In preparation for this test, you should:

- **X-Ray Spectra:**
  - understand the experiments of Moseley and their consequences;
  - know the origin of the continuous (bremsstrahlung) spectrum;
  - know the origin of the K-lines, L-lines, etc.

- **Spectroscopy**
  - be familiar with the methods of spectroscopy;
  - know the origin of the Balmer, Lyman, etc. lines for the hydrogen emission spectrum;
  - appreciate how the emitted photons correspond to the energy level structure of the excited atom.

- **Rutherford Model and Associated Experiments**
  - know Bohr’s postulates used to describe the hydrogen atom;
  - be able to state and subsequently derive the quantised energy levels associated with the Bohr atom;
  - be familiar with the details of the gold foil experiment of Geiger and Marsden; be able to describe their results, and discuss the significance and implications of their work in relation to the characteristics of an atom.

- **Franck–Hertz Experiment:**
  - be familiar with the details of the experiment;
  - be able to draw a sketch of the apparatus and discuss the measurements;
  - understand, appreciate, and be able to discuss its consequences.

- **Know deBroglie’s relationships:**\[ p = \frac{h}{\lambda} = \hbar k \] and \[ E = hf = \hbar \omega. \]

- **Wavepackets:**
  - understand and appreciate the ideas behind particle wavepackets;
  - know and understand the bandwidth theorem: \[ \Delta \omega \Delta t \sim 2\pi \] and \[ \Delta k \Delta x \sim 2\pi; \]
  - know how the bandwidth theorem relates to the Heisenberg Uncertainty Principle.

- **Wavefunctions:**
  - appreciate the origin of and be able to work with wavefunctions, \( \Psi(r, t) \);
  - understand how wavefunctions can be used to obtain probability distributions;
• The Schrödinger Wave Equation and Operators:

- be familiar with and be able to work with the time-dependent Schrödinger equation
- understand how the time-independent Schrödinger equation arises and be able to solve for \( \psi(x) \) and \( \phi(t) \) in those cases.
- know the definition of expectation value: \( \langle f(x) \rangle = \int_{-\infty}^{\infty} \psi^* \hat{f} \psi \, dx \) where \( \hat{f} \) is the operator associated with the quantity, \( f(x) \).
- know and be able to work with operators such as \( \hat{p} = \frac{\hbar}{i} \frac{\partial}{\partial x} \)
- know that \( E = K + V \) and \( K = \frac{p^2}{2m} \) as well as \( V(x) \) for one-dimensional potentials like the infinite and finite square well.
- know the definition of expectation values and understand how they are calculated. Be familiar with the operators for the observables: \( \hat{x}, \hat{p}, \) and \( \hat{E} \).

• 1-Dimensional Schrödinger Equation

- Be familiar with the idea of separation of variables, \( \Psi(x,t) = \psi(x)\phi(t) \).
- Know that \( \phi(t) = e^{-iEt} = e^{-i\omega t} \) since \( E = \hbar \omega \).
- Be able to write down the general solutions to \( \psi(x) \) for a given potential, \( V(x) \).
- Know that symmetric potentials yield symmetric wavefunctions (and know what is meant by an odd and an even function).
- Be able to recognise appropriate boundary conditions (i.e., \( \psi \) and \( \psi' \) are continuous) and be able to apply them along with the normalisation condition to solve for the wavefunction under explicit conditions.