1. $$V_{AC} = \frac{V_A + V_C}{1 + V_A V_C / c^2}$$

$$= \frac{c}{1 + 0.5^2} = \frac{c}{1.25} = 0.8c$$

$\gamma = 5/3$ for $v/c = 0.8$

$$L = L_0/\gamma = \frac{L_0}{5/3} = \boxed{0.6 L_0}$$

2. $E_i = E_f$

$p_{xi} = p_{xf}$

$p_{yi} = p_{yf}$

$$\Rightarrow \boxed{\begin{aligned} hc/\lambda_i + m_e c^2 &= hc/\lambda_f + E_e \\ h/\lambda_i &= p_e \cos\varphi + h/\lambda_f \cos\theta \\ p_e \sin\varphi &= h/\lambda_f \sin\varphi \end{aligned}}$$

3. a. $E = h\nu = 1240/310 = 4\ eV$

$E_{max} = h\nu - W = \boxed{2.8\ eV}$

b. $$\lambda = h/p = h/mv = h/\sqrt{2mK}$$

$$= 6.6 \times 10^{-34} / \sqrt{2 \cdot 9.1 \times 10^{-31} \cdot 2.8 \times 1.6 \times 10^{-19}}$$

$$= 7.3 \times 10^{-10}\ m = \boxed{0.73\ nm}$$

4. $-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U(x)\psi = E\psi$

$$\frac{d\psi}{dx} = Ae^{-ax} - Aaxe^{-ax}$$

$$\frac{d^2\psi}{dx} = -Aae^{-ax} - Aae^{-ax} + Aa^2xe^{-ax}$$

$$= A(a^2xe^{-ax} - 2ae^{-ax})$$

$$U(x)\psi = -\frac{C}{x}Axe^{-ax}$$

$$= -\frac{a\hbar^2}{m}Ae^{-ax}$$

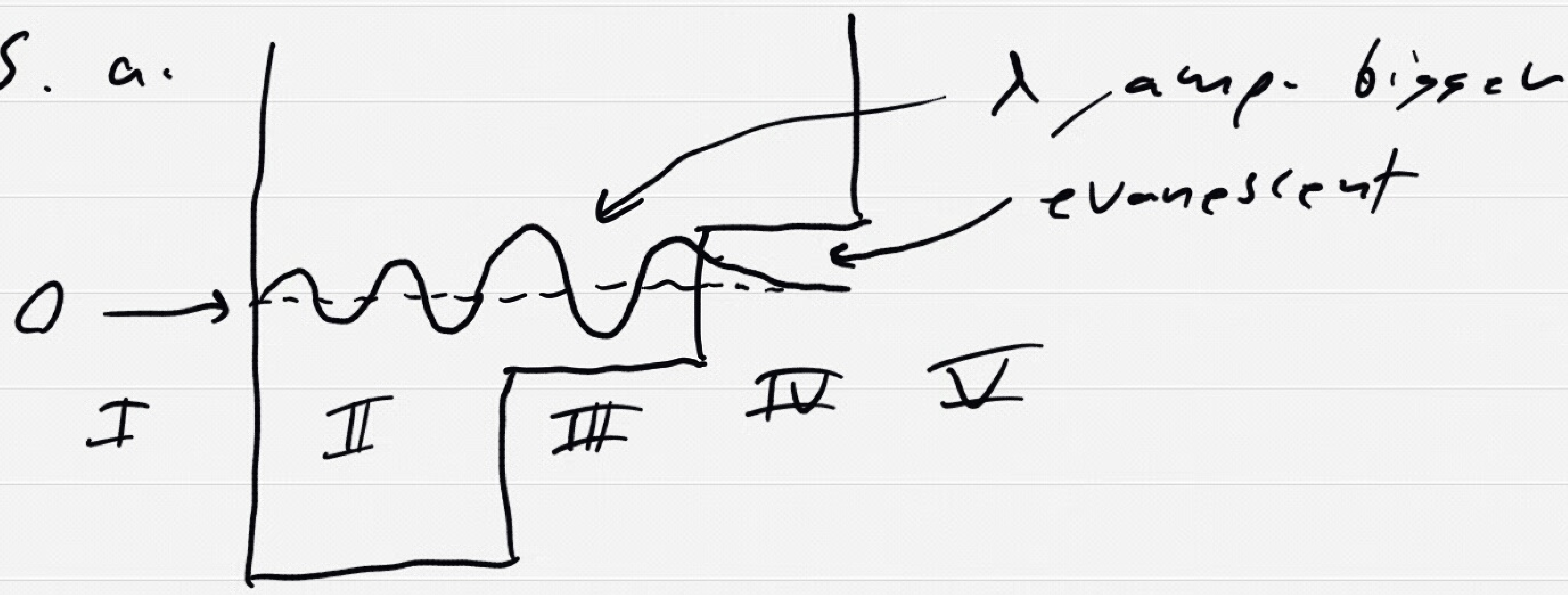
$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U(x)\psi$$

$$= \left(-\frac{\hbar^2a^2}{2m}x + \frac{2\hbar^2a}{2m} - \frac{a\hbar^2}{m}\right)Ae^{-ax}$$

$$= -\frac{\hbar^2a^2}{2m}Axe^{-ax} = -\frac{\hbar^2a^2}{2m}\psi$$

$$\Rightarrow \boxed{E = -\frac{\hbar^2a^2}{2m}} \boxed{= -\frac{mC^2}{2\hbar^2}}$$

5. a.

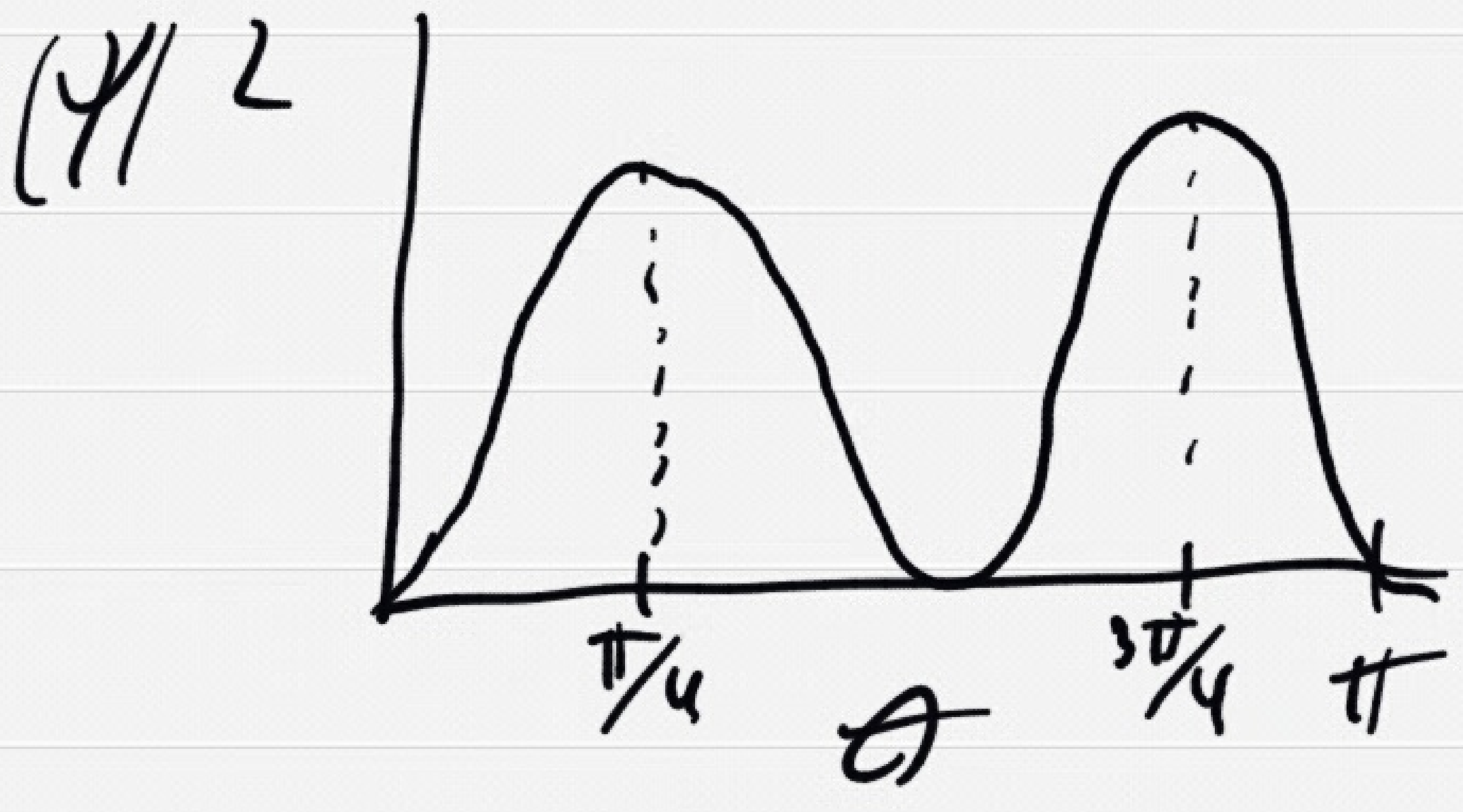


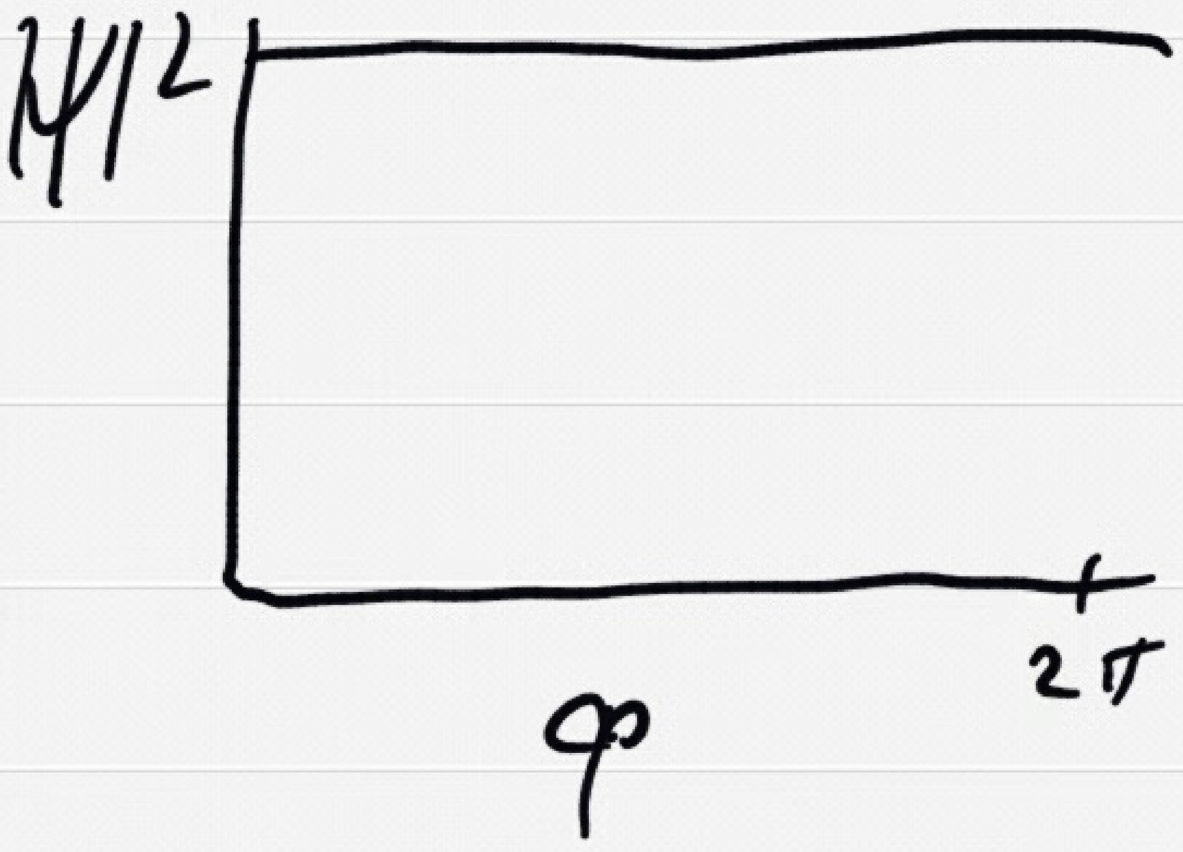
b. Max. prob in III since KE smaller so moves slower

c. zero in I & V where $U(x) = \infty$

6. A. $|\psi|^2 \propto \sin^2\theta \cos^2\theta \, e^{+i\varphi} e^{-i\varphi}$

$= \sin^2\theta \cos^2\theta$





b. $\Delta E = 13.6\left(1 - \frac{1}{3^2}\right)$

$= \frac{8}{9} \cdot 13.6$

$= \boxed{12.1 \text{ eV}}$

c. lower prob. for $\ell = 2$ since orbit more circular for higher ℓ

7. Li much lower ionization potential since 2 1s electrons efficiently screen nuclear charge.

8. E for K_α $= 13.6 \cdot (Z-1)^2 \cdot \left(1 - \frac{1}{4}\right)$

$= 10.2\,(Z-1)^2$

$(Z-1)^2 = 9180/10.2 = 900$

$\Rightarrow Z - 1 = 30$

$\Rightarrow \boxed{Z = 31}$

9. a. $E_N = (N + 1/2)\hbar\omega$

so $\Delta E_N = \hbar\omega$

$\Delta E_{21} = \Delta E_{10} = \boxed{1.5 \text{ eV}}$

b. $E_L = B L(L+1)$

$\Delta E_{10} = B \cdot 2 - 0 = 2B$

$\Delta E_{21} = B \cdot 6 - B \cdot 2 = 4B$

$= \Delta E_{10} \cdot 2$

$= \boxed{0.2 \text{ eV}}$

c. $\Delta N = \pm 1$, $\Delta L = \pm 1$

but ΔN only $+1$ for absorption

$\Delta E = 1.5 - 0.2 = 1.3$

$1.5 - 0.1 = 1.4$

$1.5 + 0.1 = 1.6$

$1.5 + 0.2 = 1.7$

10. A. @ $T = 0$ all in ground state

so $\boxed{\langle E \rangle = 2 \text{ eV}}$

B. only 2 per energy level

so $\langle E \rangle = (2 \cdot 2 + 2 \cdot 4 + 2 \cdot 6)/6$

$= 24/6$

$= \boxed{4 \text{ eV}}$