2. Particles and Waves Revision Answers

1) • An atom is almost entirely empty space.
• Mass is concentrated in the nucleus.
• Neutral in charge as the number of protons in the nucleus = number of electrons in the orbits. (3)

2) a) i) Loss in mass = $m_{LHS} - m_{RHS}$

$\Rightarrow m_{LHS} = 1.675 \times 10^{-27} + 390.2 \times 10^{-27} = 391.875 \times 10^{-27}$ kg

$\Rightarrow m_{RHS} = 227.3 \times 10^{-27} + 160.9 \times 10^{-27} + 2 \times 1.675 \times 10^{-27}$
$= 391.55 \times 10^{-27}$ kg (2)

$\Rightarrow$ Lost mass $= m_{LHS} - m_{RHS} = 0.325 \times 10^{-27}$ kg.

ii) $E = mc^2 = 0.325 \times 10^{-27} \times (3 \times 10^8)^2 = 2.93 \times 10^{-11}$ J (3)

b) i) Nuclear Fusion. (1)

ii) Nuclear Fission – A large mass nuclei is split into two nuclei of smaller mass with neutrons and energy being released. (1)

Nuclear fusion – Two nuclei of smaller mass join together to form a nuclei of larger mass with energy being released. (1)

3) a) $^4_2He \rightarrow$ Alpha Particle. (1)
b) Gamma radiation $^0_0\gamma \rightarrow$ Difficult to tell as there is no change to the mass number or the atomic number. (1)

4) a) i) $n = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sin 30^\circ}{\sin 22^\circ} = 1{\cdot}33$ (3)

ii) $n = \frac{V_1}{V_2} \Rightarrow 1{\cdot}33 = \frac{3\times10^8}{V_2} \Rightarrow V_2 = 2{\cdot}26\times10^8 ms^{-1}$ (3)

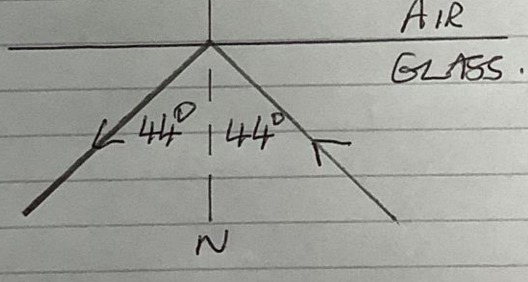
iii) $n = \frac{\lambda_1}{\lambda_2} \Rightarrow 1{\cdot}33 = \frac{600\times10^{-9}}{\lambda_2} \Rightarrow \lambda_2 = 451\times10^{-9}m$ (2)

iv) $\sin\theta_c = \frac{1}{n} = \frac{1}{1{\cdot}33} = 0{\cdot}752$

$\Rightarrow \theta_c = \sin^{-1}(0{\cdot}752) = 48{\cdot}8^\circ$ (3)

b) • angle in glass $= 44^\circ >$ Critical angle $= 42^\circ$

• T.I.R (Total Internal Reflection Occurs)



(2)

5) • path difference $= 1{\cdot}29m - 1{\cdot}12m = 0{\cdot}17m.$

• $\lambda = \frac{v}{f} = \frac{340}{4000} = 0{\cdot}085m$

(3)

• Path diff = 2 x wavelength (path diff = $m\lambda$)
• Amplitude increases when LS2 is switched on due to constructive interference.

6) a) $\lambda = \frac{v}{f} = \frac{340}{3400} = 0.1m.$ (3)

b) • Destructive Interference occurs when waves meet 180° out of phase, where crest meets trough and trough meets crest. The path difference between the waves is $\frac{1}{2}\lambda, \frac{3}{2}\lambda, \frac{5}{2}\lambda$ etc (1)

• Constructive Interference occurs when waves meet in-phase, where crest meets crest and trough meets trough. The path difference between the waves is $0, \lambda, 2\lambda, 3\lambda$ etc (1)

c) Path difference $= 1.50m - 1.25m = 0.25m.$

$\therefore$ path diff $= 2.5 \times \lambda$

$\therefore$ As the path difference is a half number of wavelengths then destructive interference takes place. (3)

7) a) 600 lines → 1mm $\therefore d = \text{Line} = \frac{1}{600}$ mm

$\Rightarrow d = 1.67 \times 10^{-3}$ mm $= 1.67 \times 10^{-6}$ m. (1)

b) $d \sin\theta = m\lambda \Rightarrow \sin\theta = m\lambda / d$

$\Rightarrow \sin\theta = \frac{1 \times 628 \times 10^{-9}}{1.67 \times 10^{-6}} = 0.376$

$\Rightarrow \theta = \sin^{-1}(0.376) = 22.1°$ (3)

c) $\lambda = 628nm$ → Orange light. (1)

8) a) Photoelectric Effect. (1)

(3)

b) $E_0 = hf_0 = 6.63 \times 10^{-34} \times 1.18 \times 10^{15} = 7.82 \times 10^{-19}\,J$

c) i) $E = hf \Rightarrow f = \frac{E}{h} = \frac{3.50 \times 10^{-19}}{6.63 \times 10^{-34}} = 5.28 \times 10^{14}\,Hz.$

(3)

$\therefore$ Potassium emits electrons.

ii) $E_K = hf - hf_0 = 3.50 \times 10^{-19} - (6.63 \times 10^{-34} \times 4.83 \times 10^{14})$

$\Rightarrow E_K = 3.50 \times 10^{-19} - 3.20 \times 10^{-19} = 2.98 \times 10^{-20}\,J$

(2)

9) a) $\lambda \times 2 \Rightarrow f \div 2 \Rightarrow E \div 2$

Energy of the photon halves. (2)

b) $\lambda \times 2 \Rightarrow f \div 2 \Rightarrow E \div 2$

Kinetic energy decreases or it may be zero as the Energy of the photons may be less than the work function of the metal $\therefore$ no photoelectric emission.

(2)

c) As the Irradiance of the radiation doubles $\Rightarrow$ the number of incident photons would increase $\Rightarrow$ number of electrons ejected from the metal surface per second would increase $\Rightarrow$ The photoelectric current will increase.

(2)

10) a) $I_1 d_1^2 = 6 \cdot 40 \times 1^2 = 6 \cdot 40$

$I_2 d_2^2 = 1 \cdot 60 \times 2^2 = 6 \cdot 40$

$I_3 d_3^2 = 0 \cdot 71 \times 3^2 = 6 \cdot 39$

$I_4 d_4^2 = 0 \cdot 40 \times 4^2 = 6 \cdot 40.$

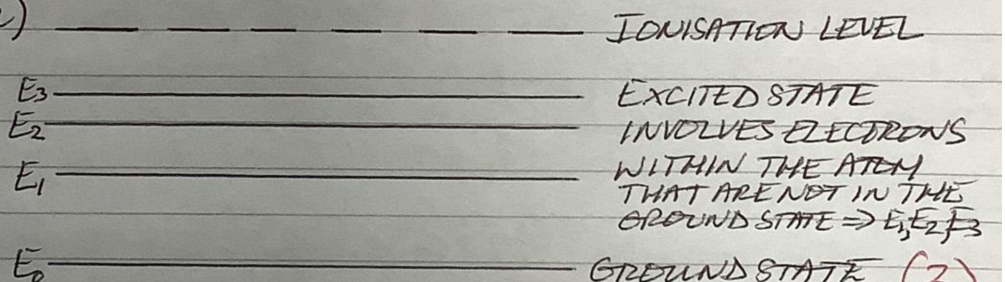
$\therefore Id^2 = \text{Constant} = 6 \cdot 40$

$\Rightarrow I = \frac{k}{d^2} \Rightarrow I \propto \frac{1}{d^2}$ (3)

b) $Id^2 = 6 \cdot 40 \Rightarrow I \times 5^2 = 6 \cdot 40$

$\Rightarrow I = \frac{6 \cdot 40}{25} = 0 \cdot 26 \times 10^{-2}\, Wm^{-2}$ (3)

11) a)



(3)

b) i) 6 TRANSITION LINES (1)

$E_0 \to E_1$, $E_0 \to E_2$, $E_0 \to E_3$, $E_1 \to E_2$, $E_1 \to E_3$ AND $E_2 \to E_3$.

(IF EMISSION OR ABSORPTION ARE NOT MENTIONED THEN GO FROM THE LOWER TO THE HIGHER ENERGY LEVEL.)

ii) LONGEST $\lambda \Rightarrow$ SMALLEST $f \Rightarrow$ SMALLEST ENERGY JUMP

$\Rightarrow E_2 \to E_3$. (2)

iii) $E_2 \to E_0 \Rightarrow$ EMISSION LINE $\Rightarrow \Delta E = 12 \cdot 19 \times 10^{-19} - 2 \cdot 96 \times 10^{-19} = 9 \cdot 23 \times 10^{-19}\, J$

- $\Delta E = hf \Rightarrow f = \Delta E / h = 9 \cdot 23 \times 10^{-19} / 6 \cdot 63 \times 10^{-34} = 1 \cdot 39 \times 10^{15}\, Hz$
- $\lambda = v/f = 3 \times 10^8 / 1 \cdot 39 \times 10^{15} = 2 \cdot 16 \times 10^{-7}\, m$ (4)

12) a) At aperture. $\Rightarrow I = \frac{P}{A}$ $\Rightarrow$ largest $\Rightarrow$ smallest

$P = 3mW$, $A = 2mm^2 = 2 \times 10^{-6} m^2$

* $1mm^2 = 1mm \times 1mm = 1 \times 10^{-3} m \times 1 \times 10^{-3} = 1 \times 10^{-6} m^2$ *

$I = \frac{P}{A} = \frac{3 \times 10^{-3}}{2 \times 10^{-6}} = 1500 Wm^{-2}$ (3)

b) At 3m.

Lowest Irradiance $\Rightarrow P = 0.6mW + A = 72mm^2$

$I = \frac{P}{A} = \frac{0.6 \times 10^{-3}}{72 \times 10^{-6}} = 8.33 Wm^{-2}$

Highest Irradiance $\Rightarrow P = 3mW + A = 36mm^2$

$I = \frac{P}{A} = \frac{3 \times 10^{-3}}{36 \times 10^{-6}} = 83.3 Wm^{-2}$

$\therefore$ Range of Irradiance $= 8.3 Wm^{-2}$ to $83.3 Wm^{-2}$

(4)

(mass of a proton $= 1.673 \times 10^{-27}$ kg)

13) a) $E_W = QV = 1.6 \times 10^{-19} \times 40 \times 10^{3} = 6.4 \times 10^{-15}$ J (3)

b) $E_W \rightarrow E_K \Rightarrow E_K = 6.4 \times 10^{-15}$ J

$E_K = \frac{1}{2}mv^2 \Rightarrow (6.4 \times 10^{-15} = \frac{1}{2} \times 1.673 \times 10^{-27} \times v^2)$

$\Rightarrow v^2 = \frac{6.4 \times 10^{-15}}{\frac{1}{2} \times 1.673 \times 10^{-27}} = 7.65 \times 10^{12}$

$\Rightarrow v = 2.77 \times 10^{6}\ ms^{-1}$ (3)

c) Into the page or down/downwards. (1)

d) • ac voltage used to change the direction of the force on protons/electric field across the gap.

(2)

• The direction of the protons across the gap keeps changing.

14) a) strong nuclear force. (1)

b) Weak nuclear force. (1)

15) a) i) Baryon → 3 quarks. (1)

ii) Long-lived particles (1)

iii) 3 matter or 3 anti-matter particles. (1)

b) i) Meson → 2 quarks. (1)

ii) short-lived particles (1)

iii) matter and anti-matter combinations. (1)

c) i) A proton = 2 up quarks + 1 down quark. (1)

ii) An antiproton = 2 anti-up quarks + 1 anti-down quark. (1)

iii) Pi-Meson = 1 down quark + 1 anti-up quark. (1)

TOTAL MARKS = 100