3.) DeBroglie Relations and the Scale of Quantum Effects.

a) Matter Particles as Waves

→ Why not made aware of Matter waves in everyday life?

→ Find deBroglie wavelength $\lambda = h/p$, $h = 6.6 \times 10^{-34}$ J.s

i) Automobile of mass 2000 kg at $22 \frac{m}{s}$

$$p = \frac{kg \cdot m}{s} = \frac{2000 kg \cdot 22 m}{s} = 44000 \frac{kg \cdot m}{s}$$

$$[J] = \frac{kg \cdot m^2}{s^2}$$

$$\lambda = h/p = \frac{6.6 \times 10^{-34} \frac{kg \cdot m^2}{s^2} \cdot s}{44000 \frac{kg \cdot m}{s}} = \boxed{1.5 \times 10^{-38} m}$$

↳ too small to notice in real life.

ii) Marble of mass 10 g with speed 10 cm/s

$$p = 0.01 kg \cdot 0.1 \frac{m}{s}$$

$$p = 0.001 \frac{kg \cdot m}{s}$$

$$\lambda = \frac{h}{p} = \frac{6.6 \times 10^{-34} J \cdot s}{0.001 \frac{kg \cdot m}{s}} = \boxed{6.6 \times 10^{-31} m}$$ → Still way too small

iii) Smoke particle, diameter 100 nm, mass of 1 fg at room temp (T=300K)

→ $KE = \frac{3}{2} k_B \cdot T$, $k_B = 1.38 \times 10^{-23} J/K$

→ $KE = (\frac{1}{2}) \frac{p^2}{m}$ (m → mass of particle)

$$\lambda = \frac{h}{p} = [m] = \frac{J \cdot s}{\frac{kg \cdot m}{s}} \quad (KE = J)$$

$$[KE] = [J] = [\frac{kg \cdot m^2}{s^2}] = [p] \cdot \frac{m}{s}$$

$$[p] = [J] \cdot \frac{s}{m}$$

$$p = \sqrt{(\frac{1}{2} \cdot KE \cdot m)}$$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{\frac{1}{2} KE \cdot mass}}$$

$$= \frac{h}{\sqrt{\frac{1}{2} \cdot (\frac{3}{2} \cdot k_B \cdot T) \cdot mass}} = \frac{6.6 \times 10^{-34} J.s}{\sqrt{\frac{1}{2} \cdot \frac{3}{2} \cdot 1.38 \cdot 10^{-23} \frac{J}{K} \cdot 300K \cdot 10^{-15} \cdot 10^{-3} kg}}$$

$$= \boxed{1.184 \times 10^{-14} m \text{ Wavelength}}$$

iv) An ^{87}Rb atom that has been laser cooled to temp T = 100 μK

Isotopic Mass ^{87}Rb = 86.909

$$\text{Atomic Mass} = \frac{M_u}{N_A} = \boxed{\frac{86.909}{6 \times 10^{23}}} =$$

$$\lambda = \frac{h}{\sqrt{\frac{3}{4} \cdot k_B \cdot 100 \times 10^{-6} \cdot \frac{86.909}{6 \times 10^{23}}}}$$

$$= \boxed{1.7 \times 10^{-9} m \text{ Wavelength}}$$