

Electronic Properties in Solids (Midterm Examination):

October 14, 2010

Name: _____

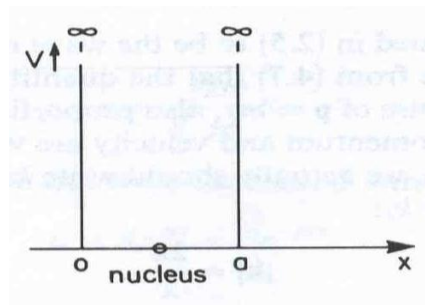
Student ID: _____

1. It is important for you to know how to derive the Schrodinger equation from the relationship between the energy and momentum equations for particle and wave duality.

For instance, the energy is expressed as $\frac{p^2}{2m} + V$, while momentum is expressed as mv ,

and each of them in wave nature is expressed as $\hbar\omega$ and $\hbar k$, respectively. Please derive the time-dependent Schrodinger equation starting from the general wave equation. (20 points)

2. Find out the allowed energy levels (E_n) for an electron confined in a potential well shown below. (20 points)



- (a) Write down the Schrodinger equation that you have to solve. This should be time-independent equation
- (b) How is the general solution written?
- (c) What are the boundary conditions?
- (d) Thus, how is the allowed energy level expressed?
3. It is important to know how to draw the Brillouin Zone of the structures. Step-by-step, please explain how you can draw the 1st Brillouin Zone of FCC structure with a lattice parameter of a . (20 points)
- (a) For FCC, what is the primitive translation vectors of $\mathbf{t}_1, \mathbf{t}_2$, and $\mathbf{t}_3$?
- (b) What is the reciprocal lattice vectors of $\mathbf{b}_1, \mathbf{b}_2$, and $\mathbf{b}_3$?
- (c) Based on this, identify what is the reciprocal lattice structure of FCC appears like?
- (d) Draw the general shape of the first BZ from this reciprocal lattice structure.
4. In the case of metal, the Fermi energy is expressed as follow; $E_F = \frac{\hbar^2}{2m} (3\pi^2 N')^{2/3}$ where

N' is the number of electrons per unit volume. Please solve how the Fermi energy is expressed as shown above. It is a rather long derivation but still is very important for you to remember. (20 points)

5. In the Drude model, the conductivity of metal is expressed as $\sigma = \frac{Ne^2\tau}{m}$, where τ is a relaxation time between two collisions. Please derive it step-by-step. (20 points)