THE SCHOOL FOR EXCELLENCE

UNIT 4 PHYSICS 2010

COMPLIMENTARY WRITTEN EXAMINATION 2

ERRORS AND UPDATES

Please report errors by email (admin@tsfx.com.au). Errors and updates relating to this examination paper will be posted at www.tsfx.com.au/vic/examupdates

SECTION A – CORE STUDIES

AREA OF STUDY 1 – ELECTRIC POWER

QUESTION 1 Answer is A

The direction can be found using the right hand grip rule. The magnetic field strength reduces by $1/r^2$ perpendicular from the surface of the conductor or wire.

QUESTION 2 N (North) at the back, S (South) at the front.

Determined using the right hand grip rule.

QUESTION 3 Down

The direction can be found using the right hand slap rule.

QUESTION 4 $F = BIl = 0.1 \times 0.5 \times 0.1 = 0.005N = 5 \times 10^{-3} N$

QUESTION 5 Force of the wire is approximately halved due to l being half.
Wire moves into the page.

QUESTION 6 Clockwise

QUESTION 7 0 Wb as the area of the coil lies parallel to the direction of the magnetic field.

QUESTION 8 $\Phi = BA = 0.4 \times (0.03)^2 = 3.6 \times 10^{-4} Wb$

QUESTION 9

$$F = nBIl$$
$$= 100 \times 0.4 \times 0.5 \times 0.03$$
$$= 0.6N$$

QUESTION 10

Place a second set of magnets above and below the coil [1 mark]. Coil will always experience a force. [1 mark]

OR

Increase I, no. of turns or B [1 mark for either]. This will increase $F=nBIl$. If increase is large enough, the coil will have enough momentum to keep rotating through the vertical. [1 mark]

QUESTION 11 Answer is C

No change in flux occurs.

QUESTION 12 Answer is C

An increase in the flux into the page will cause an anticlockwise current to be induced.

QUESTION 13 Answer is D

QUESTION 14 Clockwise [1 mark] Terminal A [1 mark]

QUESTION 15 Reading Max area from graph in correct units. [1 mark]
Time to go from Area(max) to Area(min) is ¼ of cycle. [1 mark]

$$\xi_{av} = -nB\frac{\Delta A}{\Delta t}$$

$$= -150 \times 0.2 \times \frac{1000/10^6}{0.02/4} \qquad \text{[1 mark]}$$

$$= 6V$$

QUESTION 16 Answer is B

The Emf vs. Time graph can be determined by taking the negative gradient of the Area vs. Time graph.

QUESTION 17

$$\frac{n_p}{n_s} = \frac{V_p}{V_s}$$

$$\frac{1000}{n_s} = \frac{240}{24}$$

$$n_s = 100 turns$$

QUESTION 18

$$I_p = \frac{P}{V_p}$$

$$= \frac{18}{240}$$

$$= 0.075A$$

QUESTION 19 **A** for placement of power cord [1 mark]
Power at A = Power at B [1 mark]
Therefore if $V_A > V_B$ then $I_B > I_A$ [1 mark]
Power loss in extension lead $P_{loss} = I^2R$, therefore power loss at B will be larger and less efficient. [1 mark]

AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

QUESTION 1 ULTRAVIOLET

This can be read directly from the graph or assumed given that UV radiation is of a higher frequency than blue light and results in the photoelectrons having a greater kinetic energy and therefore requiring a stopping voltage of greater magnitude.

QUESTION 2 ULTRAVIOLET

This may simply be known or evaluated by comparing the stopping voltages indicated in Figure 1.

QUESTION 3 UNABLE TO DETERMINE

Higher frequency light has photons of higher energy, so less photons are needed to provide an equivalent intensity of radiation. Less photons would result in a lower photocurrent. Therefore, because BLUE has a higher photocurrent doesn't necessarily imply it has higher intensity.

QUESTION 4 Answer is D

The greater frequency of UV (compared to blue) leads to emitted photoelectrons having a greater kinetic energy.

QUESTION 5 Answer is D

4→3, 4→2, 4→1, 3→1, 3→2, 2→1 are the 6 possible "energy drops" resulting in photons of different wavelengths.

QUESTION 6

The lowest frequency of light relates to the lowest energy drop between two levels. This is from n=3 to n=2. The energy of the emitted photons would be 1.8 eV.

$$E = hf$$

$$\therefore \; f = \frac{E}{h} = \frac{1.8}{4.14 \times 10^{-15}} = 4.35 \times 10^{14} \text{ Hz}$$

QUESTION 7

Energy of incident photon = $E = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{1 \times 10^{-7}} = 12.42\ eV$

This provides the 10.4 eV for an electron to be ejected and it will have the remaining 2.02 eV as kinetic energy. 2.02 eV → 3.232×10^{-19} J

The maximum speed of the electrons can be calculated:

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times 3.232 \times 10^{-19}}{9.11 \times 10^{-31}}} = 8.42 \times 10^{5}\ m/s$$

QUESTION 8

For electrons to behave as waves (or with a wavelength), the length of any orbit would need to equal an integer number of wavelengths. This would give rise to a standing wave pattern at each possible orbit. These quantized orbits result in the electrons only existing at particular "quantized" energy levels. Subsequently, the confirmed presence of these energy levels supports the wave model for electrons.

QUESTION 9

D, E, F spread of bands $\propto \frac{\lambda L}{w}$

QUESTION 10

Superposition, constructive, coherent, wave.

QUESTION 11

10 keV = 1×10^{4} eV

$$\lambda = \frac{hc}{E} = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{1 \times 10^{4}} = 1.24 \times 10^{-10}\ m$$

QUESTION 12 Answer is D

DETAILED STUDY 1 – SYNCHROTRON AND ITS APPLICATIONS

QUESTION 1 Answer is C

The direction of the electric field is the direction of force that would act on a test positive charge.

QUESTION 2 Answer is D

$$\frac{1}{2}mv^2 = qV$$

$$V = \frac{mv^2}{2q} = \frac{9.1\times10^{-31}\times\left(6.0\times10^{7}\right)^2}{2\times1.6\times10^{-19}} = 10230 \approx 10kV$$

QUESTION 3 Answer is D

Use of Right Hand Slap rule with current from right to left, gives DOWN.

QUESTION 4 Answer is B

Electrons don't pass through the beamline which eliminates A and D. The booster ring increases the speed of electrons passing out the linac.

QUESTION 5 Answer is A

The acceleration of the electron's path due to the magnetic field produces a changing electric field, which in turn produces a changing magnetic field.

QUESTION 6 Answer is B

$$F_M = Bqv = 0.1\times1.6\times10^{-19}\times2.9\times10^{8} = 4.6\times10^{-12}\ N$$

QUESTION 7 Answer is B

$$E = \frac{hc}{\lambda} = \frac{4.14\times10^{-15}\ 3\times10^{8}}{0.11\times10^{-9}} = 11300 = 11.3keV$$

QUESTION 8 Answer is B

$n\lambda = 2d\sin\theta$, where n =2

$$\sin\theta = \frac{2\times0.11\times10^{-9}}{2\times4\times10^{-10}} = 0.275\ ;$$

$$\theta = 16.0^o$$

QUESTION 9 Answer is C

$n\lambda = 2d\sin\theta$

$n = \dfrac{2 \times 4.0 \times 10^{-10} \times \sin\theta}{0.11 \times 10^{-9}} = 7.3\sin\theta$, therefore n = 7

(number of constructive interference zones)

QUESTION 10 Answer is A

As Thomson scattering is elastic, the scattered photons have the same momentum as the incident photons.

QUESTION 11 Answer is C

This is an example of Thomson scattering in which scattered photons maintain their momentum (and wavelength) and interfere constructively with incident photons.

QUESTION 12 Answer is D

The loss of energy from an inelastic collision results in a longer wavelength.

QUESTION 13 Answer is B

The undulator produces radiation that is more intense for specific wavelengths, whereas the multipole wiggler produces a broader spectrum of radiation that is less intense.

DETAILED STUDY 2 – PHOTONICS

QUESTION 1 Answer is B Spontaneous emission of photons.

QUESTION 2 Answer is B

$$\lambda = \frac{h.c}{E} = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{2.46} = 5.05 \times 10^{-7} = 505\,nm$$

QUESTION 3 Answer is C

Single mode reduces modal dispersion and the LD has a smaller bandwidth which reduces material dispersion.

QUESTION 4 Answer is C $\sin\theta_C = \frac{1.41}{1.46}$; $\theta_C = 75^o$

QUESTION 5 Answer is A Total internal reflection

QUESTION 6 Answer is A

The angle some of the light strikes the cladding interface changes as the wing bends resulting in some of the light dropping below the critical angle and entering the cladding.

QUESTION 7 Answer is A

QUESTION 8 Answer is D

NA = $\sqrt{n_1^2 - n_2^2} = \sqrt{1.46^2 - 1.41^2} = 0.38$

QUESTION 9 Answer is D

1 dB attenuation per kilometre over 20 km results in a total signal loss of 20 dB.

QUESTION 10 Answer is C The infrared absorption edge.

QUESTION 11 Answer is D

The immunity to electromagnetic ‘noise’ is useful but insignificant compared to the benefits associated with the extremely large bandwidth of optical fibres.

QUESTION 12 Answer is B

Different modes or paths will result in different path lengths, causing signals to be received out-of-phase.

QUESTION 13 Answer is C

The imaging fibres must be coherent but this is not necessary for the ‘illuminating’ fibres.

DETAILED STUDY 3 – SOUND

QUESTION 1 Answer is D

The sound waves vibrate a metal ribbon within a magnetic field resulting in the induction of electric current in a velocity-ribbon microphone.

QUESTION 2 Answer is C

This is the only response curve with a higher, flat region for the lower frequencies.

QUESTION 3 Answer is C

QUESTION 4 Answer is B

The thin peaks result from resonances within the speaker box. The fundamental frequencies will be most visible on a response curve. These resonances relate to the dimensions of the box.

QUESTION 5 Answer is A

$I = 10^{\frac{L}{10}-12} = 10^{\frac{140}{10}-12} = 10^2$ W/m^2

QUESTION 6 Answer is A $L = 10\log\frac{2\times10^2}{1\times10^{-12}} = 143\ dB$

QUESTION 7 Answer is D

Double the distance → intensity decreases by a factor of 4.

$\Delta L = 10\log\frac{0.25\times10^2}{1\times10^2} = -6$ dB

QUESTION 8 Answer is D v = fλ = 270 × 1.8 = 486 m/s

QUESTION 9 Answer is D

At 37ºC the speed of sound in air is approximately 350 m/s.

QUESTION 10 Answer is C

n=5 → $f_n \propto 1/L$ $f_5 = 5f_1$ $L_5 = L_1/5$

QUESTION 11 Answer is A

The time for the sound to get to the microphone is 0.005 s, so the answer can only be A or C. The period of the wave is also 0.005 s but this is so for all 4 options. Assuming the speaker commenced to oscillate from a resting (median) position, so will the sound signal at the microphone 0.005 seconds later.

QUESTION 12 Answer is C

Our hearing is more sensitive to the mid-range frequencies (2000 – 5000 Hz) and we naturally hear them louder.

QUESTION 13 Answer is A

Lower frequency sounds have **longer** wavelengths.