

Chm220 Practice Exam

Q1) Two piston/cylinder arrangements, containing 0.2 mol of an ideal gas each, are compressed isothermally, in 1-step and 2-step processes using constant external pressures. Each cylinder is initially at a temperature and pressure of 298 K and 1.0 atm. In the cylinder that undergoes the 1-step process, the constant external pressure is 5.5 atm, and 1.95 kJ of work is done, achieving a certain reduction in volume. In the cylinder that undergoes the 2-step process, the volume is first reduced by one half, using a constant external pressure equal to half that used in the 1-step process, and then it is compressed to the same final volume as the other cylinder by applying a constant external pressure of 5.5 atm as in the 1-step process.

- What is the final volume?
- What is the work applied in the 2-step process?
- Under what circumstances is the minimum amount of work applied, and what is that amount of work?
- If the gas were to be compressed in a 1-step process, what is the minimum constant external pressure that would be required, and what is the work associated with this process?

Q2) The reaction $2A \rightarrow B + C$ is first order in A. When some amount of pure A is introduced into a vessel at 350 K and allowed to react, 35% of it is found to have reacted after 800 s.

- What is the half life of the reaction?
- If the activation energy is reduced from 129 kJ mol^{-1} to 87 kJ mol^{-1} due to adding a catalyst, and the temperature is reduced from 350 K to 298 K, then what is the new rate constant? (Assume the Arrhenius pre-exponential factor remains unchanged)

Q3) a) Draw graphs of the wave function and the electron probability distribution function for $n = 4$ for a particle in a 1-D box of length L if:

$$\Psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$$

Label all axes, maxima & minima.

- Without integrating, show how to find the probability of finding the electron in the middle half of the box for $n = 4$? What is this probability?
- How does the result from (b) compare to the probability associated with $n = 1$?

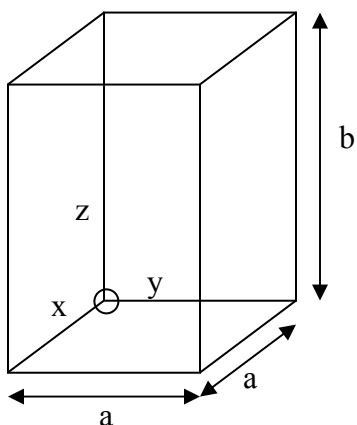
d) What is the difference in energy level of an electron being excited between these 2 states ($n=4$ and $n=1$) if the box length is 350 pm?

Q4) An excited electron at the $n = 4$ state in a Li^{2+} ion falls to an $n = 2$ state and emits electromagnetic radiation. What happens when this photon hits a sheet of aluminium with a binding energy of 4.08 eV, and what is the wavelength of light emitted by the lithium atom?

Q5) Find the probability of finding an electron in the LAST three quarters of a 1-D box of length L if the wave function takes the form:

$$\Psi(x) = \sqrt{\frac{30}{L^5}}(Lx - x^2)$$

Q6) a) On the following diagram, draw the plane according to the Miller indices (1,1,1), using the circled corner as the origin.



b) If $a = 310$ pm and $b = 450$ pm, then what diffraction angle corresponds to the first order reflection of the (1,1,1) plane if the wavelength of the incident x-rays is 0.856 \AA ?

c) If the density of the corresponding substance to this crystal structure is 12.5 g cm^{-3} , and the molecular weight is 81.5 g mol^{-1} , then find the number of atoms per unit cell.

Q7) The fundamental frequency of H^{19}F has a corresponding wavenumber of 3550 cm^{-1} . What is the zero point energy and the force constant of the bond in this molecule?