
* 1 mark for a correct approach, but a major error or two minor errors

(c) *The electrostatic force of repulsion is so much greater than the gravitational force of attraction between protons in the nucleus that there must be some other force of attraction holding them together - the strong nuclear force* **1 mark**

(d) (i) *The significance is that it is the basis of a chain reaction.* **1 mark** *Each neutron that is released can possibly be absorbed by other nuclei of* ^{235}U, *causing them to undergo fission, releasing more neutrons, and so on.* **1 mark**

(ii) *Mass of reactants* = 235.124 + 1.0087
= 236.1327 *u*

Mass of products = 147.961 + 84.938 + 3(1.0087)
= 235.9251 *u*

therefore mass loss = 236.1327 - 235.9251
= 0.2076 *u*

therefore energy released = 0.2076 x 931.5
= 193 MeV

3 marks for a well organised answer with the correct result and units.
* 2 marks a disorganised answer that produces the correct result and units, OR for an organised answer that is incorrect from a minor error.
* 0 or 1 mark for some relevant bits

(Note that you can correctly get the same answer by converting atomic mass units to kg,, using $E = mc^2$, then converting that answer in joule back to MeV)

Question 31 answers continue on next page

Question 31 answers (quantum to quarks), continued

(e) In an "evaluate" question you must look at **evidence for** and **against**, then come to a **conclusion.**

You are asked to look at four advances. These could be four of

Planck's idea of quantised energy
Bohr's model of the atom
de Broglie's matter waves
Chadwick's discovery of the neutron
Fermi's demonstration of nuclear fission
Pauli's prediction of the neutrino

and several others from the option

For each one that you choose, you should briefly indicate what the advance was, how it furthered understanding, and what further questions it raised (points against). Do not look at more than four - you could lose marks for that, and only waste time.

You should then come to a conclusion. A possible conclusion could be *"Each contribution furthered scientific thinking by explaining some previously troublesome point or points, but in every case gave rise to further questions. This is basically the way science advances, incrementally increasing scientific understanding of the world around us."*

12 or 11 marks for a clearly expressed and well structured answer that looks at four advances (with detailed points looking at what it was, how it furthered understanding and what further questions it raised), then comes to a clear conclusion based on that evidence.
* 10, 9, 8 or 7 marks for a less structured answer, but which has four advances, with detailed discussion of each, OR a well structured answer with four advances, but with only general statements about each, OR less structure and less detail
* 6, 5 or 4 marks for a less well structured answer with some vague general statements about four or fewer advances
* 1, 2 or 3 marks for some disorganised but relevant facts

32 Age of Silicon

(a) (i) *An input transducer is a device that converts some form of input from the environment (e.g. sound, temperature etc) into some electrical effect in part of the circuit (e.g. change in resistance, or a p.d.), where the amount of electrical effect is a function of the amount of input* **1 mark**

(ii) *A negative temperature coefficient thermistor is a transducer which converts a temperature input into a resistance, where the resistance decreases as the temperature increases* **1 mark**

(b) (i) *If the p.d. across the CD player is 4.5V, then the p.d. across the 12 ohm resistor must be 7.5V (12V - 4.5V).*

Question 32 answers continue on next page

Question 32 answers (age of silicon), continued

This means that the current through the 12 resistor $= V R$
$= 7.5\ 12$
$= 0.625A.$

This current splits and 0.170 A (170 mA) goes through the CD player,
so the current through R $= 0.625 - 0.170$
$= 0.455\ A$

Now, the p.d. across R is 4.5 V (in parallel with the CD player),

so, resistance of R $= V/I$
$= 4.5/0.455$
resistance of R $= 9.9$ *ohm*

3 marks for correct approach and right answer with units
* 2 mark for basically correct approach but wrong answer due to a minor error, or no units
* 1 mark for a correct approach, but a major error or two minor errors, or for an approach that is partly correct

(Note that other approaches are possible, giving the same answer)

(ii) When the CD player stops making sound and stops turning the disk, the current that it uses will drop (less energy needed). This means that less current will pass through the 12 ohm resistor. The p.d. across the 12 ohm resistor will therefore drop (since V = IR and I drops, R constant). *The p.d. across the CD player must rise above the desired 4.5 V.* **1 mark**

(iii) Potential dividers are not good "power supplies" when different currents are used, because the p.d. across each part of the potential divider will change if the current changes through anything connected across part of the potential divider. **1 mark** (Ideal power supplies give the same p.d. while supplying any value of current).

(c)

A	B	C	output
0	0	0	**0**
0	0	1	**1**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**1**
1	1	0	**1**
1	1	1	**1**

2 marks for all correct
1 mark subtracted for each error

(d) (i) *This is an inverting amplifier* **1 mark**

Question 32 answers continue on next page

Answers to Question 32 (d) (age of silicon), continued

(ii) *Amplitude of top trace = 1.0 cm*
therefore peak voltage of top trace = 0.5 V

Amplitude of bottom trace = 2.0 cm
therefore peak voltage of bottom trace = 20 V

Now,

$$gain = \frac{V_{out}}{V_{in}}$$
$$= \frac{20}{0.5}$$
$$= 40$$

therefore amplifier gain = 40 times

3 marks for a clear and well set out solution with a valid approach and correct answer.
* 2 marks for a valid approach but a minor error.
* 1 mark for an answer of 2 times or -2 times, but otherwise correct
* 0 or 1 mark for some relevant part of an answer

(Note that other approaches are correct. You could use peak to peak voltages of 1.0 V and 40 V for the two traces. Note also that you could correctly say the gain is - 40, since the amplifier is inverting.)

(e) In an "assess" question you must look at **evidence**, then come to a **conclusion.**

You are asked to look at four distinctly different semiconductor devices and their uses in technology. You could choose from:-

transducers
diodes
transistors
amplifiers
analog devices
digital devices
integrated circuits
light dependent resistors
thermistors
solar cells
light emitting diodes
logic gates

and others. Note that some of these categories overlap -you should chose four that do not.
For each one that you choose, you should briefly indicate what the semiconductor is, what it does and how it does it, and then how it is used in technology. Do not look at more than four - you could lose marks for that, and only waste time.

12 or 11 marks for a clearly expressed and well structured answer that looks at four different ways in which semiconductors are used, with detailed discussion of each device and its use, then comes to a clear conclusion based on that evidence.
* 10, 9, 8 or 7 marks for a less structured answer, but which has four different ways in which semiconductors are used, with detailed discussion of each, OR a well structured answer with four uses, but with only general statements about each, OR less structure and less detail
* 6, 5 or 4 marks for a less well structured answer with some vague general statements about four or fewer uses
* 1, 2 or 3 marks for some disorganised but relevant facts

You should then come to a conclusion. A possible conclusion could be something like *"From the evidence above it can be seen that the various uses of semiconductors have had a huge impact on the development of technology."*

HSC Trial Physics Examination Mapping Grid

For each item in the examination, the grid shows the marks allocated, the syllabus content and syllabus outcomes it relates to, and the bands on the performance scale it is targeting. The range of bands shown indicates the performance candidates may be able to demonstrate in their responses. That is, if an item is shown as targeting Bands 3 – 5, it indicates that candidates who demonstrate performance equivalent to the Band 3 descriptions should be able to score some marks on the item, while those who perform at Band 5 or above could reasonably be expected to gain high marks. In the case of one-mark items, candidates who demonstrate performance at or above the bands shown generally could be expected to answer the item correctly.

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
1	1	9.2.2	H6, H9	4 - 5
2	1	9.2.2	H6,H9	2 - 3
3	1	9.2.2	H6	4 - 5
4	1	9.2.3	H6	3 - 4
5	1	9.1.11.1, 9.1.11.2, 9.1.11.3, 9.3.4	H9, H11	3 - 4
6	1	9.3.2	H9,H14	3 - 4
7	1	9.3.3	H9	2 - 3
8	1	9.3.2, 9.3.4	H3, H4, H7, H9	3 - 4
9	1	9.3.1, 9.3.5	H3, H4, H7, H9	3 - 4
10	1	9.1.12.4, 9.1.13.1	H2, H13, H14	3 - 4
11	1	9.4.3	H8, H10	2 - 3
12	1	9.4.2	H2, H8, H10	3 - 4
13	1	9.4.4	H8	2 - 3
14	1	9.4.4	H9	4 - 5
15	1	9.1.11.2	H2	3 - 4
16(a)	1	9.1.11.2	H2, H11	4 - 5
16(b)	1	9.1.12.4, 9.1.14.1	H2, H12, H14	4 - 6
16(c)	5	9.1.12.4, 9.1.13.1,	H2, H12, H13	2 - 5
16(d)	2	9.1.13.1, 9.1.14.1	H13, H14	3 - 5
17	2	9.1.12.3, 9.1.12.4, 9.2.1	H6, H9, H12	3 - 4
18(a)	2	9.1.12.3, 9.1.12.4, 9.2.2	H6, H9, H12	3 - 4
18(b)	2	9.1.12.3, 9.1.12.4, 9.2.2	H6, H12	3 - 4
18(c)	1	9 1.14.1, 9.1.14.3, 9.2.1, 9.2.2	H14	4 - 6
18(d)	1	9.1.13.1, 9.2.2	H4, H13	3 - 4
19(a)	2	9.1.12.3, 9.1.12.4, 9.2.2	H9, H12	3 - 4
19(b)	1	9.1.12.4, 9.1.14.1, 9.2.2	H2, H12, H14	5 - 6
20(a)	2	9.1.13.1, 9.2.4	H6, H13	3 - 4
20(b)	2	9.1.14.1, 9.2.4	H1, H2, H4, H14	4 - 5
21	2	9.1.13.1, 9.2.2, 9.3.1	H9, H13	3 - 4
22(a)	1	9.3.1	H9	2 - 3
22(b)	2	9.1.13.1, 9.3.1	H9, H13	3 - 4
22(c)	2	9.1.13.1, 9.3.1	H9, H13	3 - 4
22(d)	2	9.1.12.3, 9.1.12.4, 9.3.1	H9, H12	3 - 4
22(e)	2	9.1.12.3, 9.1.12.4, 9.3.1	H9, H12	3 - 4
23	4	9.1.13.1, 9.1.14.1, 9.3.2	H3, H4, H13, H14	2 - 5
24(a)	1	9.1.13.1, 9.3.3	H9, H13	3 - 4
24(b)	2	9.1.13.1, 9.3.3	H9, H13	3 - 4
25(a)	3	9.1.13.1, 9.4.2	H7, H8, H13	3 - 5
25(b)	1	9.1.12.3, 9.1.12.4, 9.4.2	H8, H12	2 - 3
26(a)	2	9.1.13.1, 9.4.3	H10, H13	3 - 5
26(b)	2	9.1.13.1, 9.4.3	H10, H13	3 - 5
27(a)	5	9.1.11.2, 9.1.11.3, 9.1.12.4, 9.1.13.1, 9.1.14.1, 9.1.14.3, 9.4.4	H2, H11, H12, H13, H14	2 - 6
27(b)	5	9.1.13.1, 9.4.4	H3, H4, H13	2 - 6

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
Option 1: Geophysics				
28 (a)	4	9.5.2	H9, H13	2 - 4
28 (b)	2	9.1.12.4, 9.1.13.1, 9.5.2	H9	3 - 4
28 (c) (i)	1	9.1.12.3, 9.5.4	H9	3 - 4
28 (c) (ii)	1	9.1.12.3, 9.5.4	H9	3 - 4
28 (c) (iii)	3	9.1.12.4, 9.5.4	H9	3 - 5
28 (d)	2	9.1.13.1, 9.5.3	H1, H13	3 - 4
28 (e)	12	9.1.13.1, 9.1.14.1, 9.5.1, 9.5.2, 9.5.3, 9.5.4, 9.5.5	H1, H4, H9, H13, H14	2 - 6
Option 2: Medical Physics				
29 (a) (i)	3	9.1.13.1, 9.6.2	H8, H13	2 - 4
29 (a) (ii)	2	9.1.13.1, 9.6.2	H8, H13	3 - 4
29 (b) (i)	2	9.1.12.4, 9.1.13.1, 9.6.1	H8	3 - 4
29 (b) (ii)	2	9.1.12.4, 9.1.13.1, 9.6.1	H8	3 - 4
29 (c) (i)	1	9.1.13.1, 9.6.3	H10, H13	3 - 4
29 (c) (ii)	2	9.1.13.1, 9.6.3	H10, H13	3 - 5
29 (c) (iii)	1	9.1.13.1, 9.1.12.3, 9.6.3	H10, H13	2 - 4
29 (d)	12	9.1.13.1, 9.1.14.1, 9.6.1, 9.6.2, 9.6.3, 9.6.4	H1, H2, H8, H9, H10, H13, H14	2 - 6
Option 3: Astrophysics				
30 (a)	3	9.1.12.3, 9.1.13.1, 9.7.1	H8, H12, H13	3 - 4
30 (b) (i)	1	9.1.12.3, 9.7.4	H7	2 - 4
30 (b) (ii)	3	9.1.12.3, 9.1.12.4, 9.1.13.1, 9.7.4	H7	3 - 4
30 (b) (iii)	1	9.1.12.3, 9.7.4	H7	2 - 4
30 (b) (iv)	2	9.1.13.1, 9.7.4	H7, H13	3 - 5
30 (c) (i)	1	9.1.12.3, 9.7.5	H8	2 - 4
30 (c) (ii)	2	9.1.13.1, 9.7.5	H8, H13	3 - 4
30 (d)	12	9.1.13.1, 9.1.14.1, 9.7.3, 9.7.4, 9.7.5	H2, H7, H8, H9, H13, H14	2 - 6
Option 4: Quantum to Quarks				
31 (a) (i)	1	9.1.13.1, 9.8.2	H1, H8, H10	3 - 5
31 (a) (ii)	2	9.1.12.4, 9.1.13.1, 9.8.2	H8	3 - 4
31 (a) (iii)	1	9.1.13.1, 9.8.2	H2	3 - 4
31 (b)	3	9.1.12.4, 9.1.13.1, 9.8.1	H8	3 - 4
31 (c)	1	9.1.13.1, 9.8.4	H9	2 - 4
31 (d) (i)	2	9.1.13.1, 9.8.4	H10	2 - 4
31 (d) (ii)	3	9.1.12.3, 9.1.12.4, 9.1.13.1, 9.8.4	H7	3 - 4
31 (e)	12	9.1.13.1, 9.1.14.1, 9.8.1, 9.8.2, 9.8.3, 9.8.4, 9.8.5, 9.8.6	H1,H6, H7, H8, H9, H10, H13, H14	2 - 6
Option 5: Age of Silicon				
32 (a) (i)	1	9.9.3	H7	3 - 4
32 (a) (ii)	1	9.9.3	H7	3 - 4
32 (b) (i)	3	9.1.12.3, 9.1.12.4, 9.1.13.1, 9.9.2	H7	3 - 5
32 (b) (ii)	1	9.9.2	H7	3 - 4
32 (b) (iii)	1	9.1.13.1, 9.9.2	H7, H13	3 - 4
32 (c)	2	9.9.5	H7	3 - 4
32 (d) (i)	1	9.1.12.3, 9.9.6	H7	2 - 4
32 (d) (ii)	3	9.1.12.3, 9.1.12.4, 9.1.13.1, 9.9.6	H7	2 - 4
32 (e)	12	9.1.13.1, 9.1.14.1, 9.9.1, 9.9.2, 9.9.3, 9.9.4, 9.9.5, 9.9.6, 9.9.7	H3, H4, H7, H13, H14	2 - 6