중간시험 대비

> 2019142046 한창희 (전기전자공학 / 컴퓨터과학 4학년)

Constants

- Planck's constant. $h = 6.626 \times 10^{-34} \mathrm{J \cdot s}$
- Reduced planck constant. $\hbar = 1.0546 \times 10^{-34} \mathrm{J \cdot s}$
- Boltzmann's constant. $k = 1.38065 \times 10^{-23} \mathrm{m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}}$
- Electron charge. $e = 1.602 \times 10^{-19} \mathrm{C}$
- Permittivity. $\epsilon_0 = 8.854 \times 10^{-12} \mathrm{F/m}$
- Permeability. $\mu_0 = 1.257 \times 10^{-6} \mathrm{H/m}$

Equations

- Molecular speed distribution. $f(v) = 4\pi N(m/2\pi kT)^{3/2} \cdot v^2 e^{-mv^2/2kT}$
- EM wave speed. $c = 1/\sqrt{\epsilon_0 \mu_0} = f\lambda$
- Energy quanta. $E = hf = hc/\lambda$
- Photoelectric Effect
  - maximum emissive kinetic energy. $KE = hf - \phi$
  - work function. $\phi = hf_0$
- Compton Effect
  - photon momentum (massless particle). $p = E/c = hf/c$
  - $h(f - f') = KE$ (photon energy loss = electron kinetic gain)
  - compton effect. $\lambda' - \lambda = \lambda_C(1 - \cos\phi)$
  - compton wavelength. $\lambda_C = h/mc$
- De Broglie Waves
  - photon wavelength (massless particle). $\lambda = h/p$
  - de Broglie wavelength. $\lambda = h/\gamma mv$
  - relativistic factor. $\gamma = 1/\sqrt{1 - (v^2/c^2)}$

- particle total energy. $E = \sqrt{E_0 + p^2c^2} = \sqrt{mc^2 + p^2c^2}$
- particle kinetic energy. $KE = E - E_0$
- Wave Formula
  - de Broglie phase velocity. $v_p = f\lambda = (\gamma mc^2/h)(h/\gamma mv) = c^2/v$
  - wave formula. $y = A\cos(\omega t - kx) = A\cos 2\pi f(t - x/v_p)$
  - phase velocity (same as above) $v_p = \omega/k$
  - group velocity $v_g = c\sqrt{1 - (1/\gamma^2)} = \varDelta\omega/\varDelta k$
- Particle in a Box
  - de Broglie wavelengths of trapped particle. $\lambda_n = 2L/n$
  - kinetic energy of trapped particle. $KE = mv^2/2 = h^2/2m\lambda^2$
  - energy of trapped particle. $E_n = n^2h^2/8mL^2$
- Uncertainty Principle. $\varDelta x \cdot \varDelta p \geq \hbar/2$
- Bohr Atom
  - condition for stability. $n\lambda = 2\pi r$
  - orbital electron velocity. $v = e/\sqrt{4\pi\epsilon_0 mr}$
  - orbital electron wavelength. $\lambda = (h/e)\sqrt{4\pi\epsilon_0 r/m}$
  - orbital radii in Bohr atom. $r_n = n^2h^2\epsilon_0/\pi me^2$
  - electron energy. $E_n = -e^2/8\pi\epsilon_0 r_n = -me^4/8\pi{\epsilon_0}^2h^2 \cdot (1/n^2)$
- Lasers
  - absorption rate. BN_1I
  - spontaneous emission rate. AN_2 (where $A = 1/\tau$)
  - stimulated emission rate. BN_2I
  - Two-level rate equations
    - $dN_2/dt = BI(N_1 - N_2) - AN_2$
    - $dN_1/dt = BI(N_2 - N_1) + AN_2$
    - $\varDelta N = (N_1 + N_2)/(1 + 2I/I_{sat})$, $I_{sat} = A/B$
  - Three-level rate equations (level 3 decays so fast, $N_3 = 0$)

        - $dN_2/dt = BIN_1 - AN_2$
        - $dN_1/dt = -BIN_1 + AN_2$
        - $\mathit{\Delta} N = (N_1 + N_2)(1 - I/I_{sat})/(1 + I/I_{sat})$
- Schrodinger equation.
    - Time-dependent. $i\hbar(\partial\psi/\partial t) = -(\hbar^2/2m)(\partial^2\psi/\partial x^2) + U\psi$
    - Time-independent. $E\psi(x) = -(\hbar^2/2m)(d^2\psi(x)/dx^2) + V\psi(x)$
    - Probability on position. $P = \int |\psi(x)|^2 \ dx$
    - Expectation value on position. $\langle x \rangle = \int x|\psi(x)|^2 \ dx$
- Operators
    - total energy of quantum particle. $E = KE + U$
    - momentum operator. $\hat{p} = (\hbar/i)(\partial/\partial x)$
    - total energy operator. $\hat{E} = i\hbar(\partial/\partial t)$
    - Hamiltonian operator. $\hat{H} = -(h^2/2m)(\partial^2/\partial x^2) + U$
        - Schrodinger equation reduces to $\hat{H}\psi_n = E_n\psi_n$
- Hydrogen atoms in steady-state form
    - discrete energy levels (energy eigenvalues) $E_n = -me^4/32\pi^2{\epsilon_0}^2\hbar^2 \cdot (1/n^2)$
    - eigenvalues of the total angular momentum $L = \sqrt{l(l+1)\hbar}$
- Particle in a Box
    - Schrodinger equation. $d^2\psi/dx^2 + (2m/\hbar^2)E\psi = 0$
    - solution. $\psi = A\sin(\sqrt{2mE} \cdot x/\hbar) + B\cos(\sqrt{2mE} \cdot x/\hbar)$
        - this subjects to the boundary conditions, $\psi(x=0) = \psi(x=L) = 0$
    - energy of trapped particle. $E_n = n^2\pi^2h^2/2mL^2$