1. While conducting a photoelectric-effect experiment with light of a certain frequency, you find that a reverse potential difference of 1.25 V is required to reduce the current to zero. Evaluate (a) the maximum kinetic energy and (b) the maximum speed of the emitted photoelectrons.

Solution: Recall that when the current has come to a full stop, all electrons including the ones with maximum kinetic energy are held onto the plate:

$$KE_{max} = eV_0 = \left(1.60 \times 10^{-19}C\right)(1.25V) = 2.00 \times 10^{-19}J$$

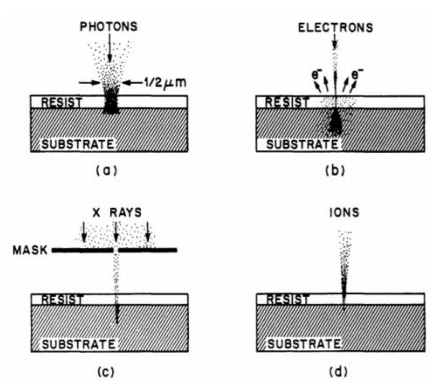
Setting that equal to $(1/2)mv^2$ and solving for v:

$$v = \sqrt{\frac{2\left(2.00 \times 10^{-19}J\right)}{9.11 \times 10^{-31}kg}} = 6.63 \times 10^5 \frac{m}{s}$$

2. What changes would you make to get 20 - 5 nm resolution and diffraction limits in lithography? Show a relationship between resolution and diffraction and explain.

Electron lithography offers high resolution because of the small wavelength of electrons (< 0.1 nm for 10-50 keV electrons). The resolution of an electron lithographic system is not limited by diffraction, but rather by electron scattering in the resist (**Figure 5.13**) and by the various aberrations of the electron optics.

The advantages of electron lithography are: (1) Generation of micron and submicron resist; geometries; (2) Highly automated and precisely controlled operation; (3) Greater depth of focus; (4) Direct patterning without a mask



ıre 5.12: Types of lithographic methods. **(a)** Optical lithography. **(b)** Electron lithography. **(c)** X-ray lithography. **(d)** Ion lithography.

Principle:

- **Resolving power** – RP of a microscope is the reciprocal of the distance between two objects (Δx) which can be just resolved when seen through the microscope

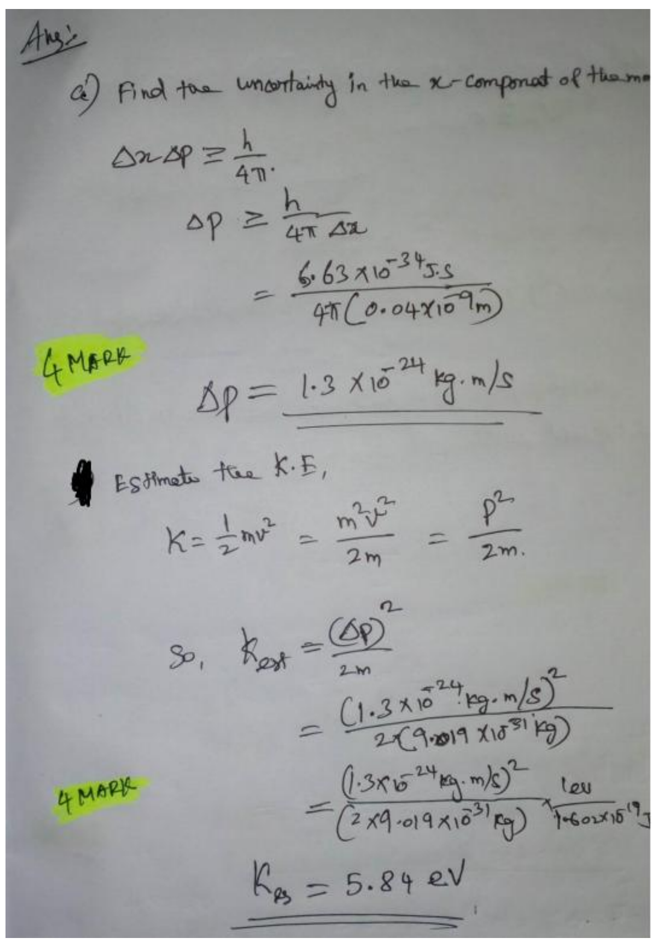
→ numerical aperture of the objective

Δx is called limit of resolution

- In an instrument for a given numerical aperture as $\Delta x \downarrow$, resolving power $\uparrow$
- Hence shorter the wavelength of the radiation, greater is the resolving power

- Balancing resolving power and magnifying power of the microscope is crucial for a better clarity image

3. (a) The uncertainty of the x-component of the electron's position is 0.04 nm, and then calculates the uncertainty in the momentum. Use the classical expressions for the momentum and kinetic energy to estimate the electron's kinetic energy.



Ans:-

a) Find the uncertainty in the x-component of the mo

$$\Delta x \, \Delta p \geq \frac{h}{4\pi}.$$

$$\Delta p \geq \frac{h}{4\pi \, \Delta x}$$

$$= \frac{6.63 \times 10^{-34} \, J.s}{4\pi (0.04 \times 10^{-9} m)}$$

4 MARK

$$\Delta p = \underline{\underline{1.3 \times 10^{-24} \, kg.m/s}}$$

Estimate the K.E,

$$K = \frac{1}{2} m v^2 = \frac{m^2 v^2}{2m} = \frac{p^2}{2m}.$$

$$\text{So, } K_{est} = \frac{(\Delta p)^2}{2m}$$

$$= \frac{(1.3 \times 10^{-24} \, kg.m/s)^2}{2 (9.019 \times 10^{-31} kg)}$$

4 MARK

$$= \frac{(1.3 \times 10^{-24} kg.m/s)^2}{(2 \times 9.019 \times 10^{-31} kg)} \frac{1 eV}{1.602 \times 10^{-19} J}$$

$$\underline{\underline{K_{es} = 5.84 \, eV}}$$

4. What is your opinion of Quantum confinement and their dimension? Explain with examples in details.

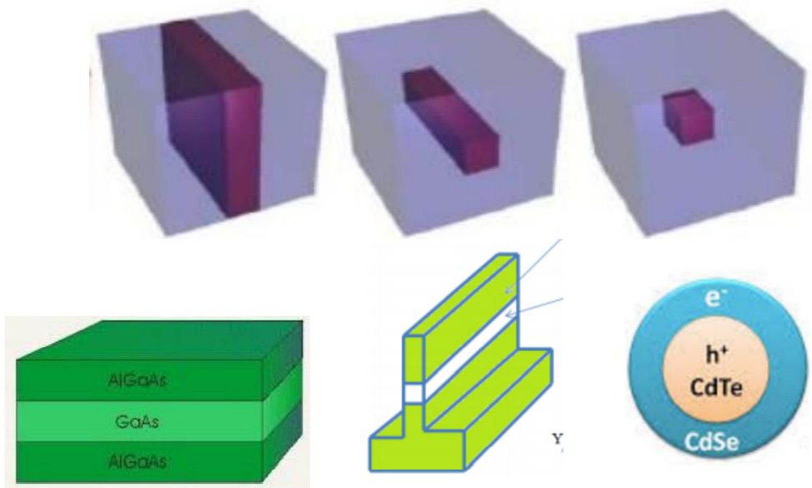
Quantum Confinement

- The confinement of the electronic wave function to the physical dimensions of the particles - "Quantum Confinement".
- In a macroscopic semiconducting crystal, the energy levels form bands separated by band gap E_g. The valence band is filled and the conduction band is completely empty at 0 K.
- When an electron gets excited due to thermal excitations, an electron-hole pair is created.
- Electron and hole can be bound when they approach each other at a finite distance. This bound pair is called an exciton.
- The Bohr radius of the exciton is $a = \frac{h^2 \varepsilon}{4\pi^2 e^2}\left(\frac{1}{m_e} + \frac{1}{m_h}\right)$

Confinement in How many dimensions..?

- If the movement of electrons is confined in 1-dimension and allowed to move freely in remaining 2-dimensions, then it is called as Quantum well.
- If the movement of electrons is confined in 2-dimensions and allowed to move freely in remaining 1-dimension, then it is called as Quantum wire
- If the movement of electrons is confined in all the 3-dimensio then the electron cannot move and it is called as Quantum dc

System	Extent of confinement	Degree of freedom
Bulk	0	3
Quantum Well	1	2
Quantum Wire	2	1
Quantum dot	3	0



Quantum well Quantum wire Quantum dot