Advanced Higher Physics

Waves and Quanta

Study Guide

2.1 Introduction to Quantum Theory

❑	1	State that a Black Body is both a perfect absorber and emitter of radiation.
❑	2	Describe Black body radiation curves (graphs of irradiance versus λ).
❑	3	Describe qualitatively the ultraviolet catastrophe.
❑	4	Describe how the Photoelectric effect is used to explain the quantisation of energy of e-m waves.
❑	5	State that a beam of radiation can be regarded as a stream of individual energy bundles called photons, each having an energy $E = hf$, where h is Planck's constant and f is the frequency of the radiation.
❑	6	Carry out calculations involving the relationship $E = hf$.
❑	7	Carry out calculations involving the relationship between wavelength and momentum, $mvr = \frac{nh}{2\pi}$.
❑	8	State that the angular momentum of an electron about the nucleus is quantised.
❑	9	Describe qualitatively the Bohr model of the atom.
❑	10	Carry out calculations involving the quantisation of angular momentum of an electron.
❑	11	State that electrons can behave like waves.

- ❑ 12 Describe evidence which shows that electrons and electromagnetic radiation exhibit wave–particle duality.

- ❑ 13 Explain Atomic spectra in terms of electron energy states.

- ❑ 14 State that the wavelength found for a particle using $\lambda = \frac{h}{p}$ is small compared with the dimensions of any physical system (except on the atomic or sub-atomic scale).

- ❑ 15 Carry out calculations involving the relationship between wavelength and momentum.

- ❑ 16 State that a more far-reaching model of atomic and nuclear structure interprets waves in terms of probabilities.

- ❑ 17 State that quantum mechanics provides methods to determine probabilities.

- ❑ 18 Describe the Uncertainty principle in terms of location and momentum.

- ❑ 19 Describe the Uncertainty principle in terms of Energy and time.

- ❑ 20 Carry out calculations involving the uncertainty principle relationships, $\Delta x \Delta p_x \geq \frac{h}{4\pi}$ $\Delta E \Delta t \geq \frac{h}{4\pi}$.

- ❑ 21 Explain the concept of quantum tunneling and give an example of its application.

2.2 Particles from Space –
a. Cosmic Rays

- ❑ 1 Describe that Cosmic rays originate from outer space.
- ❑ 2 Describe that Cosmic rays consist of high energy charged particles, travelling close to the speed of light, mainly protons and alpha particles (helium nuclei).
- ❑ 3 Describe how, when cosmic rays interact with the Earth's atmosphere, they collide with air molecules, producing millions of particles called a cosmic shower.
- ❑ 4 Describe how the range of particles and energies can be compared with those found in particle accelerators.
- ❑ 5 Carry out calculations involving converting electron volts to Joules by multiplying by 1.6×10^{-19} (charge on an electron)

b. Solar wind and the magnetosphere

- ❑ 6 Describe the 11 year solar cycle as the solar activity of cyclic solar flares.
- ❑ 7 Describe that a Solar flare is an explosive release of energy.
- ❑ 8 Describe that Solar winds originate from the sun.
- ❑ 4 Describe the composition of the solar wind as charged particles in the form of a plasma – roughly the same number of protons and electrons.
- ❑ 5 Describe the interaction of the solar wind with the Earth's magnetic field.
- ❑ 6 Calculate the motion of charged particles in a magnetic field in terms of the magnitude of the force F acting on a charge q moving with a velocity v perpendicular to a magnetic field B. Carry out calculations using the relationship $F = Bqv$

- ❑ 7 Explain the helical motion of a charged particle moving at an angle to the magnetic field.

- ❑ 8 Describe the interaction of the solar wind with the Earth's magnetic field and upper atmosphere to explain the production of the aurora.