Answer on Question #43164, Physics, Nuclear Physics

Task:

A beam of C60 molecules (basically a molecule-sized ball that is 7.0 × 10^−10 m in diameter and has a mass of 1.2 × 10^−24 kg) is directed at two small slits in a very thin metal sheet. The molecules in the beam are travelling at 1 cm/s and the apparatus is in a vacuum. We would like to use this beam + slits to observe the wave properties of the molecules via diffraction.

a) What is the de Broglie wavelength of the molecules in the beam? (ANS: 5.5 x 10^-8 m)

b) Explain / calculate what size and spacing should be used for the slits in order to observe a clear interference pattern on a screen 1 m away. (Hint: Depends on your assumptions.... but two slits, each 10 x 10^-6 m wide, spaced 55 x 10^-6 m apart would result in interference maxima 1 mm apart on the screen (which should be easily measurable).)

Solution:

a) the de Broglie wavelength of the molecules in the beam :

$$\lambda_B = \frac{h}{p} = \frac{h}{mV} = \frac{6.62 \cdot 10^{-34}}{1.2 \cdot 10^{-24} \cdot 10^{-2}} \approx 5.5 \cdot 10^{-8} m.$$

b)

$$d \sin\varphi = m\lambda; m = 1$$

$$\sin\varphi \approx tg\varphi = a / L;$$

$$\frac{\lambda L}{d} < 10^{-3}$$

a-distance between interference maximums,L=1m.

$$\frac{\lambda L}{b+c} < 10^{-3} \Rightarrow b > 5.5 \cdot 10^{-5} - c$$

d- period diffraction grating

c-slits width

b-distance between the slits

So if $c = 10 \cdot 10^{-6}$ m, then $b > 44 \cdot 10^{-6}$m for example $b = 55 \cdot 10^{-6}$ m.