Quality Assessment Task

School Assessed Practice Examination VCE Physics

Unit 4

Written Examination 1

Student Name: ______________________________

INTRODUCTION

Reading time: 15 minutes
Writing time : 90 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	Number of questions	Number of questions to be answered	Number of marks
A Core – Areas of study			
1. Electric Power (page 2)	16	16	37
2. Interactions of light and matter (page 8)	20	20	28
B Detailed studies			
1. Synchrotron and its applications (page 15)	11	11	25
Or			
2. Photonics (page 19)	10	10	25
Or			
3. Sound (page 24)	11	11	25

Students **are** permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator.

Students are **NOT** permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
Question and answer book of 38 pages with a data sheet.

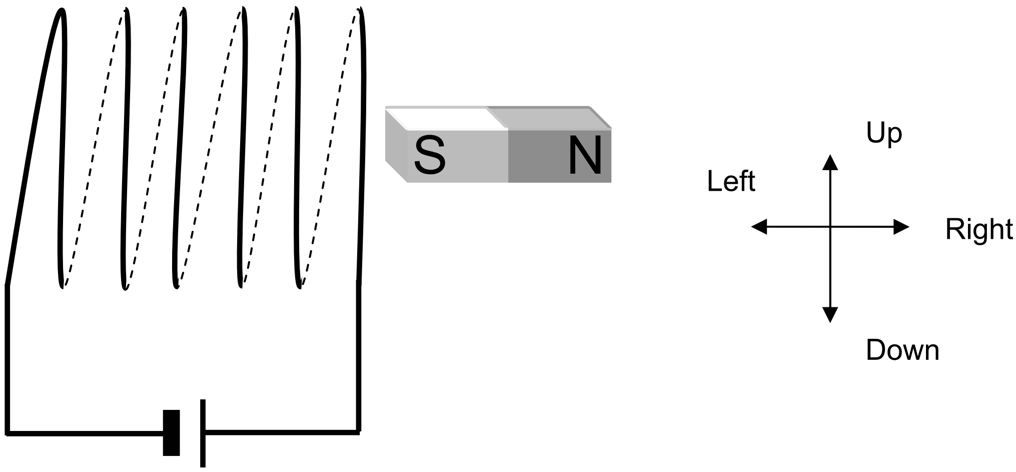
Instructions
Answer all questions in the spaces provided.
Always show your working where space is provided.
Where an answer box has a unit printed in it, give your answer in that unit.
All written responses must be in English.

TASK

SECTION A – CORE

Area of Study 1 – Electric Power

A bar magnet is placed just outside a solenoid and a current is allowed to flow through the solenoid (as shown below).



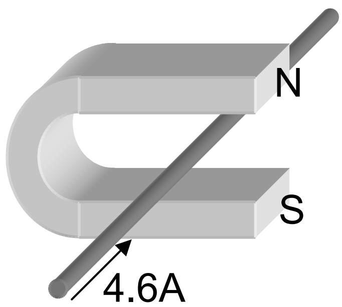
Question 1
What is the direction of the magnetic field inside the solenoid?

(1 Mark)

Question 2
Which direction will the bar magnet move?

(2 Marks)

A current carrying wire was placed in the magnetic field of a horseshoe magnet as shown below.



Question 3
What is the initial direction of the force on the wire? *(Circle the correct response)*

Up Down Left Right

(1 Mark)

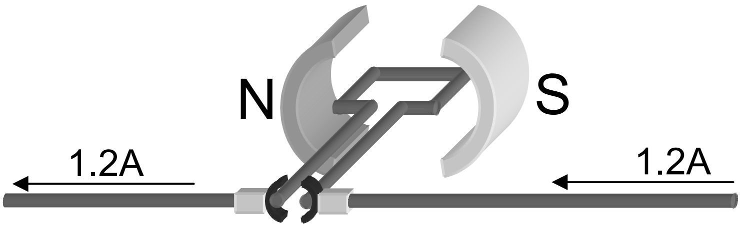
Section A – Area of Study 1 – continued
TURNOVER

Question 4
The current in the wire is 4.6 A, the length of the wire in the magnetic field is 2.0 cm and the magnetic field is 400 mT. What is the magnitude of the force?

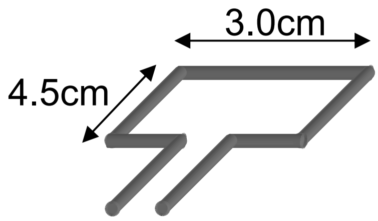
(2 Marks)

The following information refers to Questions 5 to 7.

A motor has a magnetic field strength of 0.3 T, the current flowing in the coil of the motor is 1.2 A.



Figure



Figure

Question 5
Which direction will the motor rotate in the figure above? *(circle the correct response)*

Clockwise Anticlockwise

(1 Mark)

Question 6
What is the size of the net force acting on the coil?

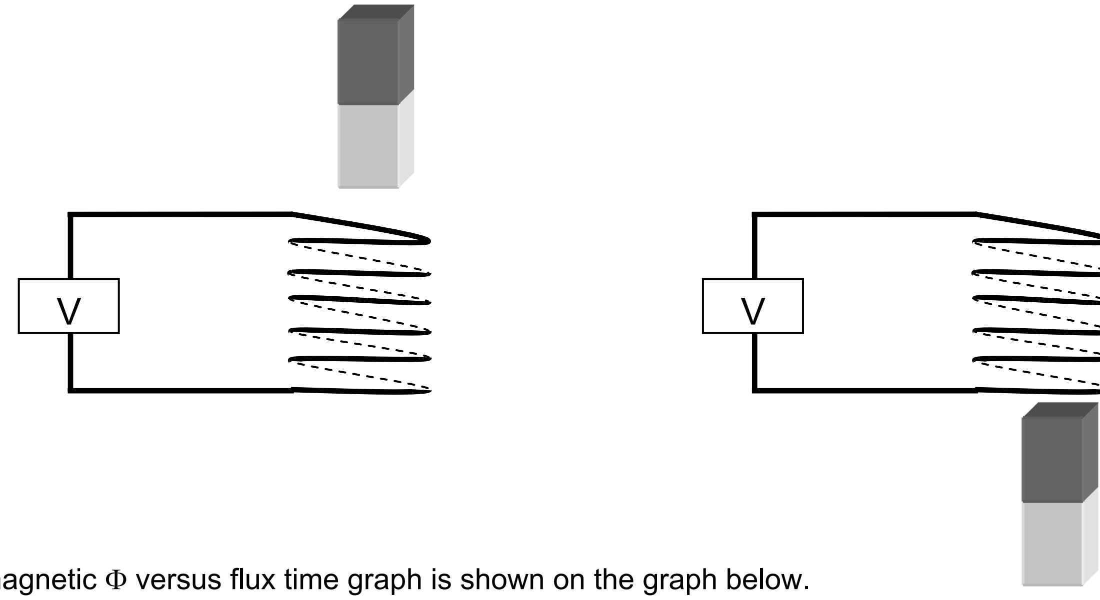
(2 Marks)

Question 7
Explain the purpose of the commutator.

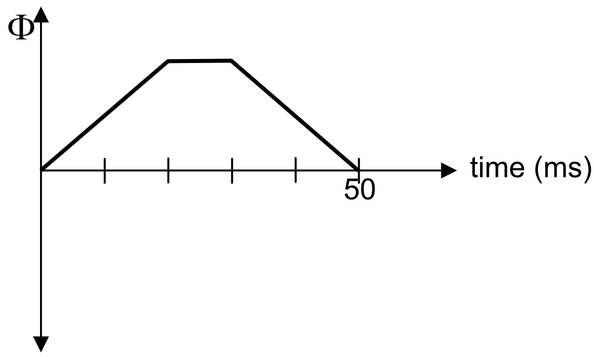
(4 Marks)

Section A – Area of Study 1 – continued
TURNOVER

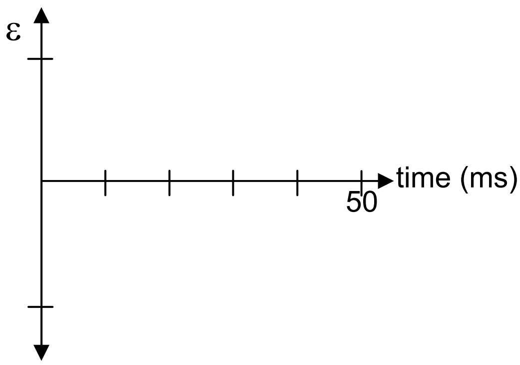
A bar magnet is passed through a solenoid at a constant speed. The solenoid is connected to a voltmeter and the voltage is read as the magnet passes through the solenoid. The solenoid has 6 turns and a diameter of 2.0 cm. The magnet has a magnetic field strength of 238.8 mT.



The magnetic Φ versus flux time graph is shown on the graph below.



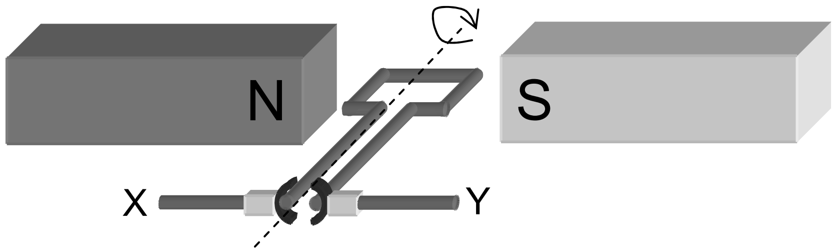
Question 8
Clearly draw the emf induced in the solenoid versus time due to moving the magnet through the solenoid. Use the information above to label the voltage-axis of the graph.



(4 Marks)

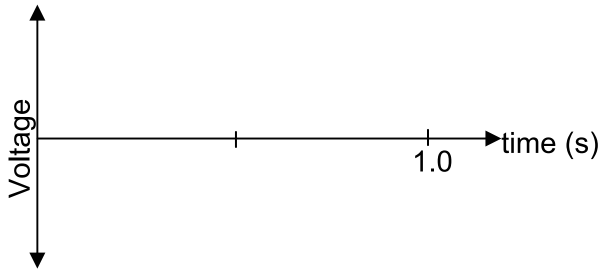
Section A – Area of Study 1 – continued
TURNOVER

The coil of a generator continuously rotates at a rate of 2 revolutions per second in a clockwise direction as viewed from this end.



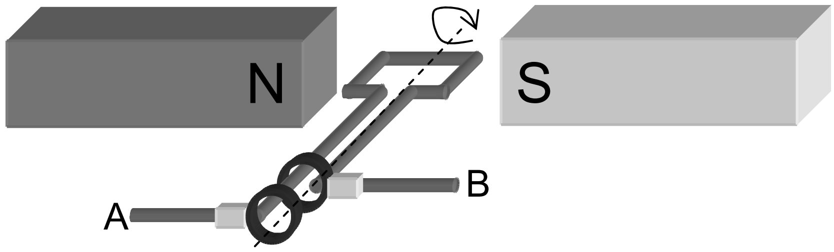
Figure

Question 9
Draw a graph of the induced voltage across X-Y for the generator shown above. Take a current from X → Y to be positive.



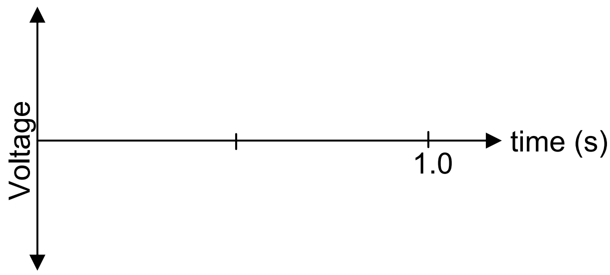
(3 Marks)

The coil of an alternator is continuously rotated at a rate of 1 revolution per second in a clockwise as viewed from this end.



Figure

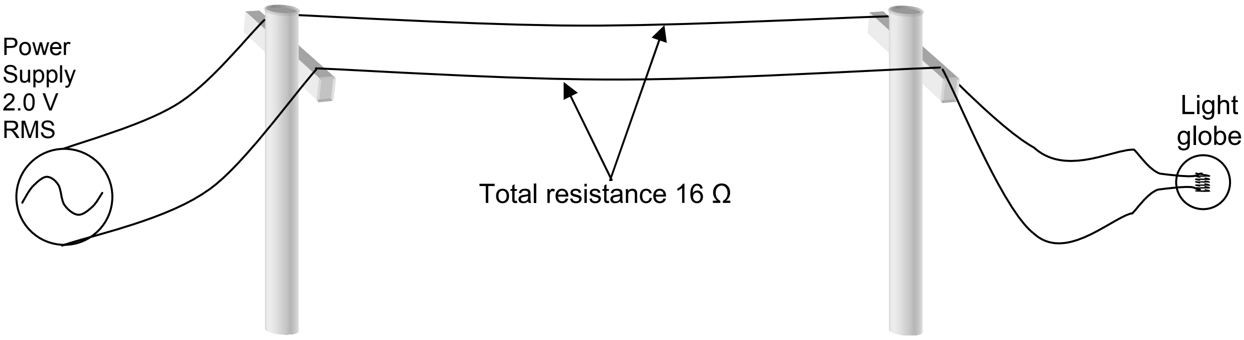
Question 10
Draw a graph of the induced voltage across A-B for the alternator shown above, take a current from A → B to be positive.



(3 Marks)

Section A – Area of Study 1 – continued
TURNOVER

The following information refers to Questions 11 to 13



The total resistance of the transmission wires is 16 Ω. The light globe is rated at 1.0 W, when it receives 2.0 V RMS is applied across it. The resistor has a constant resistance of 4.0 Ω. When the power supply is set to RMS value of 2.0V and connected to the transmission wires, the light globe is not very bright.

Question 11
Use calculations to show why the light globe is not very bright.

(3 Marks)

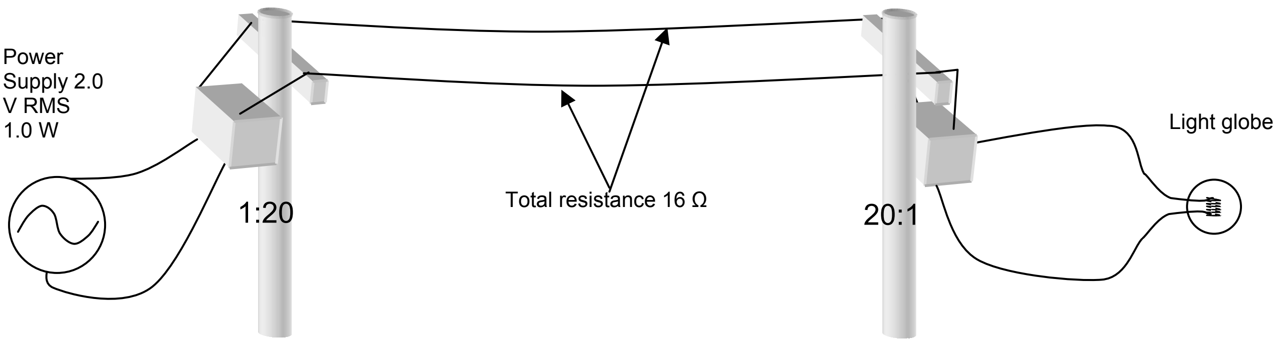
Question 12
What voltage would the power supply need to be set at in order for the light globe to operate at 1.0 W?

(2 Marks)

Question 13
What is the power loss in this circuit if the light globe was operating at 1.0 W?

(2 Marks)

Section A – Area of Study 1 – continued
TURNOVER



The power supply is now connected to a step up transformer, before being sent along the transmission wires. At the other end there is a step down transformer.
The total resistance of the transmission wires is still 16 Ω. The resistance of the light globe is still 4.0 Ω. Assume all transformers are ideal, the first transformer has a ratio of 1:20 and the second transformer has a ratio of 20:1.
The power supplied to the first transformer is 1.0 W and 2.0 V RMS.

Question 14
What is the voltage across the output of the first transformer?

(2 Marks)

Question 15
What is the voltage drop and power absorbed across the transmission wires?

(2 Marks)

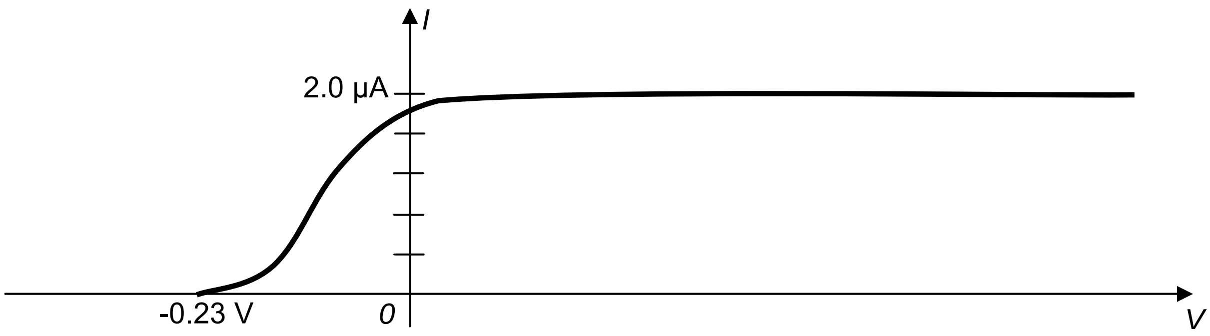
Question 16
What is the power dissipated/absorbed by the light globe?

(3 Marks)

End of Area Study 1
Section A-continued

Area of Study 2 – Light and Matter

The photoelectric effect was analysed using a Potassium electrode. Below is a graph of voltage verses current for the Potassium electrode when a light with a frequency of 6.0 x 10^{14} Hz at 100% intensity strikes the electrode.



Question 1
On the graph above, draw the curve that is produced when the frequency is 6.0 x 10^{14} Hz and the intensity is reduced to 40%.

(1 Mark)

Question 2
Calculate the maximum kinetic energy (in joule) of the photoelectrons in this experiment.

(1 Mark)

Question 3
From the graph above, what is the Work Function of Potassium in eV?

(2 Marks)

Question 4
From the graph above calculate the threshold/cut-off frequency for Potassium.

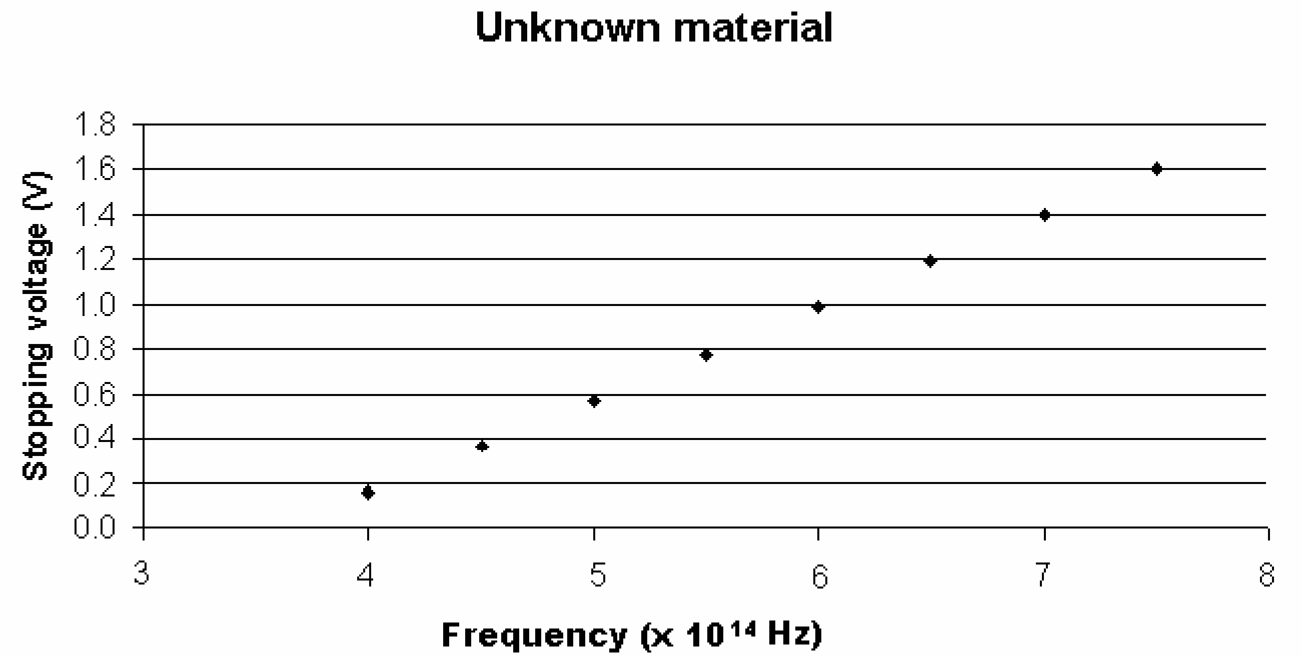
(1 Mark)

Question 5
If the frequency of the incident light was changed to 7.5 x 10^{14} Hz what would the stopping voltage for the photo electrons emitted be?

(2 marks)

Section A – Area of Study 2 – continued
TURNOVER

The following information refers to Questions 6 to 8.
An unknown material is subjected to a range of frequencies of light and the stopping voltages are recorded on the graph below.



Question 6
Use the graph above to show that Planck's constant is 6.63×10^{-34} Js.

(2 Marks)

Question 7
Use the graph above to determine the cut-off/threshold frequency of the unknown material.

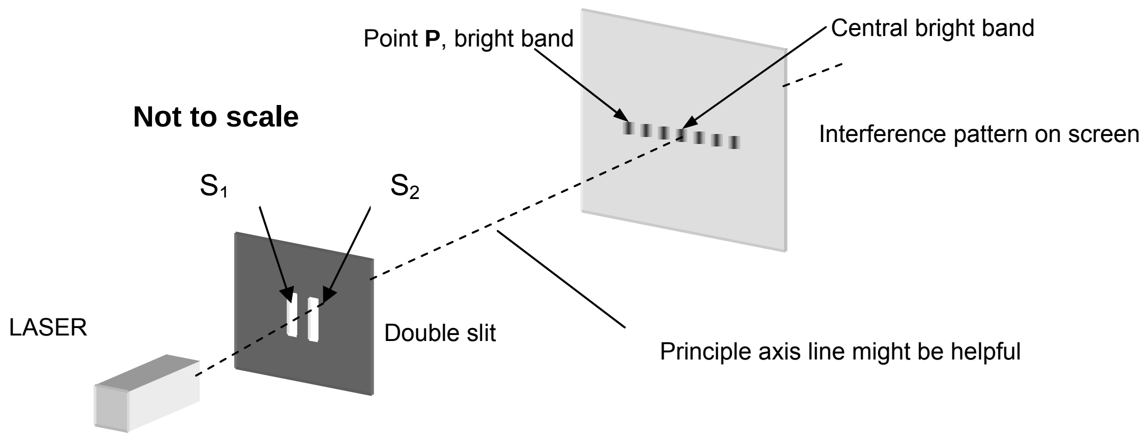
(1 Marks)

Question 8
Use the graph above to determine the work function of the unknown material. Give your answer in electron volt.

(2 Marks)

Section A – Area of Study 2 – continued
TURNOVER

Light from a LASER, with a yellow is wavelength 580 nm. It is passed through two parallel slits 1.0 mm apart. A pattern of alternating light and dark bands is produced on a screen as shown below.



Question 9
Which of the following would cause the interference pattern on the screen to spread?

A Changing the light to blue light (430 nm)
B Changing the double slits to one that has the parallel slits separated by 2.0 mm
C Do the experiment under water
D Use a red laser with a frequency of 4.75×10^{14} Hz.

(1 Mark)

Question 10
Explain why the light and dark bands form in this experiment and how this supports the wave model for light.

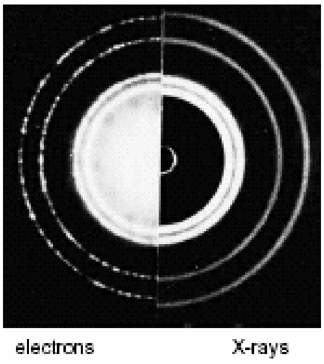
(3 Marks)

Section A – Area of Study 2 – continued
TURNOVER

Question 11
What is the path difference, for the light at point P? See diagram. Give your answer in nanometre.

(2 Marks)

Consider the diagram shown on the right. The right half illustrates the diffraction pattern formed when 250 eV x-rays are passed through thin aluminium foil. The left half is created when a beam of electrons directed at and pass through the same aluminium foil.



Question 12
What is the energy of the x-rays? Give your answer in joule.

(1 Mark)

Question 13
What is the wavelength of the x-rays?

(1 Mark)

Question 14
What is the momentum of the x-rays?

(1 Mark)

Section A – Area of Study 2 – continued
TURNOVER

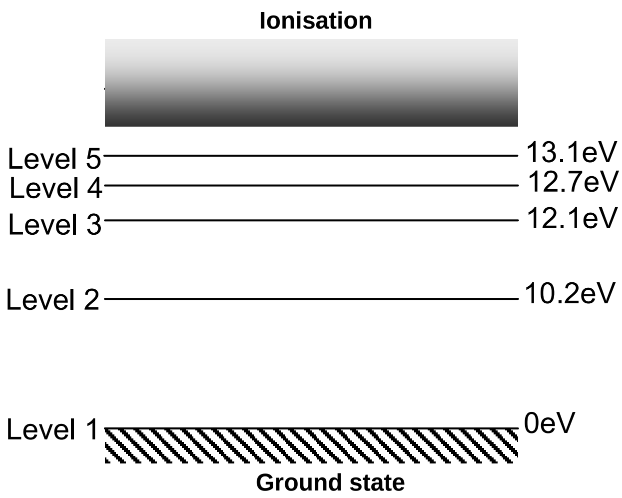
Question 15
What is the speed of the electrons?

(1 Mark)

Question 16
What is the kinetic energy of the electrons? Give your answer in joule.

(1 Mark)

In an experiment, spectrometers were used to observe the emission spectrum for Hydrogen atoms.
A photon with a wavelength of 496.95 nm was observed.



Question 17
Calculate the energy of this photon in eV.

(1 Mark)

Question 18
The different energy levels for Hydrogen in the energy level diagram above.
Between which two energy levels did the transition occur to accompany the release of a 496.95 nm photon?

From Level ___________ to Level ___________

(1 Mark)

Section A – Area of Study 2 – continued
TURNOVER

Question 19
A large number of hydrogen atoms are excited to the Level 4 state. How many different energy photons could be emitted? Circle the correct answer.

A 1 **B** 3 **C** 4 **D** 5 **E** 6

(1 Mark)

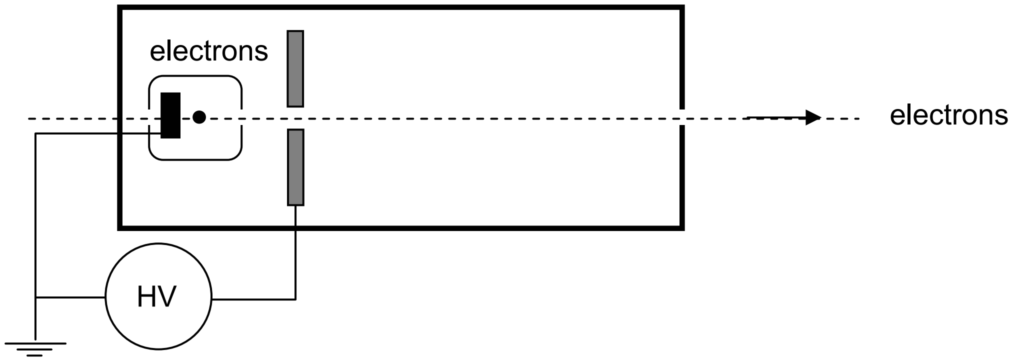
Question 20
An electron with a kinetic energy of 13 eVs <singular unit> was travelling through some Hydrogen atoms that were all at their ground state. What are the possible energies that the electron could leave the Hydrogen atoms?

(2 Marks)

End of Section A

SECTION B - Detailed Study 1 – Synchrotron and its Applications

Electrons are accelerated in an electron gun as shown below. Upon exiting the gun, the electrons have a speed of 2.4×10^7 m s^{-1}.



Question 1
What is the magnitude of the High Voltage (HV) used to accelerate the electrons?

(2 Marks)

Question 2
Determine the momentum of an electron emitted by the gun.

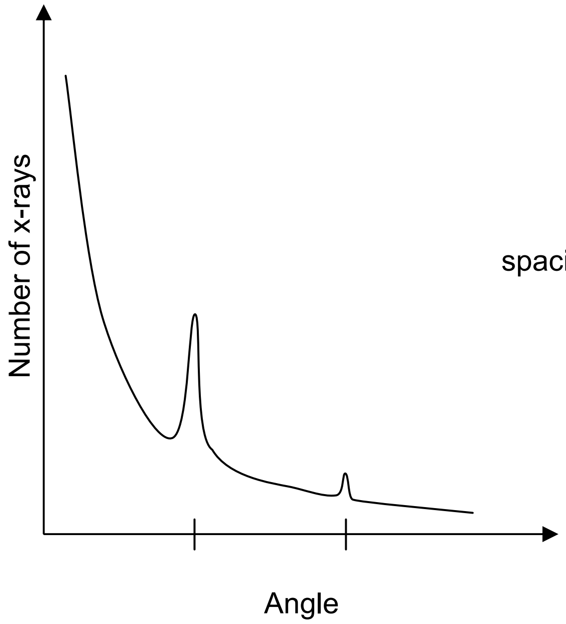
(2 Marks)

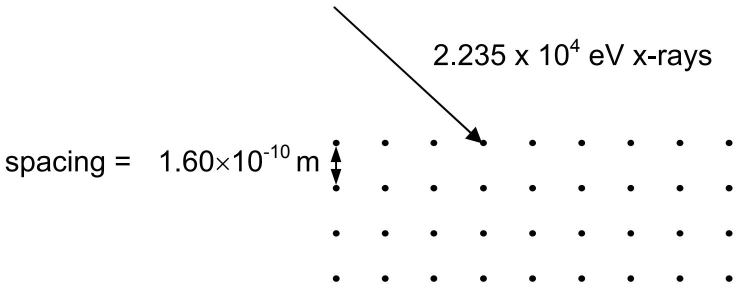
Question 3
After leaving the electron gun, the electrons enter a magnetic field of 2.6 mT, as shown below. The electrons then travel in a circular arc. What is the radius of the arc?

(2 Marks)

Section B – Detailed Study 1 – continued
TURNOVER

A 2.235×10^4 eV beam of x-rays is aimed at a crystal that has a spacing between the layers of 1.60×10^{-10} m.





Question 4
Use the above information to fill in both of the angles on the graph above.

(2 Marks)

Question 5
What is the momentum of one the x-ray photons?

(2 Marks)

Section B – Detailed Study 1 – continued
TURNOVER

Sally and Chris were having a discussion, comparing a normal x-ray tube and a synchrotron. Sally said "Since both devices emit 200 eV x-rays, the light from both devices is the same and the synchrotron was not required." Chris was not sure and needs convincing.

Question 6
Put your argument forward, either supporting Sally's opinion, or convincing Chris.

(3 Marks)

A beam of 65 pm x-rays are aimed at a silicon block. When analysing the spectrum at 45^{o} to the incident beam, it was found that there were two dominant wavelengths present, 65 pm and 68 pm.

Question 7
What is the momentum of the 65 pm x-rays?

(2 Marks)

Question 8
How much momentum does each 68 pm photon impart to the silicon block?

(2 Marks)

Question 9
Is this interaction an example of Thomson scattering or Compton scattering? Justify your choice.

(2 Marks)

Section B – Detailed Study 1 – continued
TURNOVER

Question 10
What is the purpose of the electron linac?

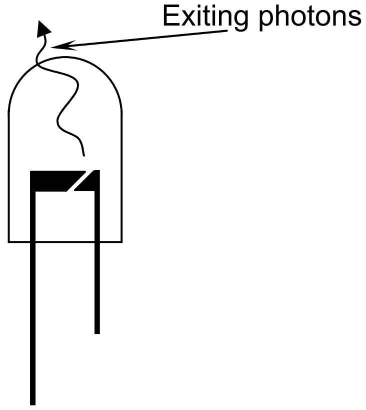
(3 Marks)

Question 11
What is the purpose of the storage ring?

(3 Marks)

End of Detailed Study 1
Section B - continued
TURNOVER

Detailed Study 2 – Photonics



An LED is connected to a voltage supply so that there is 1.97 volts across it.

Question 1
What is the band gap energy of this LED in joule?

(2 Marks)

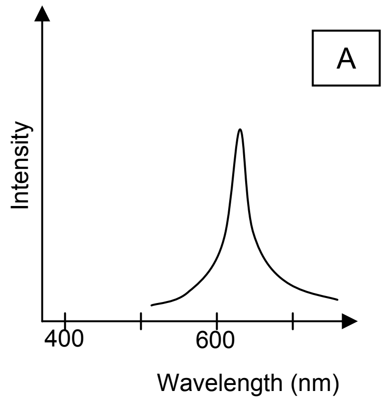
Question 2
What is the wavelength of the photons emitted by the LED?

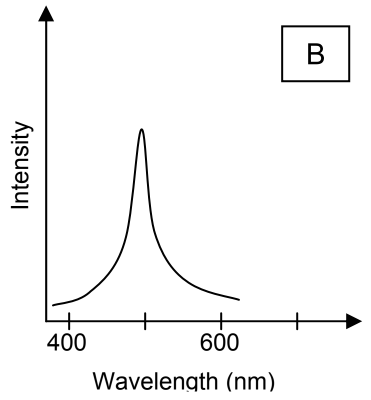
(2 Marks)

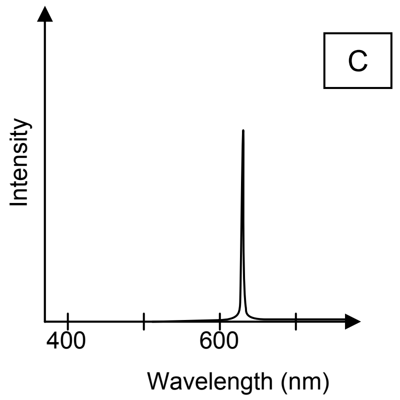
Section B – Detailed Study 2 – continued
TURNOVER

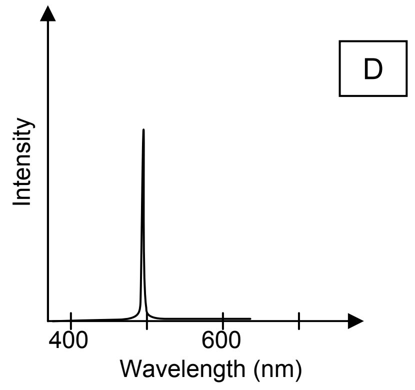
Question 3

Which of the following would be the output from the LED?





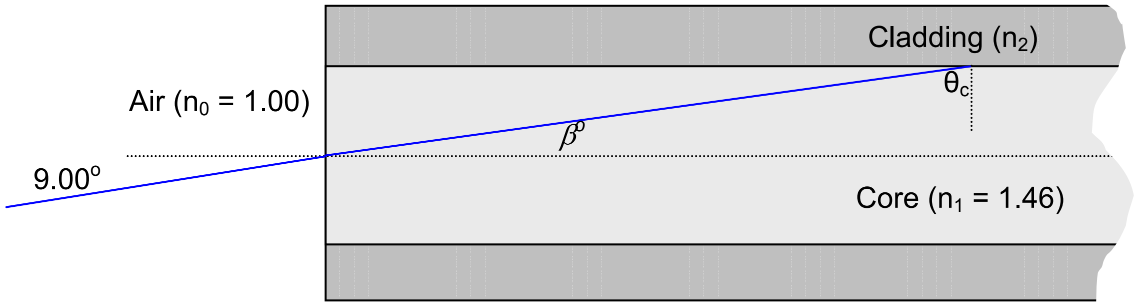




(2 Marks)

Section B – Detailed Study 2 – continued
TURNOVER

The following information refers to questions 4 to 7.
An optical fibre with a core refractive index is found to have an acceptance angle of this optical fibre is 9.00°.



Question 4
What is the numerical aperture of this optical fibre?

(2 Marks)

Question 5
What is the value of β in the diagram above?

(2 Marks)

Question 6
What is the Critical angle of the core – cladding inferace?

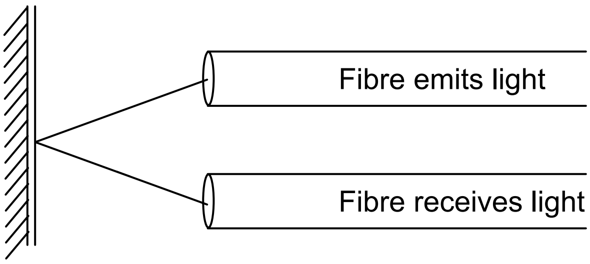
(2 Marks)

Section B – Detailed Study 2 – continued
TURNOVER

Question 7
What is the refractive index of the cladding n_2?

(2 Marks)

Below is an example of optical fibres being used as an extrinsic sensor. They are used to measure the distance between the optical fibre and the wall.



Question 8
Explain how these two fibres are used as a senor.

(3 Marks)

Section B – Detailed Study 2 – continued
TURNOVER

Question 9
Explain what dispersion is. State the two main causes of dispersion and how dispersion reduced in long distance communication applications.

(4 Marks)

Question 10
Explain how signal attenuation is reduced in long distance communication applications.

(4 Marks)

End of Detailed Study 2
Section B - continued
TURNOVER

Detailed Study 3 - Sound

Not to scale

A speaker is connected to a signal generator and the speaker is producing 4.0 W of sound at 2000 Hz.

Question 1
If the speed of sound in air is 340 m s^{-1}, what is the wavelength of the sound made by the speaker?

(2 Marks)

Question 2
Assuming the speaker behaves as a point-source of sound, what is the sound intensity 2.5 metres from the speaker?

(2 Marks)

Question 3
A sound level meter is placed 2.5 meters in front of the speaker. What will be the sound intensity level be at this position?

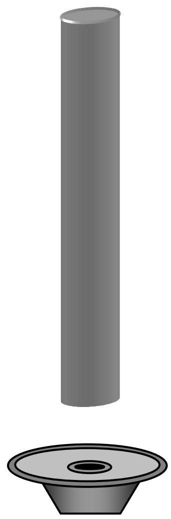
(2 Marks)

Section B – Detailed Study 3 – continued
TURNOVER

Question 4
The sound level meter was moved from the 2.5m until the sound intensity level reduced by 16 dB. How far is the sound level meter from the speaker now?

(2 Marks)

In order to determine the speed of sound in helium, a 1.5m pipe that is closed at on end is filled with helium and a speaker is placed at the bottom of the pipe. The frequency generated by the speaker is increased from zero until there is resonance in the pipe at 500 Hz.



Question 5
Determine the speed of sound in helium.

(2 Marks)

Question 6
Explain how this closed end pipe is able to resonate.

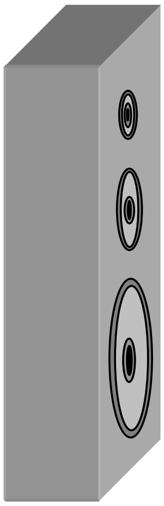
(3 Marks)

Section B – Detailed Study 3 – continued
TURNOVER

Question 7
Explain how a dynamic microphone acts as a transducer to convert a sound wave into an electrical signal.

(3 Marks)

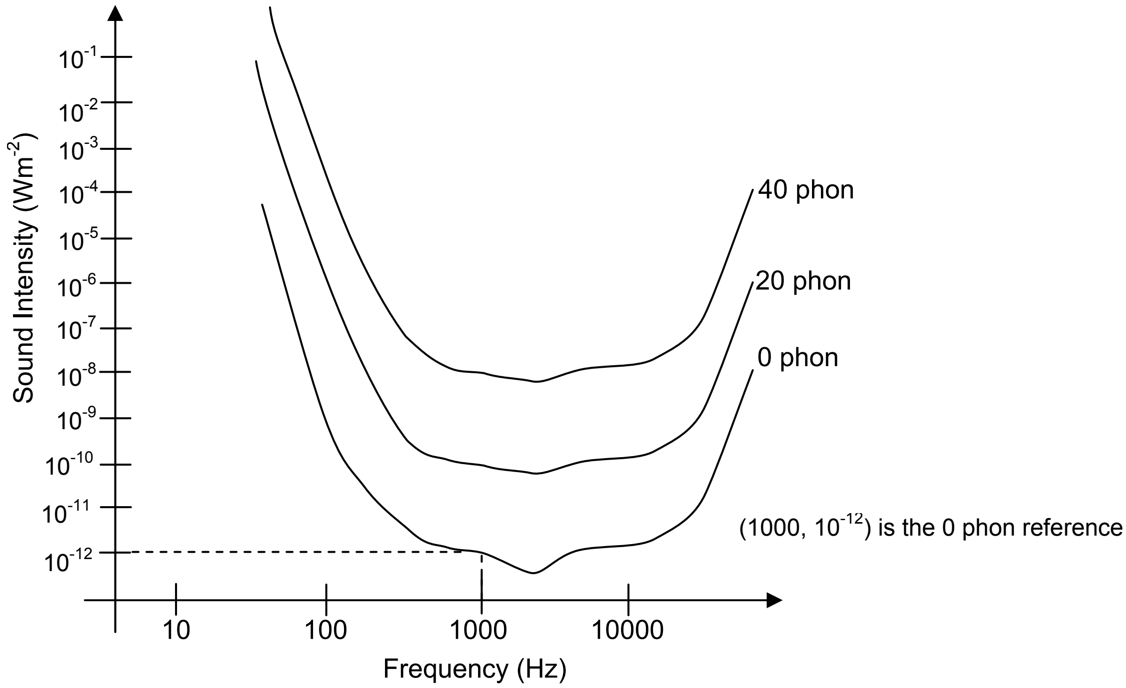
Question 8
Explain how having different sized drivers within a speaker system may allow for a greater fidelity for an audio signal.



(3 Marks)

Section B – Detailed Study 3 – continued
TURNOVER

Below is a series of three phon curves frequency response graph for Jerry, who is having his hearing tested.



Question 9
Explain how would the 0 phon frequency response graph have been made?

(2 Marks)

The frequency of sound that Jerry is listening to is set to 100 Hz and the sound intensity is set so that Jerry can just hear the sound.

Question 10
What is the sound intensity when Jerry can just hear the sound at 100 Hz?

(2 Marks)

Section B – Detailed Study 3 – continued
TURNOVER

Question 11
The sound intensity is kept constant as in Question 10 but the frequency is changed to 1000 Hz. Estimate how loud will Jerry perceive this 1000 Hz sound to be? Give your answer in phon.

(2 Marks)

END OF SECTION AND ANSWER BOOKLET

SOLUTION PATHWAY

Section A – Core
Area of Study 1 - Electric Power

Question 1
This suggests that the magnetic field is from right to left inside the solenoid.

Question 2
Right

First find the direction of the magnetic field inside the coil, using the right hand grip rule. The magnetic field inside the coil is to the left. This means that the right end of the solenoid is a magnetic south pole. The two south poles will repel and the bar magnet will move right.

Question 3
Left

Use the right hand slap rule, this wire will experience a force towards the left.

Question 4
0.037 N

Use $F = BIL$
$F = 0.4 \times 4.6 \times 0.02$
$F = 0.0368\text{N}$

Question 5
Clockwise

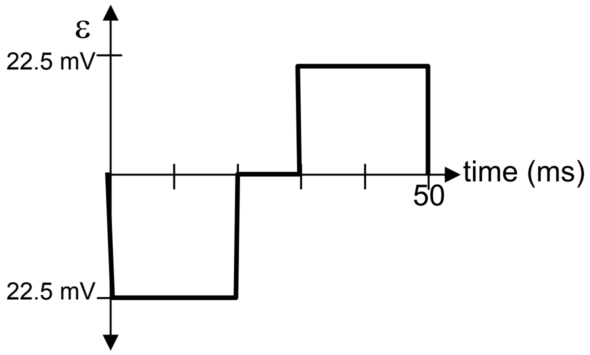
Use the right hand slap rule on one side of the loop, the right side of the loop has downward force acting on it, thus the loop will rotate in a clockwise direction.

Question 6
0 N

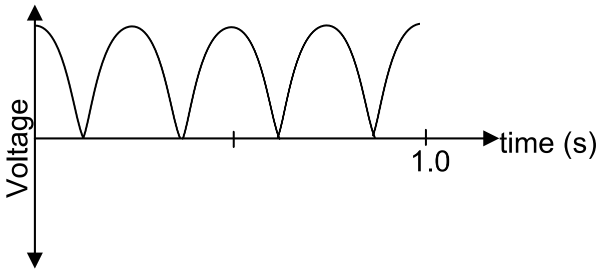
This is a tricky question, since the forces at any given time are equal in size and opposite in direction there is no net force acting on the motor.

Question 7
The purpose of the commutator is to reverse the direction of the current every half cycle. This will ensure the forces acting on one side of the motor are always in one direction and therefore a continuous rotation.

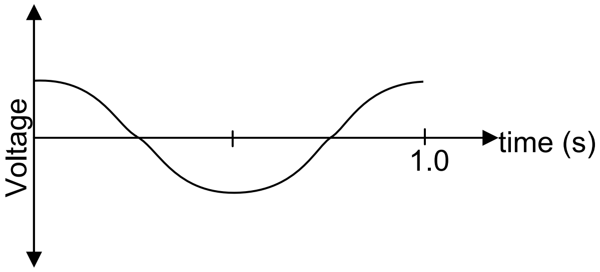
Question 8



Question 9



Question 10



Question 11

Since the light globe is 4.0 Ω out of 20 Ω for the circuit, the light globe is going to receive $\frac{4}{20}$ of the voltage supplied. So it will receive $2\times\frac{4}{20}V$ or 0.4 V.

If the light globe receives 0.4 V the power supplied to the light globe will be $P=\frac{V^2}{R}=\frac{0.4^2}{4}=0.04\,\text{W}$

So the power supplied to the light is 40 mW instead of 1.0 W so it is supplied with 25 times less power.

Question 12

For the light globe to be operating correctly it must have 2.0 V across it. This is then a simple voltage divider problem, if the light has 2.0 V then the wires must have 8.0 V, so the supply must be 10 V.

Question 13

The wires have a resistance of 16 Ω and a voltage of 8.0 V, so the power loss is

$$P_{loss} = \frac{{V_{loss}}^2}{R} = \frac{8^2}{16} = 4.0\text{ W}$$

Question 14

Simple step up 1:20
2:40

So the voltage across the secondary coil of the first transformer is 40 V.

Question 15

First calculate the current in the primary coil

I = $\frac{P}{V} = \frac{1.0}{2.0}$ = 0.50 A

then calculate the current in the second coil of the first transformer. The current is stepped down, so

20:1
0.5 : 0.025

So the current in the transmission wires is 0.025 A

Now use $V_{loss} = IR = 0.025 \times 16 = 0.4$ V

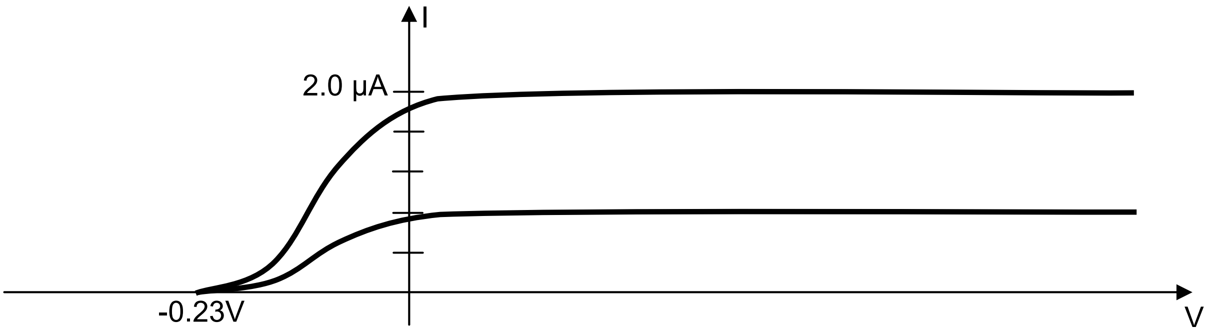
$$P_{loss} = I^2 R = 0.025^2 \times 16 = 0.01W$$

Question 16

The power used by the globe is 1.00 – 0.01 = 0.99W.

Area of Study 2 - Interaction of Light and Matter

Question 1



Question 2
$0.23 \times 1.6 \times 10^{-19} = 3.68 \times 10^{-20}$ J

Question 3
$W = hf - E_k$
$W = 6.63 \times 10^{-34} \times 600 \times 10^{12} - 3.68 \times 10^{-20}$
$W = 3.61 \times 10^{-19}$J $\div 1.6 \times 10^{-19}$
$W = 2.26$ eV

Question 4
$W = hf_o$
$3.61 \times 10^{-19} = 6.63 \times 10^{-34} \times f_o$
$f_o = 5.45 \times 10^{14}$ Hz

Question 5
$E_k = hf - W$
$E_k = 6.63 \times 10^{-19} \times 750 \times 10^{12} - 3.61 \times 10^{-19}$
$E_k = 1.36 \times 10^{-19}$J $\div 1.6 \times 10^{-19}$
$E_k = 0.85$ eV
So the stopping voltage is 0.85 volts.

Question 6
Take the gradient of the graph.

Question 7
It is where the line intercepts the x-axis, around 3.60 – 3.75 x 10^{14} Hz

Question 8
Previous answer multiplied 4.14×10^{-15}
1.49 eV → 1.55 eV.

Question 9
D, larger wavelength.

Question 10
The light bands are formed when a peak meets a peak and a trough meets a trough.
The dark bands are formed when a peak meets a trough.
This supports the wave model since the particle model would predict two dots on the wall and not the interference pattern.

Question 11
Since point P is the 3rd bright band out from the central point, the path difference must be 3λ.
So the path difference is $3\times580\times10^{-9}$ = 1740 nm.

Question 12
$250 \times 1.6\times10^{-19} = 4.0\times10^{-17}$ J

Question 13
$$\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{4\times10^{-17}} = 4.97 \text{ nm}$$

Question 14
$$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{4.97\times10^{-9}} = 1.33\times10^{-25} \text{ Ns}$$

Question 15
Since the electrons make the same pattern as the x-rays they have the same wavelength and momentum. So the momentum of the electrons is 1.33×10^{-25} Ns. The mass of the electrons is 9.1×10^{-31} kg.

Using p = mv we get $v = \frac{p}{m} = \frac{1.33\times10^{-25}}{9.1\times10^{-31}} = 1.47\times10^{5}$ mls

Question 16
Use $E_k = \frac{1}{2}mv^2 = \frac{1}{2}9.1\times10^{-31}\times1.47\times10^{5} = 9.8\times10^{-21}$ J

Question 17
Use $E = \frac{hc}{\lambda} = \frac{4.14\times10^{-15}\times3\times10^{8}}{496.95\times10^{-9}} = 2.5$ eV

Question 18
A 2.5 eV difference is from level 4 to level 2. 12.7 eV - 10.2 eV

Question 19
E, there are 6 different possibilities.

Question 20
13 eV missed everything
2.8 eV excited an electron to level 2
0.9 eV excited an electron to level 3
0.3 eV excited an electron to level 4

Section B - Detailed Study 1 - Synchrotron and its Applications

Question 1
First find the kinetic energy of the electrons

$$E_k = \tfrac{1}{2}mv^2 = \tfrac{1}{2}\times 9.1\times 10^{-31}\times\left(2.4\times 10^{7}\right)^2 = 2.62\times 10^{-16} \text{ J}$$

Now divide the energy by the charge on the electron to find the voltage.

$$V = \frac{E}{Q} = \frac{2.62\times 10^{-16}}{1.6\times 10^{-19}} = 1638 \text{ volts}$$

Question 2
Use p = mv = $9.1\times10^{-31}\times 2.4\times10^{7} = 2.18\times10^{23}$ Ns

Question 3

Use $r = \dfrac{mv}{eB} = \dfrac{2.18\times 10^{23}}{1.6\times 10^{-19}\times 2.6\times 10^{-3}} = 5.25$ cm

Question 4
First find the wavelength of the x-rays.

Use $E = \dfrac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} = \frac{4.14\times 10^{-15}\times 3\times 10^{8}}{22350} = 5.57\times 10^{-11} \text{ m}$$

Use $n\lambda = 2d\sin(\vartheta)$

For the first maximum on the graph *n* = 1

$$n\lambda = 2d\sin(\vartheta)$$

$$1\times 5.57\times 10^{-11} = 2\times 1.6\times 10^{-10}\sin(\vartheta_1)$$

$$\vartheta_1 = 10.0^\circ$$

For the second maximum on the graph *n* = 2

$$n\lambda = 2d\sin(\vartheta)$$

$$2\times 5.57\times 10^{-11} = 2\times 1.6\times 10^{-10}\sin(\vartheta_1)$$

$$\vartheta_2 = 20.4^\circ$$

Question 5

Use $p = \dfrac{h}{\lambda} = \dfrac{6.63\times 10^{-34}}{5.57\times 10^{-11}} = 1.2\times 10^{-23}\,Ns$

Question 6
Saying that they are not the same.
The divergence of the spectrum from the x-ray tube.
The brightness of the synchrotron compared to the x-ray.

Question 7

Use $p = \dfrac{h}{\lambda} = \dfrac{6.63 \times 10^{-34}}{65 \times 10^{-12}} = 1.02 \times 10^{-23}$ Ns

Question 8

Calculate the momentum of a 68pm photon first $p = \dfrac{h}{\lambda} = \dfrac{6.63 \times 10^{-34}}{68 \times 10^{-12}} = 0.975 \times 10^{-23}$ Ns

Now find the change in momentum. $1.02\times10^{-23} - 0.975\times10^{-23} = 0.045\times10^{-23}$ Ns

Question 9
Compton Scattering.

Question 10
Used to accelerate the electrons in a straight line, it will get the energy up to MeV.

Question 11
This is where the electrons are used, this is where the light is harvested.

Detailed Study 2 - Photonics

Question 1
E = $1.97 \times 1.6\times10^{-19}$
E = 3.15×10^{-19} J

Question 2
Use $E = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{3.15\times10^{-19}} = 631 \text{ nm}$$

Question 3
The correct answer is A.

Question 4
N.A. = $n_0\sin(\theta_a)$
N.A. = $1.0 \times \sin(9^o)$
N.A. = 0.156

Question 5
$n_0\sin(\theta_0) = n_1\sin(\theta_1)$
$1.0 \times \sin(9) = 1.46\times\sin(\theta_1)$
$\theta_1 = 6.15^o$

Question 6
$\theta_c = 90 – 6.15 = 83.85^o$

Question 7
$\sin(\theta_c) = \frac{n_2}{n_1}$
$n_2 = 1.45$

Question 8
As the optical fibres are brought closer to the wall, the amount of light that the receiving optical fibre get will be reduced, once calibrated this can be used to measure distance.

Question 9
Dispersion is the spreading of a light pulse, as the light pulses overlap the information is lost. Two main causes of dispersion are modal dispersion, where the light travels different paths down the optical fibre and thus arrive at different times. Modal dispersion is reduced by using single mode fibres.
The other main cause is material dispersion, this is cause by the optical fibre having different refractive indexes for different wavelengths. Material dispersion is reduced by using a monochromatic light source, e.g. LASER.

Question 10
Attenuation is the loss of the signal as it travels down the fibre; this is reduced by selecting wavelengths that have low losses.

Detailed Study 3 - Sound

Question 1
Λ = 0.17 m

Question 2
The area = $4\pi r^2 = 4 \times \pi \times 2.5^2 = 78.5\ m^2$
$I = P/A = 4/78.5 = 5.1\times10^{-2}\ W\ m^{-2}$

Question 3

Sound intensity loudness =
$$dB = 10\log\left(\frac{I}{I_0}\right) = 10\log\left(\frac{5.1\times10^{-2}}{1\times10^{-12}}\right) = 107\ dB$$

Question 4
$$\Delta dB = 10\log\left(\frac{r_2^{\,2}}{r_1^{\,2}}\right)$$
$$16 = 10\log\left(\frac{r_2^{\,2}}{2.5^2}\right)$$
$$1.6 = \log\left(\frac{r_2^{\,2}}{2.5^2}\right)$$
$$10^{1.6} = \frac{r_2^{\,2}}{2.5^2}$$
$$r_2 = 15.8m$$

Question 5
Since it is a closed end pipe, L = ¼ λ, so λ = 6.0 m
$v = f\lambda = 500\times6 = 3000\ ms^{-1}$

Question 6
A compression from the speaker travels down the pipe reflects off the closed end, travels back and reflects off the open end of the pipe as a rarefaction. If the reflecting rarefaction coincides with on generated by the speaker, the two will add together and resonate.

Question 7
The movement of the coil over the magnet induces a small current that is similar to the pressure waves.

Question 8
Smaller speakers are better at producing the higher frequencies, the larger speakers are better at producing the lower frequencies. Thus you get a better coverage of the frequencies required.

Question 9
The frequency is set to a value and the sound intensity is increased until Jerry can just hear it. This intensity is recorded. The intensity is then reduced and the frequency altered and the procedure is then repeated through the full range of frequencies.

Question 10
The sound intensity at 100Hz is 10^{-9} W m^{-2}

Question 11
If this is kept constant at 10^{-9} and the frequency is increased to 1000Hz, this will be roughly between the 20 phon and the 40 phon, so Jerry will perceive this sound to be 30 phon.

x phon = *x* dB @ 1000 kHz (reference frequency)