CS – 122: Tutorial - 1

1) Calculate the frequency of electromagnetic radiation with a wavelength of
   a) 442 nm
   b) 1.315 micrometers
   c) 4.92 cm
   d) 8973 Å

2) A particular X-ray has a wavelength of 1.2 Å. Calculate the energy of one mole of photons with this wavelength.

3) Typical street lights (sodium vapour lamps) emit bright yellow light of wavelength of 590 nm. Calculate the separation between the energy levels in sodium atom responsible for this emission? Express your answer in joules, in kilojoules per mole, electron volts.

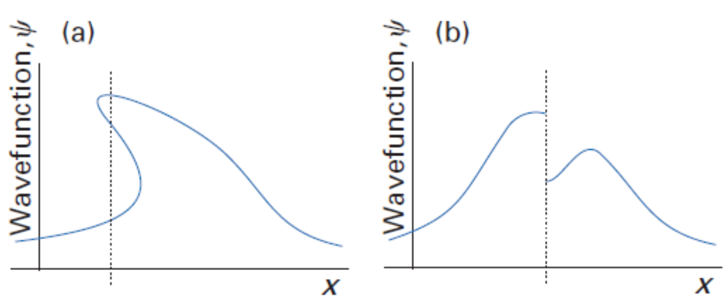
4) Calculate the speed of an electron emitted from a clean potassium surface by light of wavelength (a) 300 nm (b) 600 nm? Given that the work function of potassium is 2.3 eV.

5) (a) Suppose the speed of a certain projectile of mass 1.0 g is known to within an uncertainty of 1.0 μm s^{-1}. Using the Heisenberg's uncertainty principle estimate the minimum uncertainty in the position of the projectile along its line of flight.

6) The fastest serve in tennis is about 150 miles per hour. Calculate the wavelength associated with a tennis ball weighing 60 g traveling at this speed.

7) An electron beam obtained by accelerating a stream of electrons through a potential difference of 50 kV. Estimate the de Broglie wavelength of this electron beam (Hint: Energy (in eV) E = eΔV; 1 eV = 1.602 x 10-19 J; me = 9.109 x 10-31 kg, Plank's constant = 6.626 x 10-34 J s).

8) Comment on the suitability of each of the functions depicted below as acceptable wave functions? Briefly explain your answer.

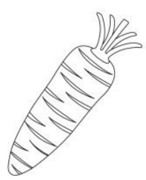
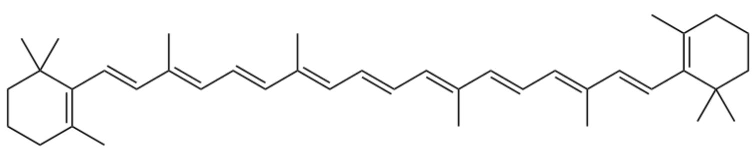


9) (*a*) The probability of finding the particle in a one-dimensional box at exactly $x = \frac{3L}{4}$ will be minimum for which of the following energy states: (*i*) $n = 2$ (*ii*) $n = 3$ (*iii*) $n = 4$ (*iv*) $n = 5$
(*b*) In which of the above energy levels (*i*) – (*iv*), will the probability of finding the particle be a maximum at the same position?

10) Write down the wave function and the energy of a particle in a two dimensional box whose one side is twice the other ($L_1 = L$, $L_2 = 2L$). Find the degenerate states of a particle in such a box with the energy: (a) $E = \frac{5h^2}{2mL^2}$ and (b) $E = \frac{5h^2}{8mL^2}$

11) Ignore the bond angles and assuming that π-electrons of conjugated alkenes, *hexatriene* $CH_2 = CH - CH = CH - CH = CH_2$, length 7.3 Å) and *octatetraene* ($CH_2 = CH - CH = CH - CH = CH - CH = CH_2$, length 8.5 Å) can be treated as particles in one dimensional boxes, calculate the energies of the lowest electronic transition in two molecules. Compare the calculated value with the experimentally determined UV-Vis absorption spectrum of *hexatriene* at 258 nm.

12) For the system of conjugated double bonds in β-carotene (*below*), assuming a particle in a one-dimensional box approximation, calculate the wavelength of the electronic transition between the highest occupied energy level to the next unoccupied energy level.
Does your result explain the colour of carrots? Explain.

13) From the exact solutions of the Schrodinger equation for the H-atom, the energy levels are given by:

$$E = -\frac{Z^2 e^4 \mu}{8\,\varepsilon_0 h^2}\left(\frac{1}{n^2}\right)$$

Derive an expression for the Rydberg constant and verify the value of R_H?
(Elementary charge (e) = 1.602×10^{-19} C; Mass of electron (m_e) = 9.109×10^{-31} kg
Mass of proton (m_p) = 1.672×10^{-27} kg; Plank's constant (h) = 6.626×10^{-34} J s
Rydberg Constant (R_H) = 109677 cm^{-1}; Permittivity of free space (ε_0) = 8.854×10^{-12} J^{-1} C^2 m^{-1})