225W Review notes

Ch 1

- Natural Gas Law $PV = Nk_BT$
- Kinetic Theory of gasses $U = \frac{3}{2}Nk_BT$ or $\frac{\#\text{deg of Freedom}}{2}Nk_BT$
- Where degrees of freedom kick in Trans/Rot/Vib (& ch 10)
- Solid $3Nk_BT$

Ch 3

3.1 Crossed E & B fields, q/m ratio

3.3 Line spectra - Easier with Bohr model

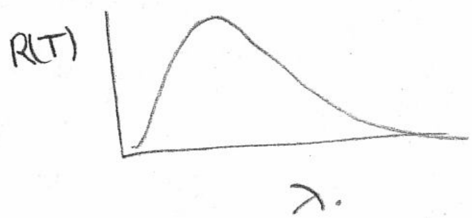
3.4 Quantization (# waves in a box)

3.5 Black Body Radiation (BBR)

- Ultraviolet catastrophy
- $\lambda_{max}T = 2.898\times10^{-3}\,mK$
- $R(T) = \varepsilon\sigma T^4$ $\sigma = 5.6705\times10^{-8}\,W/m^2K^4$

how close to a blackbody

W/m² at surface



- $E = hf$ ⇐ smaller λ's have more energy

planks constant $hc = 1239.6\,eV\,nm$

3.6 Photoelectric effect

- $KE_{max} = \frac{hc}{\lambda} - \phi$ ← work function

energy of incoming photon

no electrons till $\frac{hc}{\lambda} > \phi$

Quantum - electrons prompt, need λ specific to start

Classic - have to have electrons absorb a while

3.7 X rays $eV_0 = \frac{hc}{\lambda_{min}}$ highest energy electron gives smallest λ electron

3.8 Compton Effect $\lambda' - \lambda_0 = \frac{hc}{mc^2}(1-\cos\theta)$

remember your compton horns

- introduced $E = mc^2$ $E^2 = p^2c^2 + m^2c^4$ need for $v \sim$ few % c

$E = E_{kinetic} + m^2c^4$

3.9 Pair production $E_\gamma \rightarrow e^+ \, e^-$

- Like photoelectric effect, need a nucleus present to conserve momentum and energy, must have $E_{\gamma\, min} = 2mc^2$
- & inverse effect $e^+ \rightarrow \leftarrow e^-$ γ γ as in lab

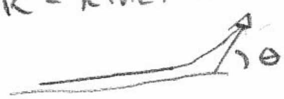
4.2 $N(\theta) = \frac{N_i \overbrace{nt}^{\#\text{ of scattering nuclei/area}}}{16}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \frac{Z_1^2 Z_2^2}{r^2 K^2 \sin^4(\theta/2)}$

$n = \frac{\#\text{ nuclei}}{\text{Volume}}$, t = thickness

N_i = # of incident particles

r = distance from target

K = kinetic energy



4.3 Classical electron orbiting loses energy

4.4 Bohr Model $L = n\hbar$, remember how we derived it.

4.5 - $r = \frac{4\pi\varepsilon_0 n^2 \hbar^2}{mq^2} = n^2 a_0$ $a_0 = 0.0529 \times 10^{-10}$ m

4.6 - $E_0 = -13.6\text{eV} = \frac{mq^4}{2\hbar^2 (K^2)}$ (m → reduced mass) (goes like Z^2 of nucleus)

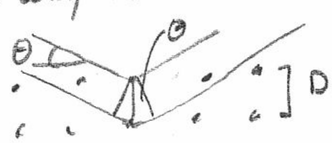
- transitions $-13.6\text{eV}\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$ → characteristic x rays
- book has (Z-1) for shielding, agree?
- limit of quantum ⇒ classical should agree w/classical
- problems with Bohr model?

4.7) example of peaks in mercury with electron bombardment

also saw later with He Ne laser

⇒ collisions way to excite w/o following transition rules

5.1) $n\lambda = 2d\sin\theta$



5.2) $\lambda = \frac{h}{p}$ de Broglie waves { like Bohr's quantization condition

5.3) Electron scattering (Electrons have wavelike behavior)
complex relationship to crystal planes

$\underbrace{n\lambda = D\sin\phi}$
complicated to get here!

5.4) Waves $\Psi(x,t) = A\sin(kx - \omega t)$

wavenumber, angular frequency, phase; $k = \frac{2\pi}{\lambda}$, $\omega = 2\pi f$

group velocity $\frac{d\omega}{dk}$ (won't see it on final

point of constant phase moves at $\frac{d}{dt}(kx-\omega t)=0$
$v = \lambda f$

⇒ used to motivate unc. princ.

5.5) Single & double slit experiments to motivate uncertainty princ.

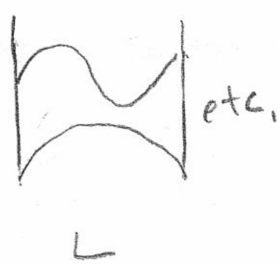
5.6) $\Delta x \Delta p_x \geq \frac{h}{4\pi}$ Heisenberg uncert. principle

$\Delta E \Delta t \geq \frac{h}{4\pi}$ estimates with ↳ assume Δ is the min
or put in Energy eqn and find minimum (did for H, Osc.)

5.7) Wave function is Probability distribution $\int_{-\infty}^{\infty} |\Psi(x)|^2 dx = 1$
add to Uncertainty principle
and can't know say x, & p_x exactly
⇒ only measurement collapses the $\Psi(x)$ {don't describe in between}
(recall our Bell inequality)

5.8) particle in a box 1st time $\frac{h^2}{8m}\left(\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2} + \frac{n_z^2}{L_z^2}\right)$

from fitting waves in a box



Essential review notes by section

5.4:

Know the form of a travelling wave

-Amplitude,phase velocity, wave number, wavelength

-note: the only real use we had for group velocity was remembering the deBroglie momentum

5.5

Know the single slit as an example of the uncertainty principle

5.6

Applications of uncertainty principle (UP) like in homework and lecture

(know how to do a minimization problem)

-different flavors of the UP xp,Et,Ltheta etc.

5.7

Know how to sketch wave functions:

-where it's like e^(ikx) and e(-ax)

-how a potential effects the wavelength

(see section 6.1)

-mathematical form of the probability density

5.8

Ccalculate energy, know wave functions for 1d,2d,3d particle in a box

(see section 6.3, and 6.5 too)

6.1

Recognize the correct form of the Schrodinger equation, using it on wave functions

-normalizing the wave function, properties of valid wave functions

6.2

Calculating expectation values, x,p,x^2,p^2 etc.

(tough integrals will be provided if needed)

5

6.3

Particle in a well again: the wave functions, using Schro. Egn to solve energy

6.4

Finite square well:

-know how to match wave functions at a boundary

-sketch the wave function

-understand the energy levels qualitatively.

(it is too hard to do the whole problem in a test!, but the semi-infinite square well is not too bad to solve (except the last step), and certainly you should understand the solutions so you can use them like in the homework (difficult equations etc. whould be provided))

-using boundary conditions to get Reflection/Transmission

6.5

refer to 5.8, understand the degeneracy of the energy levels

6.6

Know the energy levels, be ready to manipulate the solutions like in the homework

6.7

Understand the barrier tunneling formula

-know how to use it if E<V and E>V

7.1-7.2

Know how to use the solutions for expectation values (tough integrals provided)

7.3

Know the 3 quantum numbers (no spin yet!) and how many different ways a particle can populate an "n".

Test3 Notes
Section 7.3 6
Know the quantum numbers for the different states
n: principle quantum number
ell:Orbital angular momentum
ml:magnetic
And the degeneracy for different n's. ell's

Section 7.4
Zeeman effect
-how it splits an orbital
-the energy splitting (how to calculate it
-the spots on a stern gerlach apparatus due to angular momentum (spin, ell, total)

Section 7.5
Spin
-how it contributes to the degeneracy
-Pauli exclusion principle
-Energy splitting due to spin

Section 7.6
Intro shell filling
Selection rules (primarily delta-ell = +/-1)
We talked about the probability distribution in terms of filling up states (e.g. S shell fills first)

8.1
Review how shells fill up, and how to read the periodic table.
I'm not too big on the chemistry, but recall the noble gasses tend to be inert (not react) and small, The 1st column elements tend to be reactive (and large). Elements near the middle of the periodic table can have unpaired electrons etc.

8.2
Total angular momentum, j.
forming j from ell and s, mj's and degeneracy.
Example from class of doing a p level with j.
Many electron atoms: know how to fill them up, find the ground state as in class
Recall the states in helium where the spins are aligned (S=1) or opposite (S=0) and what it meant for allowed transitions. (your book has a similar example for magnesium)

8.3
Know that spins and orbital momenta can combine to split levels in a magnetic field.
Remember how we derived the Lande g factor.

9.2
Remember how we got to the speed by considering each dimension and building up the v^2dv

9.3
Equipartition should be a review for you, but remember how it works.

9.4

How to get expectation values from the f(v)dv and what f(v)dv is.

9.5
A good exercise here is to get f(v)dv in terms of energy and get the same behavior by considering the gas as particles in a square well. I.e. how to build up the number of particles considering the number of states and the probablity they are occupied. Remember the bulk behavior of the 3 distributions and how they look the same in the high temperature limit.

9.6
Recall our description of conduction and how we found the Fermi-momentum. Here is another chance to review how we build up #particles from states, and what the Fermi energy is.

9.7
Recall how we got the blackbody formula (classical and quantum) considering again the number of states and the occupation probability.

Good things to remember from the course for any test:

Energy and momentum from wavelength and frequency.

Energy states of the harmonic oscillator.

Energy states of the particle in a box.

10.1 molecular bonds

behave like SHO in their vibration $E=(n+\frac{1}{2})\hbar\omega$

& experience quantized rotation

$$E_{rot} = \frac{\hbar^2 \ell(\ell+1)}{2I}$$

rotation kicks in 1st followed by vibration for diatomic like H_2

- did some applications involving methods from ch 9

10.2 - used einsteins ideas to get back BBR distribution & motivate stimulated emission