24/3

Revision Session 24/3 Worked Solutions

1a)i) The minimum energy required for an electron to escape the surface of a metal

ii) The minimum energy required to remove an electron from the ground state

b) $E = hf$

$$f = \frac{E}{h} = \frac{1.60\times10^{-19} \times 5.5}{6.63\times10^{-34}}$$

$$= 1.24 \times 10^{15}\ Hz$$

c) $hf = E_k + \phi$

$$E_k = hf - \phi$$

$$= 6.63\times10^{-34} \times 1.24\times10^{15} - 2.28 \times 1.60\times10^{-19}$$

$$= 4.57\times10^{-19}\ J.$$

d) $\lambda = \frac{c}{f} = \frac{3.00\times10^{8}}{1.24\times10^{15}}$

$$= 2.42\times10^{-7} m$$

$$\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}}{9.11\times10^{-31} \times 2.42\times10^{-7}}$$

$$= 3010\ ms^{-1}$$

2)i) The state in which electrons (or atoms) are at their minimum energies. This is their stable state

ii) Excitation moves an electron to a higher energy level/state.
Ionisation removes an electron from the atom.

Both require electrons to gain a specific amount of energy.

2)b) Electrons can only occupy discrete energy levels. Therefore to move to a higher energy level electron need to gain a certain amount of energy. Therefore, for a photon to excite an electron, it will have to have a certain energy (or frequency, as $E=hf$) This is because all energy from the photon needs to be absorbed by the electron in a 1-to-1 interaction

c) $E = hf$

$$f = E/h = \frac{13.6 \times 1.60\times10^{-19}}{6.63\times10^{-34}}$$

$$f = 3.28\times10^{15}\ Hz$$

3) $\lambda = 656\times10^{-9}\ m$

$$E_{photon} = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{656\times10^{-9}}$$

$$= 3.03\times10^{-19}\ J$$

} Energy of photon

$$E_{final} = -3.4\,eV \times 1.60\times10^{-19}$$

$$= -5.4\times10^{-19}\,J$$

} Energy of final state.

$$E_{initial} - E_{final} = E_{photon}$$

$$E_{initial} = E_{photon} + E_{final}$$

$$E_{initial} = (-5.4 + 3.03)\times10^{-19}$$

$$= -2.4\times10^{-19}\,J$$

4)a) Constructive interference occurs, which is a property of waves rather than particles

4) b) $v = 3.5 \times 10^{7}\ ms^{-1}$

$$\lambda_{db} = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 3.5 \times 10^{7}}$$

$$= 2.1 \times 10^{-11}\ m$$

5) A

$$E = hf = \frac{hc}{\lambda}$$

After acceleration $E = eV$

$$\therefore eV = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{eV}$$

c is velocity of photon (EM wave)
V is value of potential difference
e is charge of electron.