2.13: Exercises

1. A He-Ne laser emits radiation of wavelength $\lambda = 633$ nm. How many photons are emitted per second by a laser with a power of 1 mW? What force does such laser exert on a body which completely absorbs its radiation?
2. The ionization energy of a hydrogen atom in its ground state is $E_{\text{ion}} = 13.60$ eV (1 eV is the energy acquired by an electron accelerated through a potential difference of 1 V). Calculate the frequency, wavelength, and wavenumber of the electromagnetic radiation that will just ionize the atom.
3. The maximum energy of photoelectrons from aluminium is 2.3 eV for radiation of wavelength 2000,Angstorm), and 0.90 eV for radiation of wavelength 2580 Angstrom. Use this data to calculate Planck's constant, as well as the work function of aluminium.
4. Show that the de Broglie wavelength of an electron accelerated from rest across a potential difference V is given by
$$\lambda = 1.23\times 10^{-9}\,V^{\,-1/2}\,\text{m}, \tag{2.13.1}$$
where V is measured in volts.
5. If the atoms in a regular crystal are separated by $3\times 10^{-10}\ \text{m}$ demonstrate that an accelerating voltage of about $1.5\,\text{kV}$ would be required to produce an electron diffraction pattern from the crystal.
6. The relationship between wavelength and frequency for electromagnetic waves in a waveguide is
$$\lambda = \frac{c}{\sqrt{\nu^{\,2}-\nu_0^{\,2}}}, \tag{2.13.2}$$
where c is the velocity of light in vacuum. What are the group- and phase-velocities of such waves as functions of ν_0 and λ?
7. Nuclei, typically of size 10^{-14} m, frequently emit electrons with energies of 1–10 MeV. Use the uncertainty principle to show that electrons of energy 1 MeV could not be contained in the nucleus before the decay.
8. A particle of mass m has a wavefunction
$$\psi(x,t) = A\,\exp\left[-a\left(\frac{m\,x^{\,2}}{\hbar}+{\rm i}\,t\right)\right], \tag{2.13.3}$$
where A and a are positive real constants. For what potential function $V(x)$ does ψ satisfy the Schrödinger equation?

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1. Plural of *quantum*: Latin neuter of *quantus*: how much?↩

Contributors and Attributions

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