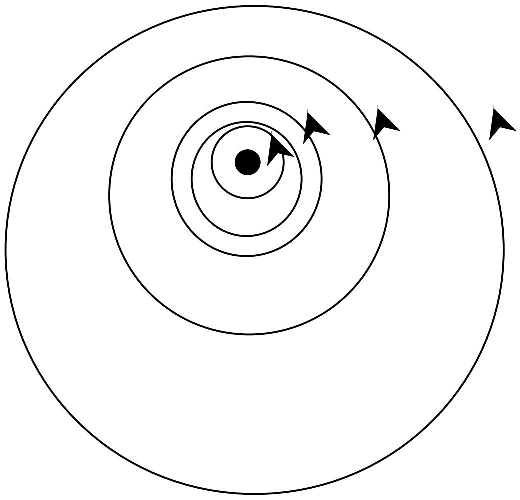
# THE SCHOOL FOR EXCELLENCE
# UNIT 4 PHYSICS 2006
# COMPLIMENTARY WRITTEN EXAMINATION 2

## SECTION A – CORE STUDIES

### AREA OF STUDY 1 – ELECTRIC POWER

**QUESTION 1**



1 mark for circular shape.
1 mark for directions correctly indicated.
1 mark for greater density of lines closer to conductor.

**QUESTION 2**

1 mark each for any 2 of:

- Insert a ferromagnetic material (eg soft iron bar)
- Decrease the diameter of the solenoid
- Increase the current into (or decrease the resistance of) the solenoid

**QUESTION 3**

$F = nBIl\sin\theta$
$\theta$ = zero N

**QUESTION 4**

$F = nBIl\sin\theta = 50 \times 0.10 \times 1.5 \times 0.12 \times \sin 90^0 = 0.90$ N

**QUESTION 5** Answer is A

**QUESTION 6** Answer is B

**QUESTION 7**

Zero Wb

**QUESTION 8**

$\varphi = BA = 0.10 \times (0.12 \times 0.08) = 9.6 \times 10^{-4}$ Wb

**QUESTION 9**

"As the armature rotates the **commutator / carbon brushes / stator coils** reverse the direction of the current leaving the generator every half a cycle resulting in **Alternating / Direct / Conventional** Current being fed to the external circuit."

**QUESTION 10** Answer is A

**QUESTION 11**

**a.** Zero.
**b.** To the left.
**c.** To the left.
**d.** To the right.

**QUESTION 12**

Increasing.

**QUESTION 13**

Bottom slip ring.

**QUESTION 14**

$$I = \frac{P}{V} = \frac{120}{240} = 0.5\,A$$

**QUESTION 15**

$$R = \frac{V}{I} = \frac{240}{0.5} = 480\ \Omega$$

**QUESTION 16**

Some power may be lost in the long connecting wires.

**QUESTION 17**

The Transformer has a 1:20 ratio so the voltage across the globe will be 20 x 10 = 200

**QUESTION 18**

$$I = \frac{V}{R} = \frac{200}{480} = 0.417A$$

**QUESTION 19**

Working backwards with the transformer ratio gives I = 0.417 x 20 = 8.3 A

**QUESTION 20**

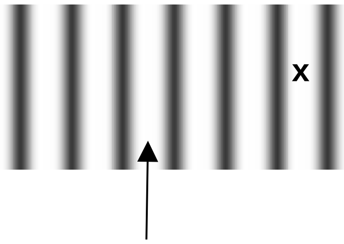
$$R = \frac{V}{I} = \frac{2}{8.3} = 0.24$$ or

$$P_{loss} = I^2 R = V_{drop} \times R = 2 \times 8.3 = 16.7\,W$$

Therefore: $R = \frac{P_{loss}}{I^2} = \frac{16.7}{8.3^2} = 0.24\ \Omega$

## AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

**QUESTION 1**




**QUESTION 2**

n = 2 (second dark band)

$$pd = (n - \tfrac{1}{2})\lambda$$

$$= (2 - \tfrac{1}{2})515 \times 10^{-9}\, m$$

$$= 7.73 \times 10^{-7}\, m$$

$$= 773\, nm$$

**QUESTION 3** Answer is A

Wavelength is larger

$\therefore$ Path difference is larger and bands are further apart.

**QUESTION 4**

$$W = hf_o$$

$$f_o = W / h$$

$$= 2.3 / 4.14 \times 10^{-15}\, Hz$$

$$= 5.56 \times 10^{14}\, Hz$$

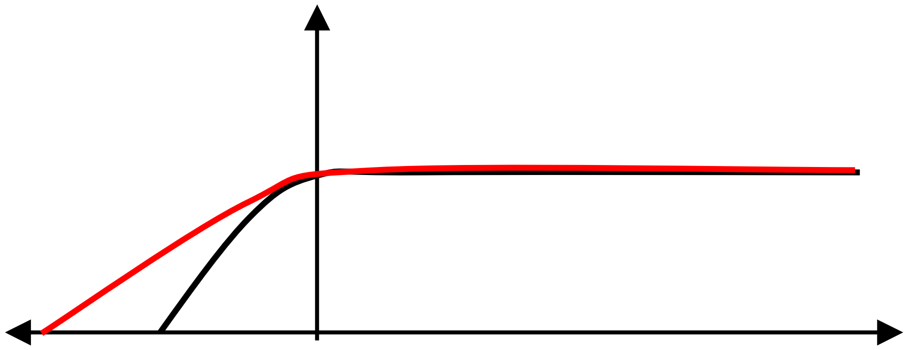
**QUESTION 5**

Voltage is the stopping voltage, $V_o$

$$V_o = hc / \lambda - W$$

$$= \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{360 \times 10^{-9}} - 2.3\, V = 1.15\, V$$

**QUESTION 6**




- 1 mark for greater stopping voltage.
- 1 mark for same photocurrent.

**QUESTION 7** Answer is D

**QUESTION 8**

4th excited state: n = 5, -0.5 eV
Ground state: n = 1, -13.6 eV

$$E_{photon} = E_5 - E_1$$
$$= -0.5 - (-13.6)$$
$$= 13.1\, eV$$

$$f = E_{photon} / h$$

$$= 13.1 / 4.14 \times 10^{-15}\, Hz$$
$$= 3.16 \times 10^{15}\, Hz$$

(1 mark for calculation of $E$, 1 mark for calculation of $f$).

**QUESTION 9**

| | | |
|---|---|---|
| n = 3 $\rightarrow$ n = 1 | n = 3 $\rightarrow$ n = 2 | n = 2 $\rightarrow$ n = 1 |
| 13.6 – 1.5 = 12.1 eV | 3.4 – 1.5 = 1.9 eV | 13.6 – 3.4 = 10.2 eV |

(1 mark for each calculation)

**QUESTION 10** Answer is D

**QUESTION 11**

Bohr's model of the atom does not explain why particular energy levels are occupied by the electrons. The wave model gives the electron a wavelength. These wavelengths must have specific lengths and therefore energies so that standing waves around the nucleus can be sustained.

**QUESTION 12** Answer is A

- To produce a clear image of the virus, diffraction must be avoided.
- Diffraction occurs when the object is of the same order of the wavelength. $w \approx \lambda$.
- To avoid diffraction need $w >> \lambda$.
- Electrons have the smallest wavelength of all the imaging equipment.

## DETAILED STUDY 1 - SYNCHROTRON AND ITS APPLICATIONS

**QUESTION 1**

Positively charged.

**QUESTION 2**

$$E = \frac{V}{d} = \frac{1000}{0.02} = 5.0 \times 10^4 \ Vm^{-1}$$

**QUESTION 3**

$$E = qV = 1.6 \times 10^{-19} \times 10^3 = 1.6 \times 10^{-16} \ J$$

**QUESTION 4**

$$v = \sqrt{\frac{2\,E}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-16}}{9.1 \times 10^{-31}}} = 1.9 \times 10^7 \ ms^{-1}$$

**QUESTION 5**

Electrons travel at a constant speed through the tubes while the polarity switches. Since the electrons are accelerating between the tubes they cover a progressively greater distance during the switching process. The tubes must therefore be of increasing length because the period of time is constant.

**QUESTION 6**

Answers include: B, C and D.

**QUESTION 7**

$6.9 \times 10^{-14}\ N$

**QUESTION 8** Answer is E

**QUESTION 9**

$$r = \frac{mv}{qB} = 0.047m$$

**QUESTION 10**

Synchrotron X-rays are:

- Broader spectrum
- More intense
- Pulsed
- Polarised

**QUESTION 11**

$$\lambda_{(1)} = 2d\sin\theta = 2 \times 0.22 \times 10^{-9} \times \sin 17.5 = 1.3 \times 10^{-10}\ m$$

**QUESTION 12**

$$\sin\theta_2 = \frac{n\lambda}{2d} = \frac{2 \times 1.3 \times 10^{-10}}{2 \times 0.22 \times 10^{-9}} = 0.59, \quad \theta = 36.2^o$$

(or 37$^o$ depending on when rounding occurs).

**QUESTION 13**

Rays scattered from the layer below the surface travel an additional two wavelengths. They constructively interfere with rays scattered from the surface layer to produce a maximum.

**QUESTION 14**

Thomson scattered X-rays have no change in wavelength or energy, whereas Compton scattered X-rays have an increase in wavelength and a decrease in energy.

## DETAILED STUDY 2 - PHOTONICS

**QUESTION 1** Answer is B

**QUESTION 2** Answer is B and C

**QUESTION 3**

$$E_{GAP} = \frac{h\,c}{\lambda} = \frac{4.14\times10^{-15}\times3\times10^{8}}{930\times10^{-9}} = 1.34\ eV$$

**QUESTION 4**

$$Atten = 10\log\frac{power\ output}{power\ input} = 10\log\frac{1.6}{6.4} = -6.0\,dB$$

**QUESTION 5**

$$Atten\ rate = \frac{attenuation}{length} = \frac{-6.0}{20} = -0.3\,dB\,km^{-1}$$

**QUESTION 6** 1500 nm

**QUESTION 7**

Absorption due to hydroxyl ions in the glass.

**QUESTION 8**

O – Si bonds in the glass absorb in the region beyond 1600 nm.

**QUESTION 9**

$$NA = n_{EXT}\sqrt{n_1^2 - n_2^2} = 1.0\sqrt{1.5^2 - 1.4^2} = 0.54$$

**QUESTION 10**

$$\sin a = 0.54; \qquad a = 33^o$$

**QUESTION 11**

(a) Use a smaller diameter fibre. This means there will be fewer possible modes.
(b) Use a graded-index fibre.
(c) Use single-mode fibres.

**QUESTION 12**

$$\text{max } freq = \frac{1}{period} = \frac{1}{40 \times 10^{-9}} = 2.5 \times 10^{7} = 25\,MHz$$

If the frequency increases beyond 25 MHz there will be overlap of signal pulses.

**QUESTION 13**

Modern telecommunications utilizes relatively high frequency signals. At these frequencies copper wire experiences significant attenuation, whereas optical fibres have low attenuation over a broad range of frequencies.

Optical fibres are not prone to interference from electromagnetic sources unlike copper wire transmission.

## DETAILED STUDY 3 - SOUND

**QUESTION 1** Answer is 0.25

**QUESTION 2** Answer is A

**QUESTION 3**

$\lambda = vT$

$\lambda = 340\,ms^{-1} \times 6.0 \times 10^{-4}\,s = 0.204\ m$ (or 0.20m to 2 sig figs).

**QUESTION 4** Answer is D

$$I \alpha \frac{1}{r^2} = r^2 \alpha \frac{1}{I} = r \alpha \frac{1}{\sqrt{I}}.$$

*I* has been changed by $\frac{4.0 \times 10^{-7}}{1.0 \times 10^{-7}} = 4$

*I* is up by a factor of 4.

Distance is reduced by a factor of $\frac{1}{\sqrt{4}} or \frac{1}{2} = \frac{400}{2}$ = 200

**QUESTION 5**

Loud (central maximum).

**QUESTION 6** 3.0 m

The second minimum (quiet region) is 0.75 $\lambda$. The wavelength of the sound is 2.0m, placing Tania 1.5m from her starting position and 3.0m from the nearest speaker.

**QUESTION 7**

The fundamental frequency for the bugle $= f_1 = 88Hz$ . The other easily produced notes are $264\ Hz = 3f_1, 352\ Hz = 4f_1\ and\ 440\ Hz = 5f_1.$, hence the bugle is an open pipe since there is an even harmonic produced.

**QUESTION 8**

For the fundamental frequency:

The length of the pipe $= \frac{wavelength}{2} = \frac{velocity}{2\times\ frequency} = \frac{340}{2\times 88} = 1.9\ m$

**QUESTION 9**

$\lambda_{fundamental} = 0.17m$

**QUESTION 10**

Sound generated from the back of a speaker is half a wavelength out of phase with sound forward of the speaker. This is because a rarefaction is produced behind the speaker when a compression is produced at the front of the speaker. However, sound emerging from the front port has also travelled an additional half a wavelength which places it in phase with the front of the speaker. Since the direct source and the reflected sources are in phase, constructive interfere occurs.

**QUESTION 11**

Principle: the air movement associated with the sound moves the metallic ribbon in the magnetic field. As the ribbon cuts the flux an emf is induced which is proportional to the velocity of the ribbon.

**QUESTION 12**

A "flat" frequency response is ideal which means that the microphone is equally sensitive to all frequencies. It should be “flat” for the broadest possible bandwidth of the human range of hearing. In this case, within the range of frequencies encountered in music and speech, no frequencies are exaggerated or reduced, resulting in a more accurate representation of the original sound (high fidelity).