23. (1) $\Delta V q = \frac{1}{2}mv^2$

$\therefore v = \sqrt{\frac{2\Delta V q}{m}}$

$\therefore v = \sqrt{\frac{2\times 50{,}000\times 1.6\times10^{-19}}{9.11\times10^{-31}}}$

$v = 1.3\times10^{8}\ ms^{-1}$

(2) Power $= \frac{E_n}{time}$

$P = \frac{10^{15}\times 8\times10^{-15}}{1}\times\frac{98}{100}$

P = 7.84 watts.

(3) Increase the current in the filament ∴ more electrons emitted ∴ more target hits ∴ more X-ray photons.

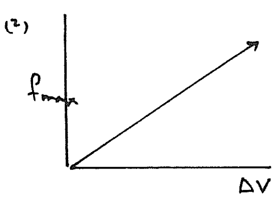
24. (1) Energy of electron $= \Delta V q \equiv \Delta V e$.

Now if all the electron's energy is transferred as a photon then

$\Delta V e = h f_{max}$.

$\therefore f_{max} = \frac{\Delta V e}{h}$.

(2)



Straight line as $f_{max} \propto \Delta V$

(3) Slope $= e/h$.

25. 'Hard' X-rays are X-rays with high penetrating power + hence high photon energies and frequencies.

(2) Hard X-rays are produced in X-ray tubes by high accelerating voltages i.e. 100,000 V

(3) The degree of absorption of X-rays by body tissue is called the attenuation of the X rays.

1. (1) $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{60\times20}$

$\lambda = 5.5\times10^{-37}$ m.

(2) $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{1.675\times10^{-27}\times1\times10^{6}}$

$\lambda = 3.9\times10^{-13}$ m

(3) 6.0 eV $= 9.6\times10^{-19}$ J.

$\therefore K = \frac{1}{2}mv^2 = 9.6\times10^{-19}$

$\therefore v = \sqrt{\frac{9.6\times10^{-19}\times2}{9.11\times10^{-31}}}$

$v = 1.45\times10^{6}\ ms^{-1}$

$\therefore \lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times1.45\times10^{6}}$

$\lambda = 5.0\times10^{-10}$ m.

2. (1) $a = \frac{\Delta v}{\Delta t}$

$\therefore a = \frac{17.1\times10^{6}}{1\times10^{-6}}$

$a = 1.71\times10^{13}\ ms^{-2}$

$\therefore F = ma$

$= 9.11\times10^{-31}\times1.71\times10^{13}$

$F = 1.56\times10^{-17}$ N

(2) $\lambda_1 = \frac{h}{mv_1}$

$\lambda_2 = \frac{h}{mv_2}$

$\lambda_1 = 3.8\times10^{-11}$ m

$\lambda_2 = 3.8\times10^{-10}$ m

$\therefore \Delta\lambda = 3.42\times10^{-10}$ m

i.e. $\lambda_{deBroglie}$ increases as it slows down.

3. (1) $K = \Delta V q$

$K = 20{,}000\times1.6\times10^{-19}$

$K = 3.2\times10^{-15}$ J.

(2) $\lambda = \frac{h}{mv}$

$\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times v}$

$\left[v = \sqrt{\frac{2E_k}{m}}\right]$

$v = 8.4\times10^{7}\ ms^{-1}$

$\therefore \lambda = 8.7\times10^{-12}$ m

(3) $\lambda = \frac{h}{mv}$

$\therefore \lambda \propto \frac{1}{v}$

∴ as electrons accelerate v increases ∴ λ decreases.

4. (1) You do! However, as your $\lambda_{deBroglie}$ is very small your diffraction is difficult to detect.

(2) In a diffraction grating the slit width is smaller than in a 2-slit setup. The 'd' value is closer to the wavelength of light ∴ light diffracts more.

(3) Electrons have a similar wavelength to the crystal spacings ∴ they show 'good' diffraction

5. Low energy electrons did not penetrate deeply into the metal surface ∴ only interference of the beams reflected off the top layer of the crystal need be considered.

6. (1) $E_k = 54 \times 1.6\times10^{-19}$

$= 86.4 \times10^{-19}$

$= 8.64 \times 10^{-18}$ J.

(2) $E_k = K = \frac{1}{2}mv^2$

$\therefore v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2\times8.64\times10^{-18}}{9.11\times10^{-31}}}$

$v = 4.3\times10^{6}\ ms^{-1}$

(3) $\vec{p} = mv$

$= 9.11\times10^{-31} \times 4.3\times10^{6}$

$= 3.97\times10^{-24}$ sN

(4) $\lambda = \frac{h}{mv}$

$\lambda = \frac{6.63\times10^{-34}}{3.97\times10^{-24}}$

$\lambda = 1.67\times10^{-10}$ m

(5) $n\lambda = d\sin\theta$ $(n=1)$

$\therefore 1.67\times10^{-10} = 2.2\times10^{-10}\sin\theta$

$\therefore \theta = 48.6°$

7. (1) Range. $E_k = \Delta Vq$

$\therefore E_k = 50{,}000 \times 1.6\times10^{-19}$

$= 8.0\times10^{-15}$ J

$\therefore E_k = 1.6\times10^{-14}$ J at 100,000 V

(2) $\lambda = \frac{h}{mv}$

at 100,000 V,

$\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times1.87\times10^{8}}$

$\lambda_1 = 3.9\times10^{-12}$ m

at 50,000 V

$\lambda = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times1.3\times10^{8}}$

$= 5.5\times10^{-12}$ m

8. The electrons are moving charges. ∴ in electric fields they will experience forces $\vec{F} = \vec{E}q$.
In magnetic fields they will experience forces
$F = Bqv\sin\theta$
∴ velocities, directions etc. can be altered.

9. (1) Better resolution
(2) Smaller λ, enables smaller objects (< 400 nm) to be "looked at"

10. (1) electron wavelengths about 10 times smaller than this ≈ 0.05 nm.

(2) take electrons of
$\lambda = 0.05$ nm
$= 0.05\times10^{-9}$
$= 5\times10^{-11}$ m.

$\lambda = \frac{h}{p}$

$\therefore p = \frac{h}{\lambda}$

$\therefore p = \frac{6.63\times10^{-34}}{5\times10^{-11}}$

$= 1.33\times10^{-23}$ sN

10 (3). $p = mv$ $\therefore v = \frac{p}{m}$

$\therefore v = \frac{1.33\times10^{-23}}{9.11\times10^{-31}}$

$v = 1.45\times10^{7}\ ms^{-1}$

$\therefore K = \frac{1}{2}mv^2 = \Delta Vq$

$\therefore \Delta V = \frac{\frac{1}{2}mv^2}{q}$

$\therefore \Delta V = \frac{\frac{1}{2}\times9.11\times10^{-31}\times(1.45\times10^{7})^2}{1.6\times10^{-19}}$

$\therefore \Delta V = 600$ Volts.

11. $1\lambda = d\sin\theta$

$\therefore \lambda = 2.0\times10^{-10}\sin 9°$

$\therefore \lambda = 3.1\times10^{-11}$ m

Energy: use $\lambda = \frac{h}{p}$

$\therefore p = \frac{h}{\lambda}$

$\therefore p = 6.63\times10^{-34} \div 3.1\times10^{-11}$

$\therefore p = 2.1\times10^{-23}$ sN

$\therefore$ velocity $= \frac{p}{m} = \frac{2.1\times10^{-23}}{1.673\times10^{-27}}$

velo. $= 1.3\times10^{4}\ ms^{-1}$.

$\therefore K = \frac{1}{2}mv^2$

$= \frac{1}{2}\times1.673\times10^{-27}\times(1.3\times10^{4})^2$

∴ Energy $= 1.4\times10^{-19}$ J.

12. $90\,eV = 90\times1.6\times10^{-19}$ J

$= 1.44\times10^{-17}$ J.

$\therefore \frac{1}{2}mv^2 = 1.44\times10^{-17}$

$\therefore v^2 = \frac{2\times1.44\times10^{-17}}{9.11\times10^{-31}}$

$v = 5.6\times10^{6}\ ms^{-1}$

$\vec{p} = mv$

$= 9.11\times10^{-31}\times5.6\times10^{6}$

$= 5.1\times10^{-24}$ sN

$\therefore \lambda = \frac{h}{mv}$

$\lambda = \frac{6.63\times10^{-34}}{5.1\times10^{-24}}$

$\lambda = 1.3\times10^{-10}$ m

∴ for the first order

$1\lambda = d\sin\theta$

i.e. $1.3\times10^{-10} = 0.306\times10^{-9}\times\sin\theta$

$\therefore \sin\theta = \frac{1.3\times10^{-10}}{3.06\times10^{-10}}$

$\theta \approx 25°$

13 (1) $95\,eV = 1.52\times10^{-17}$ J

$\therefore \frac{1}{2}mv^2 = 1.52\times10^{-17}$

$\therefore v = \sqrt{\frac{1.52\times10^{-17}\times2}{9.11\times10^{-31}}}$

$v = 5.77\times10^{6}\ ms^{-1}$

$\therefore \vec{p} = mv$

$= 9.11\times10^{-31}\times5.77\times10^{6}$

$\therefore p = 5.26\times10^{-24}$ sN

$\therefore \lambda = \frac{h}{p}$

$= \frac{6.63\times10^{-34}}{5.26\times10^{-24}}$

$= 1.26\times10^{-10}$ m

$1\lambda = d\sin\theta$

$\therefore \frac{1.26\times10^{-10}}{\sin 25°} = d$

$\therefore d = 3.0\times10^{-10}$ m

(2) neutron velocity would be $v = 1.35\times10^{5}\ ms^{-1}$

$\therefore \vec{p} = 2.26\times10^{-22}$ sN

$\therefore \lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{2.26\times10^{-22}}$

$\lambda = 2.93\times10^{-12}$ m

$\therefore 1\lambda = d\sin\theta$

$\therefore \sin\theta = \frac{\lambda}{d} = \frac{2.93\times10^{-12}}{3.0\times10^{-10}}$

$\theta = 0.56°$