2009 HSC Physics
Sample Answers

This document contains 'sample answers', or, in the case of some questions, 'answer may include'. These are developed by the examination committee for two purposes. The committee does this:

(a) as part of the development of the examination paper to ensure the questions will effectively assess students' knowledge and skills, and

(b) in order to provide some advice to the Supervisor of Marking about the nature and scope of the responses expected of students.

The 'sample answers' or similar advice, are not intended to be exemplary or even complete answers or responses. As they are part of the examination committee's 'working document', they may contain typographical errors, omissions, or only some of the possible correct answers.

Section I, Part B

Question 16 (a)

Answers could include:

$$\begin{aligned} \mathrm{w} &= \mathrm{mg} \\ &= 500 \times 9.8 \\ &= 4900 \text{ N} \end{aligned}$$

Question 16 (b)

Answers could include:

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

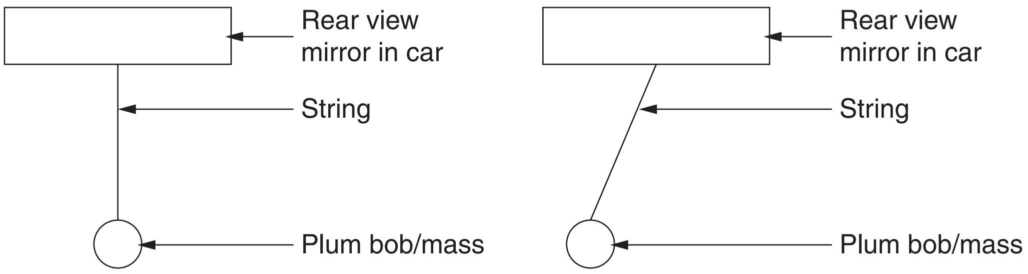
$$\therefore \mathrm{M} = \frac{4\pi^2 r^3}{\mathrm{GT}^2}$$

$$= \frac{4\pi^2 \times \left(50 \times 10^3\right)^3}{6.67 \times 10^{-11} \times \left(5.9 \times 10^4\right)^2}$$

$$= 2.13 \times 10^{16} \text{ kg}$$

Question 17 (a)

Answers could include:



Car is stationary or moving with constant velocity. This is an inertial frame of reference.

As car accelerates, plum bob and string appear to move backwards. This represents a non-inertial frame of reference.

Question 17 (b)

Answers could include:

The principle of relativity states that it is not possible to detect motion with uniform velocity while in one frame of reference without referring to another frame of reference. Thus, the principle only applies for non-accelerating steady motion, which occurs in an inertial frame of reference. Within an inertial frame of reference, experiments or observations cannot be performed which would indicate whether an object is stationary or moving with constant velocity. The speed of light, c, is constant in inertial frames of reference, which leads to time dilation, etc.

Question 18 (a)

Answers could include:

Traveller sees contracted distance

$$\ell_{\text{Traveller}} = \ell\sqrt{1-\frac{v^2}{c^2}}$$

$$= 1.70\times10^5\sqrt{1-\frac{0.999\ 99^2\ c^2}{c^2}}$$

$$= 1.70\times10^5\left(4.47212\times10^{-3}\right)$$

$$= 760\ \ell y$$

Question 18 (b)

Answers could include:

$$t_{\text{Traveller}} = \frac{\text{distance on traveller's clock}}{c}$$

$$= \frac{760\ \ell y}{c}$$

$$= 760\ y$$

Question 19 (a)

Answers could include:

Two equations are necessary.

$E = V/d$ and $F = qE$

These are combined to obtain

$$F = q\,V/d$$

$$F = 1.602 \times 10^{-19} \frac{100}{0.10}$$

$$= 1.6 \times 10^{-16} \text{ N}$$

Direction: Towards the 0V plate.

Question 19 (b)

Answers could include:

Will need to determine the value of the constant acceleration

$$F = ma$$

$$\therefore a = \frac{F}{m} = \frac{1.602 \times 10^{-16}}{9.109 \times 10^{-31}}$$

$$= 1.759 \times 10^{14} \text{ m s}^{-2}$$

Will need the perpendicular component of the velocity as the acceleration influences this component of the velocity only

$$v_h = 6.0 \times 10^6 \sin 60°$$

$$= 5.196 \times 10^6 \text{ m s}^{-1}$$

Determine time using

$$v = u + at$$

$$0 = 5.196 \times 10^6 - 1.759 \times 10^{14} t$$

$$t = \frac{5.196 \times 10^6}{1.759 \times 10^{14}}$$

$$= 2.9 \times 10^{-8} \text{ s}$$

$$= 2 \times 2.9 \times 10^{-8} \text{ s}$$

$$= 5.9 \times 10^{-8} \text{ s}$$

Question 20

Sample answer:

Appliance	*Energy Transformation/Transfer*	*Use*
Drill	Electrical to Mechanical (KE)	Industry/home Drives screws
Led Light	240 to 12V transfer Electrical to light	To illuminate objects (Industry or home)
Toaster	Electrical to heat	Cooking

Question 21 (a)

Sample answer:

Side X

Question 21 (b)

Sample answer:

$$\begin{aligned}\tau &= Fd \\ &= mgd \\ &= 40\times10^{-3}\times9.8\times30\times10^{-2} \\ &= 1.176\times10^{-1}\ \text{Nm}\end{aligned}$$

Answers could include:

0.1176 Nm

Question 21 (c)

Sample answer:

$F = BI\ell\sin\theta$

$BI\ell\sin\theta = mg\ d$ (or answer from B)

$$\begin{aligned}B &= \frac{1.176\times10^{-1}}{20\times20\times10^{-2}\times30\times10^{-2}} \\ &= 9.8\times10^{-2}\ \text{T}\end{aligned}$$

Answers could include:

B = 0.098 T

Question 22

Answers could include:

Transistors have replaced all thermionic devices which include anything with this valve style technology. In particular audio communication such as radios has been streamlined to tiny portable, go anywhere devices. Other devices such as mobile phone laptop computers and so on have been developed using transistors allow more mobile communication, which can be taken anywhere without the constraints of size and large energy supplies.

Question 23 (a)

Sample answer:

W_2 experiences a force toward W_1

Answers could include:

W_2 experiences a force to the left

Question 23 (b)

Sample answer:

$$F = \frac{k\ I_1\ I_2\ \ell}{d}$$

$$6.9 \times 10^{-4} = \frac{2 \times 10^{-7} \times I^2 \times 2.5}{5 \times 10^{-2}}$$

$$I = \sqrt{\frac{6.9 \times 10^{-4} \times 5 \times 10^{-2}}{2 \times 10^{-7} \times 2.5}}$$

$$I = 8.3\ \text{A}$$

Question 23 (c)

Answers could include:

W_2 experiences a force of attraction to W_1 as the wires carry currents in the same direction.

W2 also experiences a force of attraction toward W_3. However this force is smaller as the distance between W_2 and W_3 is larger than between W_1 and W_2. As $F = \frac{kI_1\ I_2\ \ell}{d}$, force must be smaller as *d* is larger. As a result the net force on W_2 is one of attraction toward W_1 but it is now reduced in magnitude due to the presence of W_3.

Question 24 (a)

Sample answer:

Band E

With a 0.25kg mass attached, Band E extends by a length of 0.30m while the others extend much less.

Question 24 (b)

Sample answer:

Band F

Answers could include:

Directly proportionally from 0 to 1.25kg

Question 25 (a)

Sample answer:

The charge is equal in magnitude and opposite in sign.

Question 25 (b)

Answers could include:

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

$$B = \frac{mv}{rq}$$

$$B = \frac{1.673 \times 10^{-27} \times 1.0 \times 10^{7}}{4.2 \times 1.602 \times 10^{-19}} = 2.486 \times 10^{-2}\ \text{T}$$

Question 26

Answers could include:

Energy losses essentially come about in transformers and cables. The efficiency of large transformers in step up and step down substations is quite high and may reach 99%, by including features such as laminated iron cores to reduce eddy currents but for medium and low voltages the efficiency is much less even when techniques such as the above are used. For cables its contrary, those carrying high current sustain more heating and therefore endure more energy loss. Power loss = I^2R. By carrying large voltages over long distances the energy loss is minimised. The limitation to this is safety and hence near large populations the electricity must be sent at low voltages sacrificing energy loss for safety. If a new technology such as superconductors was economically viable then these energy losses could be minimised.

It would allow current to be sent with little or no energy losses in the cables and therefore electricity could be sent over large distances at low voltages reducing the need for transformers. It could also be sent as a DC current which would further reduce the energy loss as the constant change in direction of the current.

Question 27 (a)

Sample answer:

$$v = f\lambda$$

$$f = \frac{c}{\lambda}$$

$$f = \frac{3 \times 10^8}{150 \times 10^{-9}} \text{ Hz}$$

$$f = 2 \times 10^{15} \text{ Hz}$$

Question 27 (b)

Answers could include:

No change.

Question 27 (c)

Answers could include:

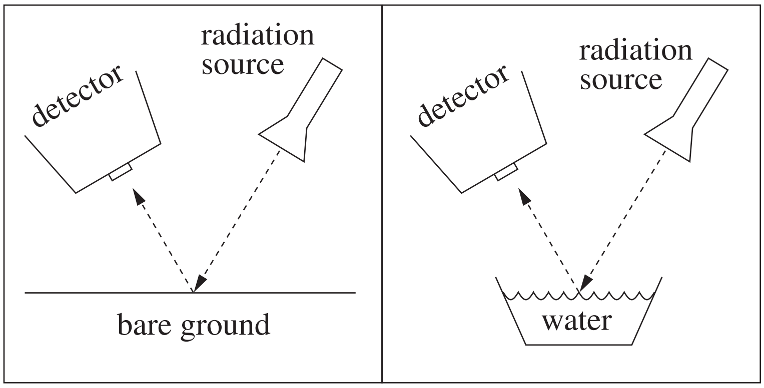
In the photoelectric effect light hits a material and electrons are released and are then able to produce a current. When light hits the *n*-type semiconductor photons hit electrons the light energy is transformed into energy for the electron. This energy frees the electrons by bridging the gap between the donor level and conduction band and also gives kinetic energy to the electrons, which produces a current in the solar cell.

When a junction is formed between the *n*-type and *p*-type semi conductor there is a potential difference set up between the n-type and p-type semiconductors at the junction. The electrons that move from *n*-type to *p*-type set up a positive potential in the *n*-type at the junction and a negative potential in the *p*-type. This potential can accelerate electrons across the field from the *p*- to *n*-type and prevents electrons from flowing from the *n*-type to *p*-type. This forces freed electrons from the *n*-type semiconductor to travel around the external circuit creating a current in the external circuit.

Section II

Question 28 (a) (i)

Answers could include:



Different intensities of radiation detected.

Question 28 (a) (ii)

Answers could include:

If the nature of the surface is such that more radiation is absorbed then less is reflected. The absorption depends on the texture, colour and the material of the surface. The molecular structure and properties relating to emission are also important.

Question 28 (a) (iii)

Answers could include:

Radiation reflected from the surface of the Earth is detected by satellites. The detected radiation is different depending on the surface features. In the event of a bushfire the radiation detected from a forested area changes.

Question 28 (b) (i)

Answers could include:

$$g = \ell\left(\frac{2\pi}{T}\right)^2 = 1.00\left(\frac{2\times\pi}{2.00}\right)^2$$

Question 28 (b) (ii)

Answers could include:

$$F = \frac{Gm_e}{r^2} = g$$

$$r = \sqrt{\frac{Gm_e}{g}}$$

Question 28 (b) (iii)

Answers could include:

The value of g is sensitive to large or dense objects close by. Even though there is no mountain nearby in the second measurement, it is likely that there is very dense rock just under the surface. The average density of this rock would be similar to that of having the mountain close by.

Question 28 (c) (i)

Answers could include:

The graphs indicate S and P waves and their different arrival times at the various locations. The time difference between the S and P waves at the locations can be used to locate the epicentre of the earthquake which station is closest to the epicentre can be determined.

Question 28 (c) (ii)

Answers could include:

An array of detectors are placed in a region. A seismic signal is generated. Time of travel can then be used to determine what lies between the source and detectors.

Question 28 (d)

Answers could include:

Seismic –> provides evidence for the structure of Earth, fault lines and over time has provided documented evidence of change

Radioactive –> carbon dating provides detail on features showing that there has been substantial ‘movement’ of large structures

Magnetic –> magnetic fields associated with rocks and sediments show that the magnetic properties of Earth has changed dramatically

Question 29 (a) (i)

Answers could include:

The barium meal is a high-density material, which can absorb x-rays. When swallowed, it passes into the small intestine. X-rays are absorbed by the high-density material and cannot reach the photographic film. Because the surrounding tissue is less dense, x-rays pass through to reach the photographic plate and so appear dark.

Question 29 (a) (ii)

Answers could include:

Electrons are produced by thermionic emission from the heating of the filament in the cathode. The electrons are accelerated across the tube by high voltages, up to 2 M volts. The tube is highly evacuated to avoid energy loss by the electrons so when they hit the tungsten target energy is released in the form of x-rays, either as a result of bremsstrahlung "braking" radiation or as a result of the rearrangement of electrons within energy levels to form stable atomic arrangements.

Question 29 (b) (i)

Answers could include:

$$
\begin{aligned}
Z &= \rho v \\
&= 1.05 \times 10^3 \times 1.53 \times 10^3 \\
&= 1.6065 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}
\end{aligned}
$$

Question 29 (b) (ii)

Answers could include:

A greater proportion of the incident pulse will be reflected

Question 29 (b) (iii)

Answers could include:

The crystal rapidly expands and contracts when an alternating electronic potential is applied. This vibration generates high frequency sound waves. The expansion and contraction is due to the realignment of the dipoles within the crystal when an electric field is applied.

When a piezoelectric crystal receives ultrasound waves they apply mechanical pressure causing the crystal to deform. The wave produces expansion and construction of the crystal, which in turn produces a very small changing electric potential due to realignment of dipoles within the crystal.

Question 29 (c) (i)

Answers could include:

It can be justified in that CAT scans can provide much better imaging of soft tissue damage, for example the rupture of spinal discs. By identifying such damage, the patient can be treated and hence live longer. They are a superior diagnostic tool to ultrasound and X rays. When fine detail is needed, for example an image of the brain, the growth of brain tumour can therefore be identified earlier. CAT scans are also preferred for the imaging of lungs as ultrasound cannot image past air spaces in the lungs.

Question 29 (c) (ii)

Answers could include:

A tracer is a particular radioisotope, which is taken up by specific organs. This enables only those organs to be imaged. For a PET scan the tracer is labelled with a positron-emitting radioisotope. When the positron encounters an electron, pair annihilation occurs and 2 gamma rays are produced. The pairs of gamma photons travel in opposite directions and emerge from the body to be detected by gamma cameras Their relative intensity is also measured. These measurements are then used to determine the position of the decaying radioisotope and hense where it has accumulated.

Question 29 (d)

Answers could include:

- Patient – initially proton spins are randomly orientated. Spins are created as protons are moving charge and create their own magnetic field.
- Magnetic field applied – proton spins align with the external field
- RF pulse is applied – Provided the frequency of the pulse is the same as that of the nuclear – larmor frequency – resonance will occur. The energy causes the protons to process around magnetic field lines.
- RF signal is turned off
- Patient produces RF signal – protons lose the absorbed energy. As they relax, return to their lower energy state, the energy is transferred into radio waves of the same frequency as the incident wave
- Receiving ion detects weak RF signal – the alternating em wave sets up an alternating electric potential
- Computer reconstructs image – image is produced on a computer screen

Question 30 (a) (i)

Answers could include:

The sensitivity of a telescope is its ability to detect light or photons. It is a measure of how faint the signals are that can be detected. Resolution is the ability to separate two closely spaced objects in an image, independent of how bright they are.

Question 30 (a) (ii)

Answers could include:

While the Parkes telescope has a large diameter is still has poor resolution due to the large wavelengths it is collecting (radio waves). It has a large diameter so its sensitivity is quite good.

Interferometry is a very useful technique for radio telescopes, such as the Parkes telescope, which involves collecting electromagnetic radiation (eg. radio waves), using two or more collectors (eg. radio antennae), separated by some distance and combining the signals. In Interferometry, the resolution then is determined by the maximum separation of the collecting elements. Radio telescopes from very large distances (hundreds) or thousands of kilometres) away can be connected to achieve much improved resolution. The sensitivity is also improved due to the increased surface area of telescope used (addition of the linked telescopes) that however is only a moderate increase in sensitivity.

Active optics are not needed in a radio telescope because the wavelength of radiation is much longer and the acceptable errors in the shape of the reflective surface are much larger. Plus the reflective surface is not very heavy like a glass mirror so it is less susceptible to deformation when the telescope slews around the sky. The physical structure of a radio telescope is able to maintain the shape of the reflective surface adequately without the use of active optics.

Question 30 (b) (i)

Answers could include:

In the Computer Simulation a binary system is modelled by two stars orbiting around a centre of mass. As the orbit progresses a light curve is produced to simulate what would happen to the brightness of the system, eg, as a small bright star passes behind a larger dull star the light intensity would decrease. The simulation allows you to change the types of stars and see the different possible light curves generated from an eclipsing binary.

Question 30 (b) (ii)

Sample answer/Answers could include:

$$m = \frac{4\pi^2 r^3}{GT^2} = 5.0 \times 10^{30}\,\text{kg} = 2.5\ \text{m}_{\text{sun}}$$

Question 30 (b) (iii)

Sample answer:

Some of the spectral lines in diagram 2 have been red shifted and some have been blue shifted. The red shifted lines are due to one of the binary stars travelling away from the observer while the blue shifted lines are due to one of the binary stars travelling towards the observer as they rotate around a centre of mass. (Answers could include decreased brightness of line).

The disappearance of one of the spectral lines is due to the overlap of a red and a blue shifted spectral line from each star.

Question 30 (c) (i)

Sample answer:

The star will be redder.

Question 30 (c) (ii)

Answers could include:

You take a measurement of the brightness of the star using a CCD through a blue-green (V) filter. You then take a measurement of the brightness of the star using the same CCD through a blue (B) filter. You subtract the measurement V from B and this B–V value is a standard numerical/quantitative representation of the colour of the star.

Question 30 (d)

Answers could include:

Photoelectric	Photographic
• easy to store	• difficult to store
• quick and easy and can be done remotely	• takes time
• broad range of wavelengths	• narrow range of wavelengths
• developing high resolution	• high resolution
• more sensitive	

Question 30 (e)

Answers could include:

A protostar is formed by the accretion of a large molecular cloud which is cool enough to undergo gravitation collapse. As the gravitational potential energy is turned into KE the star heats up. The heat causes an outwards pressure and works against the gravitation collapse. When hot enough the core becomes stable as a balance between radiant and gravitational pressure is reached in the core. The protostar shell heats up as it shrinks causing it to become less luminous and hotter moving down and to the left towards the Main sequence at B.

At B – As the core reaches a critical temperature hydrogen fusion starts in the core. This is mostly p–p chain reaction. H→He. Helium builds up in the core. A hydro dynamic equilibrium and thermal equilibrium is established in the core and shell. This remains until the hydrogen in the core is used up. Then the star starts the progression from B→C. The core collapses as the gravitational pressure is greater than radiant pressure. It shrinks and heats up. This in turn heats the shell which will start to fuse hydrogen in the shell. The shell then expands and cools moving up and to the right on the HR diagram. The core continues to collapse until a critical temperature is reached and Helium begins to fuse to carbon in the core in a triple alpha reaction.

Question 31 (a) (i)

Answers could include:

Most alpha particles passed straight through the gold foil but some about 1 in 10000 were deflected through angles greater than 90 degrees. Rutherford’s model envisaged the atom as having a solid positive nucleus, surrounded at a distance by orbiting electrons. This would leave a large amount of empty space. This would explain why most of the alpha particles were able to pass through the foil with little or no deflection. The small number of positive alpha particles, which did encounter the nucleus, would be deflected through large angles.

Question 31 (a) (ii)

Answers could include:

Rutherford’s model could not explain why an orbiting electron, with a continuous centripetal acceleration, did not radiate electromagnetic radiation; lose energy and spiral into the nucleus. Rutherford’s model also made no attempt to explain spectral lines emitted by hot gases, in particular, hydrogen.

Bohr’s model attempted to deal with these problems. He proposed a model where the electrons existed in specific non-radiating energy levels around the nucleus. Energy could only be released or absorbed in discrete quanta, or packets of energy when electrons moved between energy levels. Bohr also used evidence collected by Planck and Einstein and utilised the work of Balmer, to develop his theory, which had three main postulates:

- electrons in an atom exist in stable, circular orbits (note that Bohr could not explain the existence of these stable orbits)
- electrons in stable orbits do not emit radiation
- electrons absorb or emit quanta of energy when they move from one stable energy level to another – which explained spectral lines.

Question 31 (b) (i)

Outcomes assessed: H8, H10

Answers could include:

De Broglie, in considering the fact that no-one had yet conclusively deduced whether light was a wave or a particle, believed that particles could have a wave nature as well as a particle nature. When he considered the equations for the energy and momentum of light, he believed that both momentum (a particle property) and frequency (a wave property), were equally important:

E -= hf and momentum = hf/c

Question 31 (b) (ii)

Sample answer:

Davidson and Germer were studying the refection of electrons from a nickel surface. The vacuum tube they were using developed a crack in it, causing the nickel surface inside to oxidise. After heating the nickel strongly, presumably to remove nickel oxide, Davidson and Germer actually produced nickel crystals on the surface, larger than the electron beams they were using, and, as a result, the next time they observed electron beams, these beams displayed interference – which was a wave property, not a particle property – thus confirming de Broglie's hypothesis.

Question 31 (b) (iii)

Answers could include:

Wavelength = $h/_{mv}$

$$\lambda = h/_{mv}$$

Question 31 (c) (i)

Answers could include:

Mass defect is the difference between the mass of the nucleus and the mass of various constituent nucleons

Question 31 (c) (ii)

Sample answer:

The graph shows that the average binding energy of the nucleus with a mass number of 200 is smaller than the average binding energy of the nucleus of mass number 50. Because binding energy is a measure of the stability of an atom, this implies that the nucleus with a mass number of 200 is less stable than with mass number 50.

Question 31 (d)

Answers could include:

It was suggested that a yet undiscovered particle could exist and that this particle had no charge, with approximately the same mass as the proton. Despite many attempts to observe this particle, it took over 12 years to demonstrate the existence of the neutron. When Chadwick bombarded beryllium particles with alpha particles, he noticed that in addition to the carbon atom released, there was another particle / radiation emitted. He designed and conducted an experiment to collide these particles / radiation with small atoms and molecules, such as hydrogen and nitrogen. By measuring the final velocity of the molecules after the collision, and assuming the collisions were elastic, Chadwick was able to use the laws of conservation of momentum and KE to calculate the mass of the unknown particle – demonstrating that it was indeed a particle and not radiation. He found that the mass of the particle was almost the same as the mass of the proton, but with no charge.

Question 31 (e)

Answers could include:

The standard model of matter describes the composition of matter. It states that 12 matter particles and 4 force-carrying particles can explain how matter is composed and behaves. Of the matter particles, there are 6 quarks and 6 leptons. Hadrons, baryons, mesons and prions represent the force carrying particles. 3 forces act between particles and act by the exchange of force-carrying particles called bosons. The standard model has developed out of both research and theorising about the structure and properties of matter. Whilst linear accelerators and cyclotrons were once very important tools in studying the composition and property of matter, today synchrotrons and particle accelerators, such as the LHC, have become the major tools. Whilst the SM of M is a great achievement and many experiment, using the accelerators listed above, have confirmed its predictions, the model has some serious flaws and continues to generate even more questions. These include:-

- Why are there 6 quarks and 6 leptons? Coincidence or fundamental reason?
- Is there some underlying fundamental particle which could explain the electrical charges of quarks and leptons?
- Given that the SM of M is a quantum – mechanical model, it is incompatible with Einstein's general theory of relativity, which means that gravity cannot unify the forces
- The SM of M does not have a mechanism to generate the observed masses of particles – which may be linked to the as yet undiscovered Higgs-Boson.

Question 32 (a) (i)

Answers could include:

It is a potential divider. Voltage divider (different terminology)

Question 32 (a) (ii)

Sample answer:

$$Vt = (5.0)\frac{0.5 \times 10^3}{(0.5 + 1.0 + 1.0 + 0.5) \times 10^3}$$

$$= 0.83 \text{ V}$$

Question 32 (a) (iii)

Answers could include:

The amplifiers are used without any feedback circuit between their outputs and inputs. This means they are being used in an open-loop configuration.

Question 32 (a) (iv)

Answers could include:

D_2	D_1	D_0	0_1	0_0
0	0	0	0	0
0	0	1	0	1
0	1	X	1	0
1	X	X	1	1

X = don’t care.

Question 32 (b) (i)

Sample answer:

Transducers act as an interface between electronic circuits and the environment. An input transducer measures an environmental characteristic, while an output transducer allows an electronic circuit to influence its environment.

Question 32 (b) (ii)

Answers could include:

	Sunlight	**Temperature**	**Pump**
Transducer type	LDR	Thermistor	Relay
Input or Output Transducer	Input	Input	Output
Outline of Operation	Resistance of LDR changes in response to light level	Resistance of Thermistor changes in response to temperature	Smaller current through electromagnet coil pulls contacts together and switches longer current to external circuit

LDR would be replaced by photo cell + ‘input’ + “output current produced by photo cell depends on the amount of light incident on it”

Question 32 (c)

Sample answer:

A digital signal represents a binary value and therefore has only one of two values. An analogue signal represents a continuous quantity and can therefore have any value. In a CD player music is stored as a digital representation of an analogue quantity ie. the digital data on the CD is converted to an analogue voltage signal and outputs to the headphones.

Question 32 (d)

Answers could include:

The development of the integrated circuit (IC) meant that large circuit boards, containing many separate transistors and components, could be replaced with one small device. This minitransisation reduced circuit size, increasing processing power/efficiency and reducing the energy required to build the circuits. This combination greatly increased the power efficiency of electronics. However, this also made electronics much cheaper and the number of circuits produced increased greatly, increasing the overall/combined energy consumption of electronics used by society.

Question 32 (e)

Answers could include:

- The advancement of silicon-based electronics is based on a successive miniaturisation of circuit features.
- As circuit features in digital devices are reduced, more circuits can be manufactured within a given area of silicon. This results in increased processing power and increased storage capacity, both leading to increased 'computer' performance (including PCs, mobiles, MP3 players).
- Quantum mechanical effects and the dimension of atoms mean that this miniaturisation must stop soon. This means that new techniques to miniaturise circuits must be developed $\rightarrow$ a reconceptulisation must occur.
- In general these effects/pressures are not present for analogue electronics since their size is determined by discrete components and power switching requirements.
- Society is now very accustomed to, and expects, this rapid increase in digital circuit performance (speed and capacity). If this reconceptulisation cannot be realized, computer (internet, mobile, MP3 player…) performance will be frozen. This will essentially stop the evolution of computing and communications as we see it occurring today.
- But analogue electronics would not be affected; its performance would still progressively improve since this is not directly connected to circuit feature size and hence to the required reconceptulisation.