Additional higher level

Topic 12: Atomic structure

2 hours

Essential idea: The quantized nature of energy transitions is related to the energy states of electrons in atoms and molecules.

12.1 Electrons in atoms

Nature of science:

Experimental evidence to support theories—emission spectra provide evidence for the existence of energy levels. (1.8)

Understandings:

- In an emission spectrum, the limit of convergence at higher frequency corresponds to the first ionization energy.
- Trends in first ionization energy across periods account for the existence of main energy levels and sub-levels in atoms.
- Successive ionization energy data for an element give information that shows relations to electron configurations.

Applications and skills:

- Solving problems using $E = hv$.
- Calculation of the value of the first ionization energy from spectral data which gives the wavelength or frequency of the convergence limit.
- Deduction of the group of an element from its successive ionization energy data.
- Explanation of the trends and discontinuities in first ionization energy across a period.

Guidance:

- The value of Planck's constant (*h*) and $E = hv$ are given in the data booklet in sections 1 and 2.
- Use of the Rydberg formula is not expected in calculations of ionization energy.

International-mindedness:

- In 2012 two separate international teams working at the Large Hadron Collider at CERN independently announced that they had discovered a particle with behaviour consistent with the previously predicted "Higgs boson".

Theory of knowledge:

- "What we observe is not nature itself, but nature exposed to our method of questioning."—Werner Heisenberg. An electron can behave as a wave or a particle depending on the experimental conditions. Can sense perception give us objective knowledge about the world?
- The de Broglie equation shows that macroscopic particles have too short a wavelength for their wave properties to be observed. Is it meaningful to talk of properties which can never be observed from sense perception?

Utilization:

- Electron microscopy has led to many advances in biology, such as the ultrastructure of cells and viruses. The scanning tunnelling microscope (STM) uses a stylus of a single atom to scan a surface and provide a 3-D image at the atomic level.

Syllabus and cross-curricular links:
Topic 3.2—periodic trends
Topic 4.1—ionic bonding
Topic 15.1—lattice enthalpy

Aims:

- **Aim 7**: Databases could be used for compiling graphs of trends in ionization energies and simulations are available for the Davisson-Germer electron diffraction experiment.