Neap:

Trial Examination 2010

VCE Physics Unit 4

Written Examination

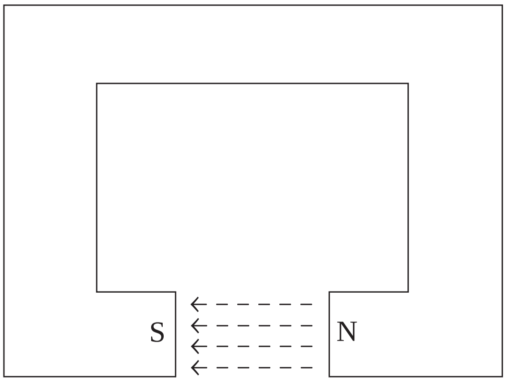
Suggested Solutions

SECTION A

Area of study 1 – Electric power

Question 1

The magnetic field lines between the poles of the magnet are as shown below. Note: the direction must be correct (North to South).



1 mark

Question 2 **B** 2 marks

The direction of the magnetic force acting on the current carrying wire is down (use the right hand slap rule or the left hand FBI rule).

Question 3

$F = IlB$

$= (5.0)(0.1)(1.2)$ 1 mark

$= 0.6\ \text{N}$ 1 mark

Question 4

$P = IV$

$I = \frac{2400}{240}$

$= 10\ \text{A}$ 2 marks

Question 5

The peak voltage for the kettle is $240\sqrt{2} = 339\ \text{V}$. 1 mark

Question 6

$P = I^2R$

$R = \frac{2400}{100} = 24\ \Omega$ 2 marks

Question 7

$F = NIlB$

$= (200)(2.0)(0.1)(1.0)$ 1 mark

$= 40\ \text{N}$ 1 mark

Question 8 **G** 2 marks

There is no force acting on side *BC* as the current runs parallel to the field lines.

Question 9 **B** 2 marks

DC motors require a split-ring commutator to work properly.

Question 10 **F** 1 mark

The direction of the magnetic field passing through the loop is out of the page (arrow convention).

Question 11

$\Phi_B = BA$

$= (1.5 \times 10^{-2})(0.1)(0.04)$ 1 mark

$= 6.0 \times 10^{-5}\ \text{Wb}$ 1 mark

Question 12

$\varepsilon = \left|\dfrac{-(BA)}{t}\right|$

$= \dfrac{(6.0 \times 10^{-5}\ \text{Wb})}{(0.2)}$ 1 mark

$= 3.0 \times 10^{-4}\ \text{V}$ 1 mark

consequential: $\dfrac{-\text{Ans(Q11)}}{(0.2)}$

Question 13 **A** 2 marks

As the loop is pulled out of the magnetic field, the direction of the induced current runs from *P* to *Q* (use Lenz's law).

Question 14

AC 1 mark

The voltage shown on the graph alternates between positive and negative values of voltage, hence producing an alternating current (AC) through a load resistor. 1 mark

Question 15

X	17.6	Volts
Y	–17.6	Volts
Z	0.025	seconds

3 marks

1 mark per correct answer

Question 16

$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$

1 mark

$$\frac{500}{N_S} = \frac{V_P}{V_S} = \frac{240}{12}$$

$$N_S = 25 \text{ turns}$$

1 mark

Question 17

Ideal transformer so that $P_P = P_S$ 1 mark

$P = IV$

$12 = I(240)$

$I = 0.05\ A$

1 mark

Question 18 **A** 2 marks

The transformer is warm because $P_{\text{primary}} > P_{\text{secondary}}$.

Question 19

$P = IV$

$$I = \frac{2.0 \times 10^5}{5 \times 10^3} = 40.0\ \text{A}$$

2 marks

Question 20

$P = I^2R$

$= (40)^2(5)$

$= 8.0\ \text{kW}$

2 marks

Area of study 2 – Interactions of light and matter

Question 1 **B** 2 marks

When light passes through each slit it initially undergoes **diffraction**.

Question 2 **B** 2 marks

Maximum diffraction of light occurs when the slit width is approximately equal to the wavelength of the light.

Question 3

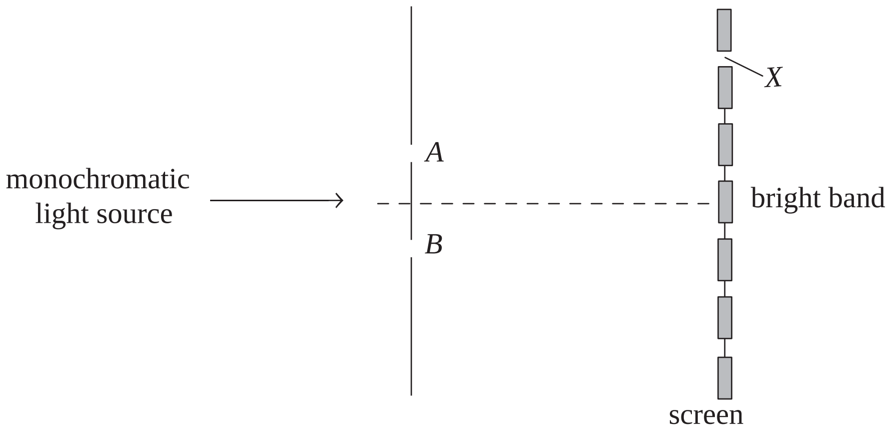
Path difference = 1750 nm, wavelength = 700 nm

$$\frac{\text{Path difference}}{\text{wavelength}} = \frac{1750}{700} = 2.5$$ 1 mark

Since destructive interference occurs when $\text{PD} = \left(n - \frac{1}{2}\right)\lambda$,

$n = 3$ and so X will be the third dark band from the centre. 1 mark

Marking on diagram the location of point X closer to slit A. 1 mark



Question 4

Bright bands occur when light waves undergo constructive interference because they are in phase when they meet at the screen. 1 mark

Dark bands occur when light waves undergo destructive interference because they are out of phase when they meet at the screen. 1 mark

This cannot be explained by the particle model as it is not possible for particles to meet and cancel each other out, hence the dark bands cannot be explained. 1 mark

Question 5

$W = hf_0 = (4.14 \times 10^{-15}) \times (6.0 \times 10^{14})$ 1 mark

$W = 2.5$ eV 1 mark

Question 6

V_0 is the **stopping voltage**. 1 mark

This is the voltage required to stop the **most energetic photoelectrons** which are ejected from the metal. 1 mark

Question 7

$E_{k(\max)} = hf - W = (4.14 \times 10^{-15} \times 7.0 \times 10^{14}) - 2.5 = 0.4$ eV 1 mark

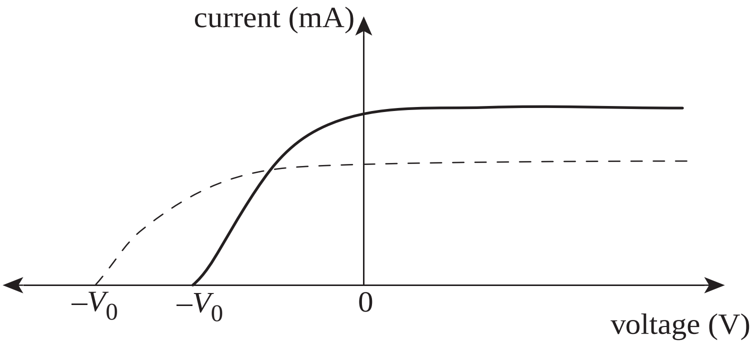
$0.4\ \text{eV} = 0.4 \times (1.6 \times 10^{-19})\ \text{J} = 6.6 \times 10^{-20}\ \text{J}$ 1 mark

$E_k = \frac{1}{2}mv^2$ so $6.6 \times 10^{-20} = \frac{1}{2}(9.1 \times 10^{-31})v^2$

$v = 3.8 \times 10^5\ \text{m s}^{-1}$ 1 mark

$\lambda = \frac{h}{mv} = \frac{(6.63 \times 10^{-34})}{(9.1 \times 10^{-31})} \times (3.8 \times 10^5) = 2.0 \times 10^{-9}$ m 1 mark

Question 8



Higher energy photon means more energetic photoelectrons so the magnitude of V_0 should be greater. 1 mark

The intensity is less so less photons are incident on the metal, resulting in less photoelectrons ejected and a lower photocurrent. 1 mark

Question 9

$E = \frac{hc}{\lambda}$

$(5.5 - 1.6) = (4.14 \times 10^{-15}) \times \frac{(3 \times 10^8)}{\lambda}$ 1 mark

$\lambda = 3.2 \times 10^{-7}$ m 1 mark

Question 10

$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{3.2 \times 10^{-7}}$ 1 mark

$= 2.1 \times 10^{-27}\ \text{kg m s}^{-1}$ 1 mark

Question 11

Since the energy of the photon (12 eV) is greater than the ionisation energy of the atom (10.4 eV), the photon will be absorbed. 1 mark

As a result of this, an electron would be ejected from the atom and ionisation would occur. 1 mark

SECTION B – Detailed Studies

Detailed study 1 – Synchrotron (26 marks)

Question 1 **C**

$\Delta E_k = qV(\text{in joules}) = V(\text{in electron volts})$. Hence the energy gain is 500 keV.

Question 2 **C**

$$F = \frac{qV}{d} \text{ so } a = \frac{qV}{dm} = (1.6 \times 10^{-19}) \times \frac{(500 \times 10^3)}{(0.4 \times 9.1 \times 10^{-31})}$$

$$A = 2.2 \times 10^{17} \text{ m s}^{-2}$$

Question 3 **D**

In the linac, electric fields further increase the speed of electrons initially accelerated by the electron gun.

Question 4 **A**

Using the right hand push rule, thumb points in direction of current (up the page) and fingers point in direction of magnetic field (into the page), palm pushes to the left so this is the direction of the force on the electron.

Question 5 **B**

$$B = \frac{mv}{rq} = \frac{(9.1 \times 10^{-31}) \times (1.5 \times 10^8)}{(0.1 \times 1.6 \times 10^{-19})} = 8.5 \times 10^{-3} \text{ T}$$

Question 6 **C**

$$a = \frac{v^2}{r} = \frac{(1.5 \times 10^8)^2}{0.1} = 2.3 \times 10^{17} \text{ m s}^{-2}$$

Question 7 **C**

Useful synchrotron radiation is predominantly produced in the storage ring.

Question 8 **D**

Synchrotron radiation is produced when electrons are accelerated by a magnetic field perpendicular to their direction of travel.

Question 9 **A**

Wigglers are used to produce a beam of intense, incoherent, broadband light.

Question 10 **B**

$$2d\sin\theta = n\lambda \text{ so } 2 \times d \times \sin(15.7) = 1 \times 1.3 \times 10^{-10}$$

$$d = 2.4 \times 10^{-10} \text{ m}$$

Question 11 C

For second order diffraction, $n = 2$.

$2d\sin\theta = n\lambda$ so $2 \times (2.4 \times 10^{-10}) \times \sin(\theta) = 2 \times 1.3 \times 10^{-10}$

$\theta = 32.7°$

Question 12 B

When Thompson scattering occurs there is no change in the wavelength as the collision is elastic. When Compton scattering occurs the collision is inelastic and the emerging photons have lower energy, hence lower frequency and longer wavelengths.

Question 13 D

In Bragg diffraction, photons are diffracted off a layer of atoms and no energy is transferred.

In Compton scattering, a photon-electron collision occurs and some (but not all) of the photon energy is transferred to the electron.

In Thompson scattering there is no transfer of energy to the electron.

In the photoelectric effect the photon is absorbed and all of its energy is transferred to the electron.

Detailed study 2 – Photonics (26 marks)

Question 1 B

The spectrometer would show that the light emitted by a 20 W incandescent light globe is polychromatic (creating a rainbow-like spectrum).

Question 2 D

The light emitted by a 20 W incandescent light globe is out of phase (incoherent).

Question 3 B

A laser produces light by the stimulated emission of photons.

Question 4 D

Laser light is coherent, monochromatic and in phase.

Question 5 B

The need for extreme caution when using lasers in the physics laboratory relates to the intensity of the laser light which is extremely concentrated and dangerous for human eyes.

Question 6 C

An LED produces red light by spontaneous emission of photons.

Question 7 B

The band energy gap is smaller for a red LED compared to a green LED as the red light has a lower frequency (and $E = hf$).

Question 8 B

The energy gap required for the production of the green light from the LED is

$$E = hf = \frac{hc}{\lambda}$$

$$= \frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{(5.15 \times 10^{-7})}$$

$$= 2.41 \text{ eV}$$

Question 9 C

Using Snell's law

$$n_1 \sin\theta c = n_2 \sin 90°$$

$$\theta c = \sin^{-1}\left(\frac{1.50}{1.52}\right)$$

$$= 80.7°$$

Question 10 B

Using the formula for the acceptance angle

$$\theta a = \sin^{-1}\sqrt{((n_1^2) - (n_2^2))}$$

$$= \sin^{-1}(0.2457)$$

$$= 14.2°$$

Question 11 D

Rayleigh scattering in relationship to an optic fibre is best explained as the scattering of light due to variations in impurities in the fibre.

Question 12 C

A coherent optic fibre bundle as used for medical imaging purposes is designed so that the individual fibres at both ends of the bundle are in the same position relative to each other to give an exact image.

Question 13 C

The 400 optical fibres bundle will give a more detailed image as, in a sense, these individual fibres behave like pixels in the formation of the image. The greater number of pixels per unit area, the greater the detail of the image.

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Detailed study 3 – Sound (26 marks)

Question 1 D

When sound travels through air, it travels as a longitudinal wave, where the particles vibrate parallel to the direction of wave motion.

Question 2 B

For a tube open at both ends, $f_n = \frac{nv}{2l}$

$$880 = \frac{(1 \times 350)}{(2 \times l)}$$

$$l = 0.20 \text{ m}$$

Question 3 D

The tube can produce whole number multiples of the fundamental frequency (880 Hz).

Since $3520 = 4 \times 880$, the frequency that can be produced is 3520 Hz. None of the other options are whole number multiples of 880.

Question 4 C

$$\text{dB} = 10\log_{10}\left(\frac{I}{10^{-12}}\right)$$

$$65 = 10\log_{10}\left(\frac{I}{10^{-12}}\right)$$

$$10^{6.5} = \frac{I}{10^{-12}}$$

$$I = 3.2 \times 10^{-6} \text{ Wm}^{-2}$$

Question 5 C

If the distance from the source doubles then the intensity will be a quarter of the original intensity (I varies with $\frac{1}{r^2}$).

For each half in intensity the dB level decreases by 3 dB, so the total decrease will be 6 dB and the new sound intensity level will be 59 dB.

Question 6 B

The middle of the tube is a pressure antinode and so the pressure varies between a value much higher than outside the tube and a value much lower than outside the tube.

Question 7 C

For the fundamental frequency in an open-ended tube, the middle of the tube will be an antinode where constructive interference is occurring.

Question 8 **A**

$\lambda = \frac{v}{f} = \frac{350}{880} = 0.4 \text{ m}$

For Chris to hear the sound, clearly diffraction must be occurring. This occurs most effectively if the gap size is smaller than or equal to the wavelength of the sound, hence the doorway must be less than or equal to 0.4 m in width.

Question 9 **C**

$v = f\lambda = \frac{\lambda}{T}$

From the graphs, $\lambda = 0.4 \text{ m}$, $T = 4 \times 10^{-3}$ sec, so $v = \frac{0.4}{(4 \times 10^{-3})} = 100 \text{ m s}^{-1}$.

Question 10 **B**

The electret-condenser microphone uses the principle of changing capacitance in its operation.

Question 11 **B**

In a moving coil loudspeaker, the movement of the speaker cone occurs because the changing current in the coil induces a changing magnetic field around the speaker coil. This interacts with the field of the bar magnet and the resultant magnetic force causes the coil and cone to move backwards or forwards.

Question 12 **C**

The ear is most sensitive in the section of the graph where the lowest intensities are required to hear the sound. This occurs between 2000 Hz and 5000 Hz.

Question 13 **A**

For sounds to be of equally perceived loudness, both points must be on the same curve. The only pair of sounds that are not points on the same curve are 100 Hz at 40 dB and 1000 Hz at 40 dB.