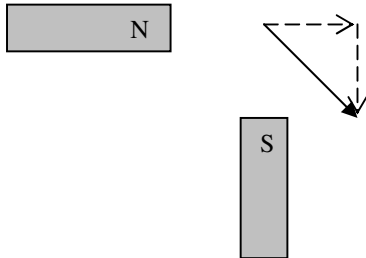


2011 VCAA Physics Exam 2 Solutions

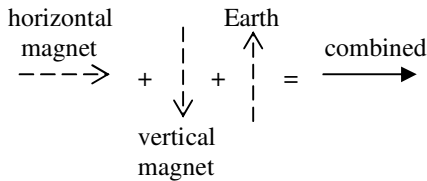
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Area of study 1 – Electric power

Q1

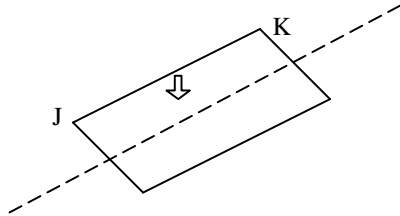


Q2



Q3 Reverses the current direction every half-turn, makes the torque on the rectangular loop to stay in the same direction every half-turn, so that the rectangular loop keeps on rotating in the same direction. The loop will oscillate without the commutator.

Q4



Q5 $F = nBIL = 50 \times 0.30 \times 6.0 \times 0.050 = 4.5 \text{ N}$

Q6 AC is changed to DC with the split-ring commutator. A

Q7 The polarity of each end of the coil will alternate between + and – every $\frac{1}{2}$ turn without the commutator. The commutator ensures the same current flow direction every $\frac{1}{2}$ turn and thus the same polarity at each end of the coil.

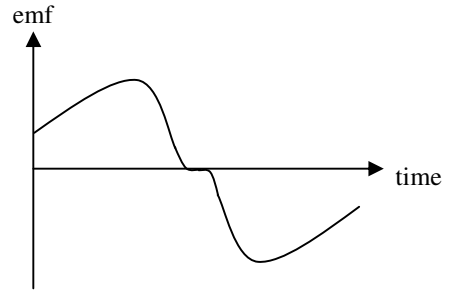
Q8 $\phi = BA \cos \theta = 2.0 \times 0.020 \times \cos 45^\circ \approx 0.03 \text{ Wb}$ B

Q9 The sign of the average emf cannot be determined from the given information.

$$|\xi_{av}| = n \left| \frac{\Delta \phi}{\Delta t} \right| = 50 \times \frac{2.0 \times 0.020}{0.15} \approx 13 \text{ V}$$

Q10 As the magnet moves closer to the loop the magnetic field through the loop increases, \therefore the magnetic flux to the left through the loop increases and thus induces an emf. As the magnet leaves the loop the magnetic flux to the left decreases and induces an emf.

Q11 The following sketch is an approximation without the knowledge of the size of the magnet and the loop.



Q12 The N-pole of the magnet is on the left. As the magnet moves away from the loop, the magnetic flux to the left decreases, Lenz's law says that the induced current in the loop must generate its own magnetic field to oppose the decrease, i.e. more magnetic field to the left, \therefore the induced current flows anticlockwise when viewed from the left.

Q13 $P = VI = 50000 \times 15 = 750000 \text{ W}$

Q14 For the same power lower voltage means higher current through the transmission lines. Since $\text{power loss} = I^2 R$, \therefore higher current causes higher power loss in the lines.

Q15 $\text{power loss} = I^2 R$, $9000 = 15^2 R$, $R = 40 \Omega$

Q16 $\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{49400}{250} \approx 198$

Q17 $\text{peak current} = 30\sqrt{2} \approx 42.4 \text{ A}$,

$$F_{\text{peak}} = BI_{\text{peak}}L \approx 1.0 \times 10^{-4} \times 42.4 \times 1 = 4.24 \times 10^{-3} \text{ N} \quad \text{B}$$

Q18 For A: $P = VI = 12 \times 2 = 24 \text{ W}$

For B: $P = VI = 12 \times 3 = 36$ B

Area of study 2 – Interactions of light and matter

Q1 $S_2P - S_1P = \frac{3}{2} \lambda = \frac{3}{2} \times 560 = 840 \text{ nm}$

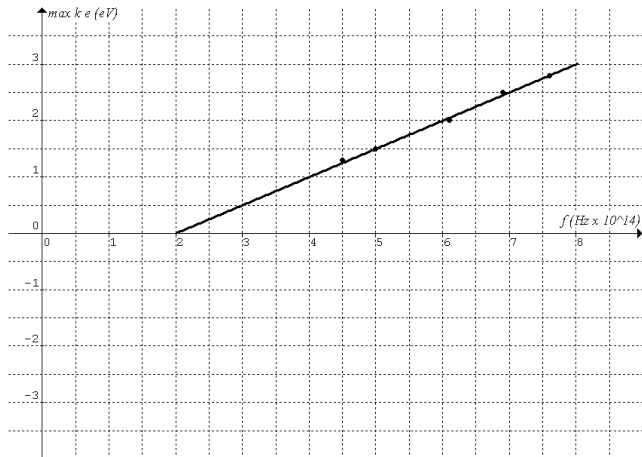
Q2 Increased spacing

Q3 Increased spacing

Q4 In Young's experiment an interference pattern was produced when light passed through the two slits. Interference is one of the properties of waves. This led to his conclusion about the wave-like nature of light.

Q5 The voltage used is a retarding voltage and it slows down the photoelectrons which have a range of kinetic energy. Those with the lowest kinetic energy will be first prevented from moving across the photocell and thus the ammeter reading drops. Eventually the voltage is high enough to stop all electrons to give zero ammeter reading.

Q6 The given stopping voltages equal to the maximum kinetic energies in eV numerically.



Q7 Planck's constant = gradient = $\frac{3}{6 \times 10^{14}} = 5 \times 10^{-15} \text{ eV s}$

Q8 Threshold frequency = $2 \times 10^{14} \text{ Hz}$,

\therefore longest wavelength = $\frac{c}{f} = \frac{3 \times 10^8}{2 \times 10^{14}} = 1.5 \times 10^{-6} = 1500 \times 10^{-9} \text{ m}$

$\therefore 1500 \text{ nm}$

Q9 Light has particle-like nature. The intensity of light is related to the number of particles (photons) in the beam of light, and the energy carried by each photon is related to the frequency of the light.

Q10 $E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{0.20 \times 10^{-9}} \approx 6210 \text{ eV}$

Q11 Same pattern and spacing \rightarrow same wavelength for the X-ray beam and the beam of electrons, 0.20 nm

\therefore momentum of each electron:

$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{0.20 \times 10^{-9}} \approx 3.315 \times 10^{-24} \text{ kg ms}^{-1}$

$E_k = \frac{p^2}{2m} = \frac{(3.315 \times 10^{-24})^2}{2 \times 9.1 \times 10^{-31}} \approx 6.04 \times 10^{-18} \text{ J} \approx 38 \text{ eV}$

Q12 The electrons have wave-like nature and this nature is

characterised by $\lambda = \frac{h}{p}$ which has the same value as the

wavelength of the X-rays.

Q13 0.7, 1.9, 2.6, 10.2, 12.1, 12.8 eV

Detailed study 1 – Synchrotron and its applications

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

Q1 C

Q2 $eV = \frac{1}{2}mv^2, \therefore V = \frac{mv^2}{2e} = \frac{(9.1 \times 10^{-31})(2.65 \times 10^7)^2}{2(1.6 \times 10^{-19})} = 2000$

Injector at Y must be positive to accelerate the electrons. A

Q3 $B = \frac{mv}{re} = \frac{(9.1 \times 10^{-31})(1.3 \times 10^6)}{(0.35)(1.6 \times 10^{-19})} \approx 2.1 \times 10^{-5}$ B

Q4 The magnetic field does no work on the electrons. C

Q5 Rate of change of direction is acceleration. B

Q6 B

Q7 D

Q8 $E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{0.14 \times 10^{-9}} \approx 8900 \text{ eV}$ D

Q9 $d = \frac{n\lambda}{2 \sin \theta} = 1 \left(\frac{0.140 \times 10^{-9}}{2 \sin 15^\circ} \right) \approx 0.27 \times 10^{-9} \text{ m}$ B

Q10 $\sin \theta = \frac{n\lambda}{2d} = 2 \left(\frac{0.140 \times 10^{-9}}{2 \times 0.27 \times 10^{-9}} \right), \therefore \theta \approx 31^\circ$

$\sin \theta = \frac{n\lambda}{2d} = 3 \left(\frac{0.140 \times 10^{-9}}{2 \times 0.27 \times 10^{-9}} \right), \therefore \theta \approx 51^\circ$ C

Q11 $E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{0.081 \times 10^{-9}} \approx 15300 \text{ eV}$

$E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{0.063 \times 10^{-9}} \approx 19700 \text{ eV}$ C

Q12 After undergoing Compton scattering, the X-ray beam loses energy.

Since $\lambda = \frac{hc}{E}$, lower energy \rightarrow longer wavelength. D

Detailed study 2 – Photonics

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

- Q1 C
- Q2 C
- Q3 $E = \frac{hc}{\lambda} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{620 \times 10^{-9}} \approx 2.0 \text{ eV}$ D
- Q4 C
- Q5 $V_{LED} = 2.2 \text{ V}, \therefore V_R = 3.0 - 2.2 = 0.8 \text{ V}$
 $\therefore I = \frac{V}{R} = \frac{0.8}{100} = 0.008 \text{ A, i.e. } 8 \text{ mA}$ C
- Q6 Each LED in the series requires 2.2 V to operate but the supply voltage is only 3.0 V. Neither will operate. D
- Q7 B
- Q8 $\theta = \sin^{-1}\left(\frac{1.36}{1.42}\right) \approx 73^\circ$ B
- Q9 Snell's: $n_{air} \sin \theta_{air} = n_{core} \sin \theta_{core}$
 $\sin \alpha = 1.48 \sin(90^\circ - 63^\circ), \sin \alpha = 1.48 \sin 27^\circ, \alpha \approx 42^\circ$ D
- Q10 B
- Q11 B
- Q12 $0.5^3 P = 2.0, \therefore P = 16 \mu \text{ W}$ C

Detailed study 3 – Sound

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

- Q1 A
- Q2 $L = 10 \times \log_{10}\left(\frac{1.1 \times 10^{-4}}{10^{-12}}\right) \approx 80 \text{ dB}$ C
- Q3 Point Y is at half of the distance of point X from the source, \therefore the sound intensity is 4 times that at X (inverse square law).
 $I = 4 \times 1.1 \times 10^{-4} = 4.4 \times 10^{-4} \text{ W m}^{-2}$ D
- Q4 The sound at 3000 Hz and 40 dB is slightly above the 40 phon loudness curve. D
- Q5 At 100 Hz on the 20 phon loudness curve, the sound level is about 50 dB. C
- Q6 Open end is a pressure node. B
- Q7 $\lambda = 4 \times 1.1 = 4.4, v = f\lambda = 90 \times 4.4 = 396 \text{ ms}^{-1}$ D
- Q8 B
- Q9 Option B (wide source) is more directional (i.e. less diffracted) than Option A. A
- Q10 D
- Q11 A
- Q12 C

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