FCH 361 **Homework #3- Revised** **Spring 2020**

EXERCISES

A) A mole of molecules with a total energy of 400 kJ. Each photon has the same frequency. What is the frequency and wavelength of the photons?

B) Go to https://phet.colorado.edu/sims/html/blackbody-spectrum/latest/blackbody-spectrum_en.html
Click the boxes for “Graph Values” and “Labels” to display the graph values and labels.

From the Blackboard site, download the “Blackbody Questions and answer them.

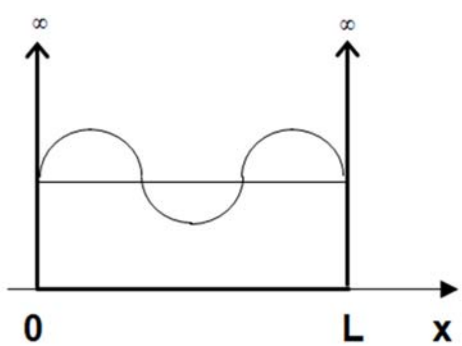
C) Problem 8.4 (8th Ed.) or 7.4 (9th Ed.), do parts (**a**) and (**d**), only.
For (**a**), use the approximation that ψ is constant over the range of x considered.
For (**d**), use logic.

D) The value of a wavefunction is constant:

$$\psi(x) = a \quad \text{for } 0 \leq x \leq 2 \times 10^{-10} \text{ meters}$$

If the probability of finding the particle between 0 and 2×10^{-10} meters is 0.01, what is the value and units of a?

E) Consider the figure below**.**



a) Is this a plot of ψ or ψ^2?

b) Without calculation, determine the probability of the particle being found between
i) $0 \leq x \leq L/2$?
ii) $0 \leq x \leq L/3$?
iii) $L/3 \leq x \leq 2L/3$?
iv) $L/2 \leq x \leq 2L/3$?

c) Can you determine the probability without calculation for $0 \leq x \leq L/5$?

F. Consider an electron in a 1-D box of length 5.0×10^{-10} meters.
a) What are the energies of the three lowest-energy states of the system?
b) What is the frequency of the photon that excites the electron from n=1 state to n=3?

G. Consider particle in a 1-D box of length L.
a) By what factor does the energy change if it goes from n=3 to n=1?
b) Is a photon absorbed or emitted in the process described in part a?
c) By what factor does the energy of the n=1 state change if particle were to be in box b whose length is 1/5 that of the box in part a?

The numbers refer to the Exercises (not Problems) in *Physical Chemistry*, **8th Edition**, by Peter Atkins and Julio De Paula. Numerical answers for the (b) exercises these are available in the back of the textbook, and more complete answers are in the Student Solutions Manual.

8.1 8.3-4 8.7 8.8 8.10, 8.12

The numbers refer to the Exercises (not Problems) in *Physical Chemistry*, **9th Edition**, by Peter Atkins and Julio De Paula. Numerical answers for the (a) exercises these are available in the back of the textbook, and more complete answers are in the Student Solutions Manual.

7.1 7.3-4 7.7 7.8 7.10 7.15

PROBLEMS

1. Consider an electron in a 1-D box of length 8.0×10^{-10} meters.

a) What is the frequency of the photon that excites the electron from n=1 state to n=4?

b) There is a second 1-D box whose n=8 level is at the same energy as the n=2 level of the first box. What is the value of L for the second box?

2. Consider a particle in the n = 4 level of a 1-dimensional box.

a) Sketch ψ versus x

b) Sketch ψ^2 versus x

c) Use logic and/or a sketch to determine the probability the particle is between:

i) $0 \le x \le 0.25L$

ii) $0.875\ L \le x \le L$

iii) $0.20L \le x \le 0.45L$

d) EXPLAIN why can't we use logic or a sketch to determine the probability for:

$$0 \le x \le 0.10L$$

e) Use **CALCULUS** to determine the probability that the particle is between 0 and 0.25L

NOTE 1: $\int \sin^2(ax)dx = \frac{x}{2} - \frac{1}{4a}\sin(2ax)$ NOTE 2: (e) and (c.i) have the same answer!

3. **CHANGED**! Compute the energy and quantum number (<u>to 3 sig figs</u>) of a particle in a 1-D box of length 1 cm:

a) If the particle is an electron with Kinetic Energy = $1/2k_BT$ at 298 K

b) If the particle is an argon atom with Kinetic Energy = $1/2k_BT$ at 298 K

c) If the particle has a mass of 1 μg and a speed of 100 m/sec

d) Create an spreadsheet with columns as indicated below to calculate n for any combination of mass and speed.

label	m (kg)	v (m/sec)	E (J)	L (meter)	n