

CHEM 332 – TAKE-HOME EXAMINATION 2 – Spring 2021

DATED: April 7, 2021

DUE: April 14, 2021

Note that you may have to look up the values of definite integrals in a table of integrals and also the values of some universal constants.

Please return by email to rgrose@ccny.cuny.edu as a **SINGLE** document using your **OFFICIAL CCNY EMAIL ADDRESS**. Make sure that your name, **AS IN YOUR REGISTRATION RECORD**, is clearly written on the document.

Question 1 (30 points)

Consider the following normalized wave-functions for the harmonic oscillator corresponding to states $n = 0$ and $n = 1$,

$$\psi_0 = \left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2/2}$$
$$\psi_1 = \left(\frac{4\alpha^3}{\pi}\right)^{1/4} x e^{-\alpha x^2/2}$$
$$\alpha = \sqrt{\frac{k\mu}{\hbar^2}}$$

Derive a relationship between the expectation values of the kinetic energy and the potential energy for each of these two states. What is the relationship of these expectation values to the total energy when the system is in each of these states?

Question 2 (30 points)

A particle of mass m moves in a potential that varies linearly with position from 0 to a (with a minimum of 0 at $x=0$ and a maximum of V_0 at $x=a$), the potential is ∞ outside this region. Define the form of the potential and calculate the first order correction to the energy of the ground state using the one-dimensional particle-in-a-box as the unperturbed system.

Question 3 (40 points)

Use the following trial function $\psi(r) = e^{-r/k}$ to estimate the ground-state energy of the hydrogen atom. How does this compare to the actual ground-state energy of the hydrogen-atom?