2009 VCAA Physics Exam 2 Solutions

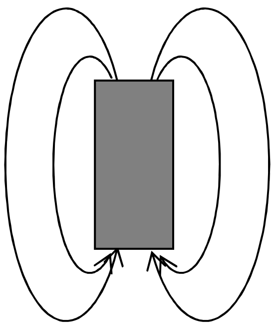
Area of study 1 – Electric power

Q1 Alternator because slip-rings are used to connect to the output.

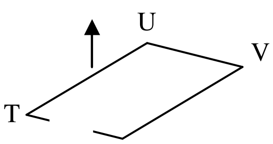
Q2 $\phi = BA$, $B = \frac{\phi}{A} = \frac{7.2\times10^{-6}}{9.0\times10^{-4}} = 8.0\times10^{-3}$ T

Q3 $|\xi_{av}| = \left|\frac{7.2\times10^{-6} - 0}{0.020}\right| = 3.6\times10^{-4}$ V

Q4



Q5



Q6 $F = BI\ell = 0.25\times2.0\times0.0090 = 0.0045$ N

Q7 0 N

Q8 Reverses the current direction every half-turn, makes the torque on the square loop to stay in the same direction every half-turn, so that the square loop keeps on rotating in the same direction.

Q9 $P = VI = 500\times20.0 = 1.00\times10^4$ W

Q10 $P_{loss} = I^2R = 20.0^2\times10.00 = 4.00\times10^3$ W

Q11 $V_{drop} = IR = 20.0\times10.00 = 200$ V

$\therefore V_{PQ} = 500 - 200 = 300$ V

Q12 Step-up voltage $V_{XY} = 500\times10 = 5000$ V_{RMS}

Q13 Step-down transformer: $\frac{N_S}{4800} = \frac{1}{10}$, $N_S = 480$ turns

Q14 Step-up transformer: $I_S = \frac{20.0}{10} = 2.00$ A_{RMS}

$P_{loss} = I^2R = 2.00^2\times10.00 = 40.0$ W

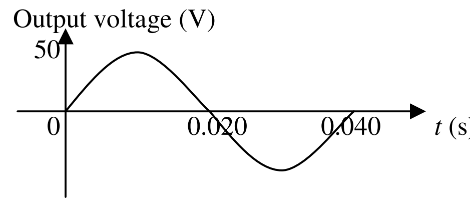
Q15 $V_{drop} = IR = 2.00\times10.00 = 20$ V_{RMS}

Voltage at step-down transformer input

$= 5000 - 20 = 4980$ V_{RMS}

$V_{PQ} = \frac{4980}{10} = 498$ V_{RMS}

Q16



Area of study 2 – Interactions of light and matter

Q1 In Young's experiment an interference pattern was produced when light passed through the two slits. Interference is one of the properties of waves. $\therefore$ the experiment supported the wave model.

Q2 Some of the results of the photoelectric effect experiment were: Maximum current flow depended on the light intensity, not on the frequency; existence of a threshold frequency for a particular metal; existence of a stopping voltage for a particular frequency of light, not its intensity. These could not be explained by the wave model. Einstein was able to explain these by means of Planck's photon model, a particle model of light. Hence the photoelectric effect experiment supported the particle model.

Q3 Thelma is correct. Same distance from the central band to S_1 and S_2. $\therefore$ constructive interference gives rise to a bright band.

Q4 At A, path difference is $2\frac{1}{2}\lambda$; at B path difference is $1\frac{1}{2}\lambda$.

The difference $= 1\lambda = 496$ nm.

$\therefore$ the laser wavelength is 496 nm.

Q5 $E_{K\max}$ is the maximum kinetic energy of the electrons emitted, and it is given by qV, where q is the electron charge and V the stopping voltage.

f is the frequency of the light used depending on which filter is placed between the light source and the tube.

W is the work function of the metal, which indicates the minimum photon energy required for photoelectrons to be emitted.

Q6 $h = \frac{2}{4\times10^{14}} = 5.0\times10^{-15}$ eVs (Gradient of the straight line).
$W = 1.5\,\text{eV}$

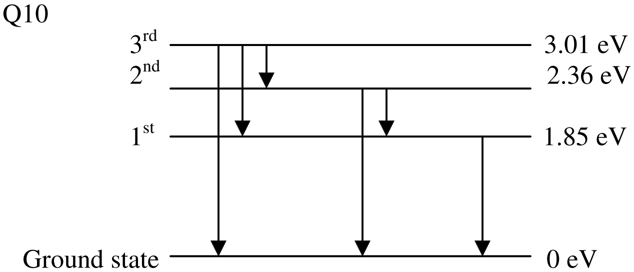
Q7i Maximum kinetic energy will not be affected.

Q7ii The number of electrons emitted will be doubled.

Q8 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{1.4\times10^{-10}} = 8.9\times10^{3}\,\text{eV}$

Q9 $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{1.4\times10^{-10}} = 4.7\times10^{-24}\,\text{kg ms}^{-1}$

Q10



Q11 The first excited state is the initial state.
From the 1st to the 2nd, $2.36 - 1.85 = 0.51\,\text{eV}$.
From the 1st to the 3rd, $3.01 - 1.85 = 1.16\,\text{eV}$.

Q12 Only those standing waves of circumference equal to a whole number of wavelength can be sustained, each corresponds to a particular energy, hence quantised energy states.

Detailed study 1 – Synchrotron and its applications

Q1 C

Q2 B

Q3 $F = qE = (1.6\times10^{-19})(200\times10^{3}) = 3.2\times10^{-14}\,\text{N}$ C

Q4 $Fd = E_K$, $3.2\times10^{-14} d = \frac{1}{2}(9.1\times10^{-31})(8.4\times10^{7})^2$,
$d = 0.1\,\text{m}$ B

Q5 $F = qvB = (1.6\times10^{-19})(8.4\times10^{7})(2.4\times10^{-4})$
$= 3.2\times10^{-15}\,\text{N}$ C

Q6 $r = \frac{mv^2}{F} = \frac{(9.1\times10^{-31})(8.4\times10^{7})^2}{3.2\times10^{-15}} = 2.0\,\text{m}$ D

Q7 D

Q8 B

Q9 C

Q10 $n\lambda = 2d\sin\theta$
$1\times0.150\times10^{-9} = 2d\sin15°$, $d = 0.29\times10^{-9}\,\text{m} = 0.29\,\text{nm}$ B

Q11 $\sin\theta = \frac{n\lambda}{2d} = \frac{nc}{2df}$. When the frequency is decreased, the incident angle increases. A

Q12 Elastic scattering. Same energy after scattering. C

Q13 Inelastic scattering. Less energy after scattering. B

Detailed study 2 – Photonics

Q1 C

Q2 C

Q3 A

Q4 D

Q5 $\lambda = \frac{hc}{E} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{2.30}$

$= 5.4\times10^{-7}$ m $= 540$ nm B

Q6 C

Q7 $n_{cladding} = 1.36\sin 80° = 1.34$ B

Q8 Snell's law: $1.00\sin\alpha = 1.36\sin 10°$, $\alpha = 13.7°$ B

Q9 B

Q10 $\sin\alpha = \frac{1.36\sin 10°}{1.33}$, $\alpha = 10.2°$ C

Q11 B

Q12 D

Q13 A

Detailed study 3 – Sound

Q1 B

Q2 B

Q3 $f = \frac{v}{\lambda} = \frac{333}{2} \approx 167$ Hz C

Q4 B

Q5 Intensity becomes a quarter of the original, $\therefore$ distance is doubled, i.e. 40.0 m. C

Q6 $\frac{1}{4} = \frac{1}{2}\times\frac{1}{2}$, intensity level drops by 6 dB. D

Q7 C

Q8 $I = 10^{\frac{L}{10}-12} = 10^{\frac{40}{10}-12} = 10^{-8}$ Wm^{-2} C

Q9 The 200 Hz 40 dB sound is on the 20 phon curve. B

Q10 $\lambda = \frac{v}{f_1} = \frac{333}{385} = 0.8649$, $L = \frac{\lambda}{2} \approx 0.432$ m C

Q11 $T = \frac{1}{f} = 0.0026$ s $= 2.6$ ms A

Q12 $f_1 = 385$, $f_2 = 770$, $f_3 = 1155$, $f_4 = 1540$ A

Q13 $\lambda = 4L \approx 4\times0.432 = 1.728$ m

$f = \frac{v}{\lambda} \approx \frac{333}{1.728} \approx 193$ Hz A

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