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Institution: Beijing-Dublin International College
Module: University Physics 2 (BDIC2008J)
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Problem Set 10

Quantum Mechanics & Atomic Structure

Problem 1. *At what rate does the Sun emit photons? For simplicity, assume that the Sun's entire emission at the rate of* $3.9 \times 10^{26}\,\mathrm{W}$ *is at the single wavelength of* $550\,\mathrm{nm}$.

Problem 2. *A* $100\,\mathrm{W}$ *sodium lamp* ($\lambda = 589\,\mathrm{nm}$) *radiates energy uniformly in all directions.* ***(a)*** *At what rate are photons emitted by the lamp?* ***(b)*** *At what distance from the lamp will a totally absorbing screen absorb photons at the rate of* $1.00\,\mathrm{photon/cm^2{\cdot}s}$*?* ***(c)*** *What is the photon flux (photons per unit area per unit time) on a small screen* $2.00\,\mathrm{m}$ *from the lamp?*

Problem 3. *A satellite in Earth orbit maintains a panel of solar cells of area* $2.60\,\mathrm{m}^2$ *perpendicular to the direction of the Sun's light rays. The intensity of the light at the panel is* $1.39\,\mathrm{kW/m}^2$. ***(a)*** *At what rate does solar energy arrive at the panel?* ***(b)*** *At what rate are solar photons absorbed by the panel? Assume that the solar radiation is monochromatic, with a wavelength of* $550\,\mathrm{nm}$, *and that all the solar radiation striking the panel is absorbed.* ***(c)*** *How long would it take for a "mole of photons" to be absorbed by the panel?*

Problem 4. *Light of wavelength* $200\,\mathrm{nm}$ *shines on an aluminum surface;* $4.20\,\mathrm{eV}$ *is required to eject an electron. What is the kinetic energy of* ***(a)*** *the fastest and* ***(b)*** *the slowest ejected electrons?* ***(c)*** *What is the stopping potential for this situation?* ***(d)*** *What is the cutoff wavelength for aluminum?*

Problem 5. *The stopping potential for electrons emitted from a surface illuminated by light of wavelength* $491\,\mathrm{nm}$ *is* $0.710\,\mathrm{V}$. *When the incident wavelength is changed to a new value, the stopping potential is* $1.43\,\mathrm{V}$. ***(a)*** *What is this new wavelength?* ***(b)*** *What is the work function for the surface?*

Problem 6. *Singly charged sodium ions are accelerated through a potential difference of* $300\,\mathrm{V}$. ***(a)*** *What is the momentum acquired by such an ion?* ***(b)*** *What is its de Broglie wavelength? (Hint: The mass of a single sodium atom is* $3.819 \times 10^{-26}\,\mathrm{kg}$*)*

Problem 7. *What is the wavelength of* ***(a)*** *a photon with energy* $1.00\,\mathrm{eV}$*,* ***(b)*** *an electron with energy* $1.00\,\mathrm{eV}$*,* ***(c)*** *a photon of energy* $1.00\,\mathrm{GeV}$*, and* ***(d)*** *an electron with energy* $1.00\,\mathrm{GeV}$*?*

Problem 8. *An electron in a multielectron atom is known to have the quantum number* $\ell = 3$. *What are its possible* n, m_ℓ, *and* m_s *quantum numbers?*

Problem 9. *Two of the three electrons in a lithium atom have quantum numbers* (n, ℓ, m_ℓ, m_s) *of and* $(1, 0, 0, +\frac{1}{2})$*, and* $(1, 0, 0, -\frac{1}{2})$*. What quantum numbers are possible for the third electron if the atom is* ***(a)*** *in the ground state and* ***(b)*** *in the first excited state?*

Problem 10. *Show that the number of states with the same quantum number n is $2n^2$.*