Physics 133 3:30pm, Sp2006; May 18th

Name: KEY

TA: ______

This is midterm 2 for Physics 133; write your name on every page of this exam. Do it NOW....

There are a total of 6 pages, including this cover sheet, and the last page which is an equation sheet. You may detach the equation sheet and refer to it during the exam.

Page 2 has four multiple choice problems.

Pages 3,4,5 each have show work problems. All work must be shown in order to receive credit.

GOOD LUCK.

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Multiple choice. (5 pts each)

1) A free electron moves along the x-axis, and has a localized wave function. The uncertainty in its momentum is decreased if:

A. The wave function is made more narrow
(B.) The wave function is made less narrow
C. Wave function is unchanged, but its energy is increased
D. Wave function is unchanged, but its energy is decreased
E. None of the above

2) A particle is in a finite potential well, and it can have any one of 5 quantized energy values and no more. What would allow it to have possibly a 6^{th} energy level?

A. Increase the energy of the particle
B. Decrease the energy of the particle
(C.) Make the well wider
D. Make the well narrower
E. Make the well shallower

3) Light beams A and B have the same intensity but λ_A is longer than λ_B. The rate of photons is:

(A.) Greater for A than for B
B. Greater than B than for A
C. The same for A and B
D. Not enough info to decide

$$R = \frac{P}{hf} = \frac{IA}{hc}\lambda$$

4) The intensity of a beam of light is decreased and the light's frequency is increased. Circle which things are true:

A) The photons travel faster
(B)) Each photon has more energy
C) The photons are larger
D) There are more photons per second

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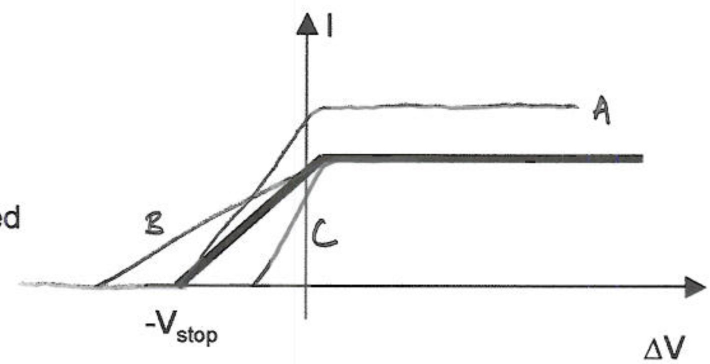
1) The figures below each show typical graphs for a photoelectric experiment. On each figure, CLEARLY draw and label (with the appropriate letter) graphs for each situation described.

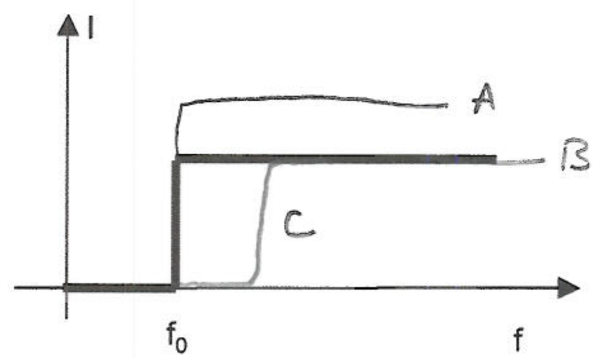
Current vs potential difference graph:

A) The light intensity is increased
B) The light frequency is increased
C) the cathode work function is increased
In each case, no other parameters are changed.



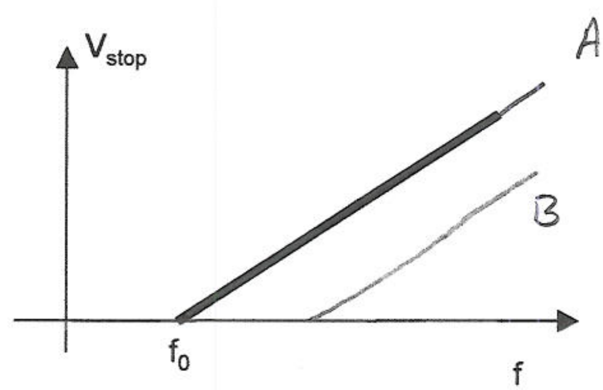
Current vs frequency graph:

A) The light intensity is increased
B) The anode-cathode potential difference is increased
C) the cathode work function is increased
In each case, no other parameters are changed.



Stopping potential vs frequency graph:

A) The light intensity is increased
B) the cathode work function is increased
In each case, no other parameters are changed.



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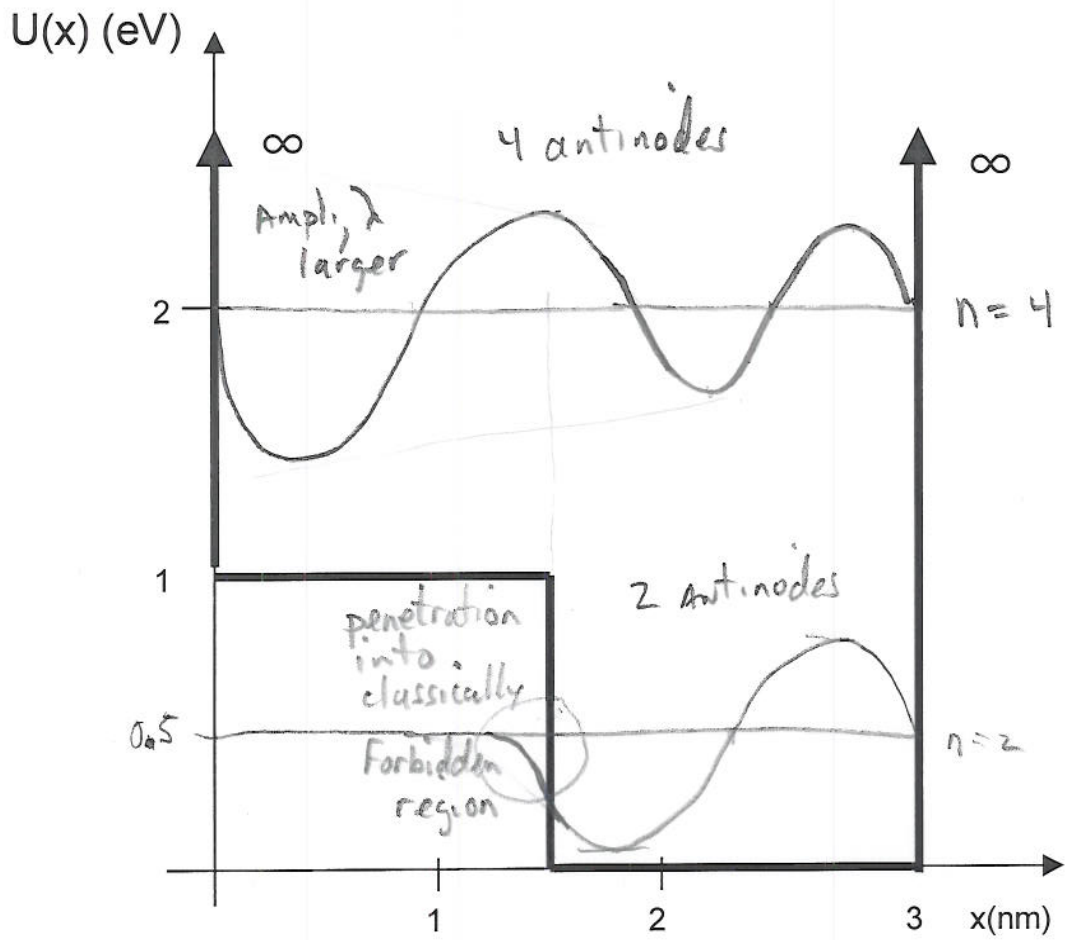
Show work; all work must be shown to receive credit.

2) The figure below shows potential energy function U(x) of an electron. The solution of the Schrodinger equation finds that the n=2 level has E_2=0.5eV and the n=4 level has E_4=2.0eV. $m_e=9.11\times10^{-31}$kg (25 pts)
Draw on the figure the energy lines for these states. Also, sketch the wavefunctions for these states, oscillating about the appropriate energy line. For each state, note on the curve if there any penetration into classically forbidden region.



Does the amplitude and/or the wavelength of either state change? If so, describe the change (increase or decrease) for that state and give a short explanation.

The amplitude and wavelength of the n=4 state both increase for x<1.5nm. Since $\lambda = \frac{h}{\sqrt{2mK}}$, λ is larger for x<1.5nm because K is smaller. The amplitude is larger because K is smaller as well → v is smaller, and the particle is more likely to be found where it is slower.

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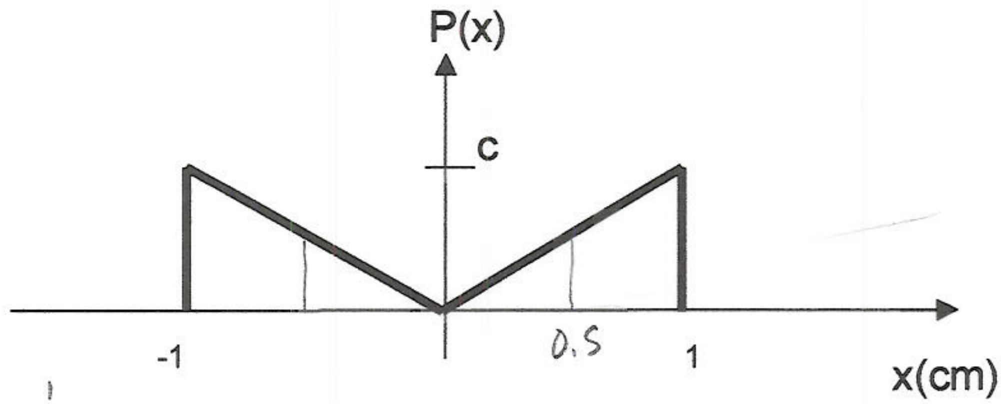
3) The figure below shows P(x) for the electrons in an experiment.
A) What is the value of c (make sure to give the correct units)?
B) Draw a graph of ψ(x)| over the same interval, giving a numerical scale on both axes (there may be more than one correct answer).
C) What is the probability that an electron will be detected in a 0.001cm wide region at x= 0.50cm? How about x= 0.999cm?
D) If 10^4 electrons are detected in this experiment, how many are expected to fall in the interval $0 \le x \le 0.5$cm?

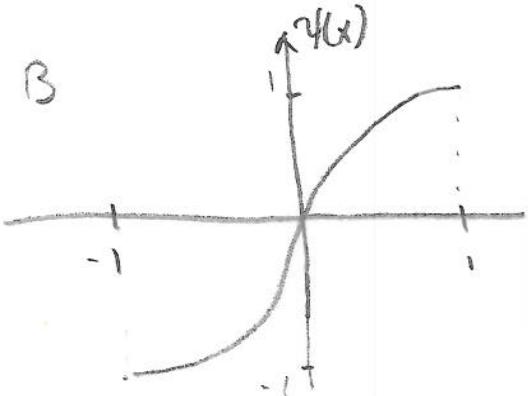


A) $\int_{-1}^{1} P(x)\,dx = 1$

$2\left(\frac{1}{2}\right)(1\text{cm})(c) = 1$

$c = 1\ \text{cm}^{-1}$

B)



C) Prob (x in 0.001cm at x = 0.5cm)

$= (0.5\ \text{cm}^{-1})(0.001\ \text{cm})$

$= 0.0005$

Prob (x in 0.001cm at x = 0.999cm)

$= (0.999\ \text{cm}^{-1})(0.001\ \text{cm})$

$= 0.000999$

D) Prob $= \int_{0.0}^{0.5} P(x)\,dx = \left(\frac{1}{2}\right)(0.5)(0.5)$

$= 0.125$

$N = 0.125 \times 10^4$

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Chapters 24/37:

Light: $c = \lambda f \qquad E = hf$

DeBroglie: $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mk}}$

Particle in a Box: $E_n = \frac{h^2 n^2}{8mL^2}$

$1eV = 1.60 \times 10^{-19} J$

$\hbar = 1.05 \times 10^{-34} Js$

Chapter 40

$$\frac{d^2\psi}{dx^2} = -\frac{2m}{\hbar^2}[E - U(x)]\psi(x)$$

$$P_{class}(x) = \frac{2}{Tv(x)}$$

$$P_{quant} = |\psi_n(x)|^2$$

Infinite well:

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right) \qquad 0 \le x \le L$$

$$\psi_n(x) = 0 \qquad x < 0 \quad \text{and } x > L$$

$$E_n = \frac{h^2 n^2}{8mL^2}$$

Finite well in region $0 \le x \le L$,

particle with energy E:

forbidden region

$$\psi_n(x) = \psi_{edge} e^{-(x-L)/\eta} \qquad x \ge L$$

$$\eta = \frac{\hbar}{\sqrt{2m(U_0 - E)}}$$

Tunneling through barrier of width w:

$$P_{tunnel} = e^{-2w/\eta}$$

Chapter 38:

$P = Rhf$

$I = P / A$

$K_{max} = eV_{stop} = hf - E_0 = hf - hf_0$

Bohr model:

$2\pi r = n\lambda$

$r_n = n^2 a_B \qquad a_B = 0.0529\text{nm}$

$E_n = -\frac{13.60eV}{n^2}$

$\hbar = \frac{h}{2\pi}$

Chapter39

Prob(in δx at x) = $P(x)\delta x$

Photons: $P(x) \propto |A(x)|^2$

Matter: $P(x) = |\psi(x)|^2$

$$\int_{-\infty}^{\infty} P(x)dx = \int_{-\infty}^{\infty} |\psi(x)|^2 dx = 1$$

$\Delta f \Delta t \ge 1$

$\Delta x \Delta p_x \ge \frac{h}{2}$

$\Delta E \Delta t \ge \frac{h}{2}$