46. Estimate the deBroglie wavelength of thermal neutrons at room temperature, if they are diffracted by a crystal with a slit separation of 2.82 Å. Find the angle at which the first diffraction maximum occurs.

[Ans: $\lambda = 1.447 Å, \theta = 15''$]

Solution:

Kinetic Energy $= p^2/2m$

Energy associated / freedom $= \frac{1}{2} kT$

For 3 degrees of freedom $= \frac{3}{2} kT$

$\therefore \frac{p^2}{2m} = \frac{3}{2} kT$

$\Rightarrow p = \sqrt{3mkT}$

Mass of neutron, $m = 1.67 \times 10^{-27}$ kg

$$\lambda = \frac{h}{\sqrt{3mkT}} = \frac{6.6 \times 10^{-34}}{\sqrt{3 \times 1.67 \times 10^{-27} \times 300 \times 1.67 \times 10^{-27}}}$$

$\lambda = 1.447 Å$

$2d \sin\theta = n\lambda$, for $n = 1$

$2d \sin\theta = \lambda$, $d = 2.82 Å$

$\therefore \sin\theta = \frac{\lambda}{2d} = \frac{1.447}{2 \times 2.82 Å}$

$\Rightarrow \theta = 14.86^\circ$