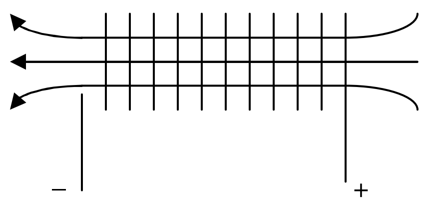
2010 VCAA Physics Exam 2 Solutions

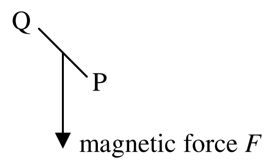
Area of study 1 – Electric power

Q1



Q2 Zero flux, the magnetic field inside the solenoid is parallel to the plane of the rectangular loop.

Q3



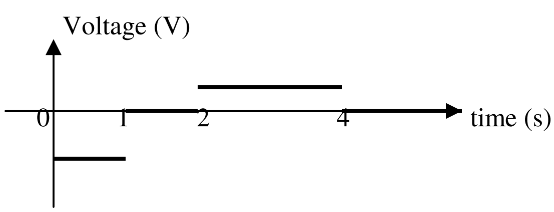
Q4 $F = nBIL = 3\left(5.0\times10^{-2}\right)(4.0)(0.040) = 0.024\text{ N}$

Q5 Zero force, QR is parallel to the magnetic field inside the solenoid.

Q6 Graph A, $\xi_{av} = -\frac{\Delta\phi}{\Delta t}$

Q7 A split-ring commutator alternates the contact of the loop terminals with the two brushes. This happens every half turn of the loop if the ring is split in halves. It is used in DC generators (in the context of electric generator).
Slip rings maintain the contact of each loop end with the same brush. It is used in alternators.

Q8



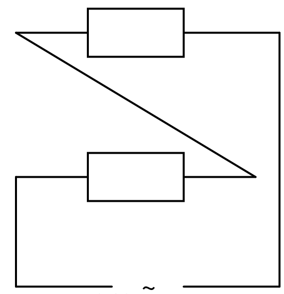
Q9 Faraday's law

Q10 $\xi_{av} = -n\frac{\Delta\phi}{\Delta t} = -120\times\frac{0-3.0\times10^{-4}}{0.012} = 3.0\text{ V}$

Q11 Direction: Q $\rightarrow$ P
According to Lenz's law, induced current flows in the direction so that it generates a magnetic field to *oppose* the reduction in the magnetic field of an external source.

Q12 $P = \frac{V^2}{R} = \frac{240^2}{48} = 1200\text{ W}$

Q13



Q14 There is a drop in voltage in the transmission lines. .: the voltage across the globe is less than 2.0 V and does not operate at its optimal power of 4.0 W.

Q15 $I = \frac{P}{V} = \frac{4.0}{2.0} = 2.0\text{ A}$

$V_{drop} = IR = 2.0\times4.0 = 8.0\text{ V}$

$V_{setting} = 8.0 + 2.0 = 10\text{ V}$

Q16 $P_{loss} = I^2R = 2.0^2\times4.0 = 16\text{ W}$

Q17 AC is often used so that transformers can be employed to step up the voltage for transmission to reduce power loss due to heating, then step down to the correct voltage for household or commercial usage.

Q18 Answer D.

$V_{peak} = \sqrt{2}\times20.8 = 29.4\text{ V}$

$V_{peak-peak} = 2\times29.4 = 58.8\text{ V}$

Q19 $\frac{n}{1460} = \frac{1}{10}$, $n = 146$

Q20 $I_{globe} = 2.0\text{ A}$, $I_{lines} = \frac{1}{10}\times2.0 = 0.20\text{ A}$

$P_{loss} = 0.20^2\times4.0 = 0.16\text{ W}$

Area of study 2 – Interactions of light and matter

Q1 Young's double-slit experiment produced an interference pattern of light from two slits. Interference pattern is a wave phenomenon and can be easily demonstrated using water waves from two dippers generating coherent circular waves at the surface of water. .: Young's experiment supports the wave model.

Q2 Observation number 2: Einstein used Planck's photon (particle) model to explain the photoelectric effect in his equation $KE_{\max} = hf - W$, where *f* is the frequency of the light and *W* the work function for the metal. Intensity of the light does not appear in the equation. Clearly the energy of emitted electrons depends on the frequency of the light and is independent of the intensity. Only light, with frequency higher than certain value (called the threshold frequency), can cause the emission of photoelectrons.

Q3 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{580\times10^{-9}} = 2.14 \text{ eV}$

Q4 $S_2X - S_1X = 2\lambda = 1160 \text{ nm}$, .: $\lambda = 580 \text{ nm}$
$S_2Y - S_1Y = 2.5\lambda = 1450 \text{ nm}$

Q5 Graph D. Intensity has no effects on the energy of photoelectrons.

Q6 Graph A. Both graphs have the same gradient (same *h*), and the '*y*-intercept' for magnesium is above that for selenium.

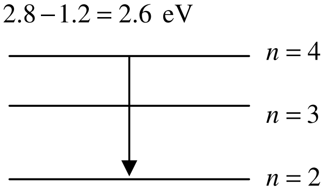
Q7 $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(9.1\times10^{-31})(1.5\times10^{7})} = 4.86\times10^{-11} \text{ m}$
$= 0.0486 \text{ nm}$

Q8 Pattern A. Higher speed $\rightarrow$ higher momentum
$\rightarrow$ shorter wavelength $\rightarrow$ less diffraction, i.e. smaller ring radii.

Q9 X-rays are electromagnetic waves, and electrons have wave behaviours. Diffractions can occur for both. If they have the same wavelength, they produce a similar pattern.

Q10 *Electron energy* $= 600 \text{ eV} = 600\times(1.6\times10^{-19}) = 9.6\times10^{-17} \text{ J}$
Electron momentum $= p = \sqrt{2mE_k}$
$= \sqrt{2(9.1\times10^{-31})(9.6\times10^{-17})} = 1.322\times10^{-23} \text{ kg ms}^{-1}$
Similar pattern .: same λ and .: same *p*.
Photon energy $= E = pc = (1.322\times10^{-23})(3.0\times10^{8})$
$= 3.965\times10^{-15} \text{ J} = \frac{3.985\times10^{-15}}{1.6\times10^{-19}} = 2.5\times10^{4} \text{ eV}$

Q11 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{478\times10^{-9}} = 2.6 \text{ eV}$
$E_{n=4} - E_{n=2} = 12.8 - 1.2 = 2.6 \text{ eV}$



Detailed study 1 – Synchrotron and its applications

1	2	3	4	5	6	7	8	9	10	11	12
B	C	B	B	C	B	A	C	A	B	D	D

Q1 $E = \frac{F}{e} = \frac{ma}{e} = \frac{(9.1\times10^{-31})(1.8\times10^{15})}{1.6\times10^{-19}} = 10237.5 \text{ Vm}^{-1}$
$\approx 10 \text{ kVm}^{-1}$ B

Q2 $eV = \frac{1}{2}mv^2$
$V = \frac{mv^2}{2e} = \frac{(9.1\times10^{-31})(4.6\times10^{7})^2}{2(1.6\times10^{-19})} = 6017 \text{ V}$ C

Q3 $B = \frac{mv}{re} = \frac{(9.1\times10^{-31})(4.6\times10^{7})}{0.40(1.6\times10^{-19})} = 6.5\times10^{-4} \text{ T}$ B

Q4 $F = evB = (1.6\times10^{-19})(4.6\times10^{7})(6.5\times10^{-4}) = 4.8\times10^{-15} \text{ N}$
B

Q5 C

Q6 B

Q7 $n\lambda = 2d\sin\theta$, $\lambda = 2\times0.314\sin15° = 0.163 \text{ nm}$ A

Q8 $\sin\theta = \frac{n\lambda}{2d} = n\left(\frac{0.200}{2\times0.314}\right) = 0.3185n$, where $0 \le \theta \le 90$.
Maximum value of $\sin\theta = 1$, .: $n = 3$ C

Q9 A

Q10 B

Q11 D

Q12 Changing direction is acceleration. D

Detailed study 2 – Photonics

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	C	D	B	B	C	D	C	B	C

Q1 C

Q2 $\lambda = \frac{hc}{Ve} = \frac{(6.63\times10^{-34})(3.0\times10^{8})}{2.0(1.6\times10^{-19})} = 6.22\times10^{-7}\text{ m} = 622\text{ nm}$ C

Q3 $V_{diode} = 2.0\text{ V},\ V_R = 12 - 2.0 = 10\text{ V},$

$I_{ammeter} = I_R = \frac{V_R}{R} = \frac{10}{400} = 0.025\text{ A} = 25\text{ mA}$ B

Q4 $V_{diode} = \frac{hc}{e\lambda}$, blue light has shorter wavelength .: V_{diode} is higher .: V_R is lower and hence $I_{diode} = I_R$ is reduced. C

Q5 $i_c = \sin^{-1}\left(\frac{1.38}{1.44}\right) = 73.4°$ D

Q6 $1.00\sin\alpha = 1.44\sin(90 - 73.4)°,\ \alpha = 24.3°$ B

Q7 B

Q8 The refractive index of water (1.33) is higher than that of the plastic rod (1.20). Total internal reflection cannot now occur. C

Q9 D

Q10 Add up the attenuation due to Rayleigh scattering and absorption. At 1200 nm the sum is about 1.6 watt/km which is the least signal loss. C

Q11 B

Q12 C

Detailed study 3 – Sound

1	2	3	4	5	6	7	8	9	10	11	12
B	D	A	C	C	D	C	C	B	B	A	D

Q1 $\lambda = \frac{v}{f} = \frac{330}{512} = 0.64\text{ m}$ B

Q2 D

Q3 $I = 10^{\frac{L}{10}-12} = 10^{7-12} = 1.0\times10^{-5}\text{ W m}^{-2}$ A

Q4 20 m is 4 times 5 m .: I becomes $\frac{1}{16} = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$. Every time I is halved, L is lowered by 3 dB.
The new $L = 70 - 4\times3 = 58\text{ dB}$ C

Q5 Read from graph. C

Q6 $\lambda = \frac{v}{f} = \frac{320}{133} = 2.4\text{ m}$
For a tube closed at one end, the first resonant frequency occurs when $4L = \lambda$. .: $L = \frac{\lambda}{4} = \frac{2.4}{4} = 0.6\text{ m}$ D

Q7 The next higher resonant frequency $= 3\times133 = 399\text{ Hz}$ C

Q8 When the tube is open at both ends, $\lambda = 2L = 1.2$ m.
$f = \frac{v}{\lambda} = \frac{320}{1.2} = 267\text{ Hz}$ C

Q9 The range which gives constant response is 200 – 2000 Hz. B

Q10 The wavelength of 1000 Hz sound is 3 times that of 3000 Hz sound. The microphone gives a higher response to the 3000 Hz than the 1000 Hz sound. .: 3000 Hz has a greater amplitude displayed on the oscilloscope. B

Q11 A

Q12 D

Please inform physicsline@itute.com re conceptual, mathematical and/or typing errors