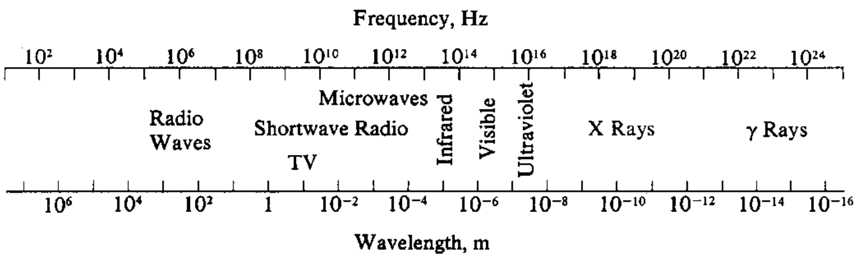
Quantum Chemistry
Exercises 1

1. Radiation in the ultraviolet region of the electromagnetic spectrum is usually described in terms of wavelength, λ, and is given in units of angstrom (1 Å = 10^{-10} m) or nanometers (10^{-9} m). Calculate ν, $\tilde{\nu}$, and the energy, E, for ultraviolet radiation with λ=2000 Å and compare your results to the figure below.



2. Chromium has a work function of 4.4 eV.
   - Calculate the maximum wavelength of light able to remove electron from a chromium surface.
   - Calculate the kinetic energy of electrons emitted from a chromium surface when it is irradiated with ultraviolet radiation of wavelength 2000 Å.
   - What is the stopping potential for these electrons?

3. A homogeneous light beam of wavelength λ=300 nm and intensity $5 \cdot 10^{-2}$ W m^{-2} falls on a sodium surface. The photoelectric work function for sodium is 2.3 eV. Calculate:
   - the average number of photons striking the surface per m^2 and per second
   - the average number of electrons emitted per m^2 and per second
   - the maximum kinetic energy of the photoelectrons

4. According to Planck's law the energy per unit time radiated per unit area *per unit frequency* by a black body at temperature *T* is given by:

$$I(\nu,T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{kT}}-1}$$

a. From this, derive Wien's displacement law which relates the wavelength at which the intensity *per unit wavelength* of the radiation produced by a black body is at a maximum to the temperature of the black body.

b. Assuming that the sun can be described as a black body and knowing that the wavelength of maximum emission intensity is 500 nm, calculate the temperature of the sun.

5. Show that the Lyman series occurs between 912 Å and 1216 Å, that the Balmer series occurs between 3630 Å and 6563 Å, and that the Paschen series occurs between 8210 Å and 18760 Å. Identify the spectral regions to which these wavelengths correspond.

6. Calculate the de Broglie wavelength for:
   - an electron with a kinetic energy of 100 eV
   - a proton with a kinetic energy of 10^5 eV