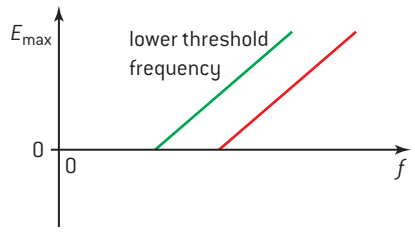
Solutions for Topic 12 – Quantum and nuclear physics (AHL)

1. a)



b) electron ejected when energy of light $E = hf$ is greater than the work function (threshold frequency) of the metal

2. a) (i) no change in ammeter

(ii) reading will increase as more electrons are being produced per second

b) (i) photon energy is the sum of the energy of emitted electron plus the work function

(ii) $\varphi = \frac{hc}{\lambda} - eV = 6.4 \times 10^{-20}$ J

3. a) why certain transitions are more likely to occur than others

b) electrons in an atom exist in stationary states; electrons may move from one stationary state to another by absorbing or emitting a quantum of electromagnetic radiation

c) substitute r into equation for E_n to get required expression

d) binding energy of that level

e) electron described by wavefunction; energy levels can be thought of as standing waves in a potential well; harmonics of standing wave give different levels

4. a) uncertainty in position is ± half of slit width so minimum uncertainty

$$\Delta p = \frac{6.63 \times 10^{-34}}{4\pi \times 0.01 \times 10^{-3} \times 0.5} = 1.1 \times 10^{-29} \text{ N s}$$

b) component parallel to gap

5. a) particle brought to rest when all kinetic energy has been converted to potential energy, so e.p.e. is 3.8 MeV $= 6.1 \times 10^{-13}$ J

b) Z = 46 so $d = \frac{kZe \times 2e}{E_\alpha} = 3.5 \times 10^{-14}$ m

c) higher Z so d would be greater

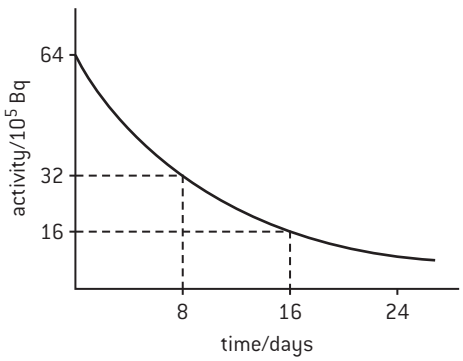
d) (i) mass = A × u

(ii) $\rho = \frac{m}{v} = \frac{3u}{4\pi \times (1.2 \times 10^{-15})^3} = 2 \times 10^{17}$ kg m^{-3}

6. a) nucleus or atom with specific number of protons and neutrons

b) beta minus decay so neutron turns into proton so atomic number must decrease by one; electron antineutrino also produced

c) (i)



(ii) $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = 0.087 \text{ day}^{-1}$

(iii) $A = A_0 e^{-\lambda t}$

$$t = -\frac{1}{0.087} \ln \frac{0.5}{6.4} = 29 \text{ days}$$

7. a) (i) proton or neutron

(ii) proton: uud; neutron: udd

(iii) argon-39 has more neutrons so there is a higher chance of it undergoing beta decay by changing a neutron into a proton

b) (i) Z = 19; N = 39; x is electron antineutrino

(ii) emitted electrons have continuous energy spectrum, so third particle must be produced so that momentum and mass-energy are conserved

(iii) $(38.96431 - 38.96370) \times \text{u} \times \text{c}^2 = 9.1 \times 10^{-14} \text{ J}$

c) (i) separate pure sample of nuclide in a known chemical form, measure its mass then take count rate; use dimensions of G-M tube to calculate activity

(ii) use mass and activity of sample to find half life

8. a) separate pure sample of nuclide in a known chemical form, measure its mass then take count rate; use dimensions of G–M tube to calculate activity

b) fraction remaining $= 2^{-1.6} = 0.33$