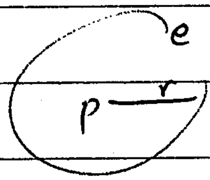
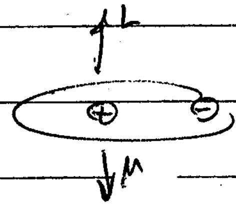
Thurs 26 Feb

Finishing modern physics - week 8

Angular momentum, magnetic moment, Zeeman effect

BOHR ATOM





$F = ma$

27 Ex 9 / 697 $\frac{kqQ}{r^2} = \frac{e^2}{4\pi\epsilon_0 r^2} = \frac{mv^2}{r} \longrightarrow$ Solve for v

Current $I = \frac{dq}{dt} = \frac{e}{\text{period}}$ period $= T = \frac{\text{circumference}}{v}$

$I =$ ______

Area of e^- orbit $A = \pi r^2$

MAGNETIC MOMENT $\mu \equiv IA =$ ______

40.7 / 1015 Write this using ANGULAR MOMENTUM $L = mvr$

solve for vr, plug into $\mu =$ ______

QUANTIZATION of orbital angular momentum: $L = m_\ell \hbar$

new quantum #

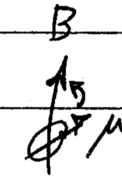
Write μ in terms of m_ℓ: $\mu =$ ______ $= -m_\ell \mu_B$

BOHR MAGNETON $\mu_B =$

Bohr atom: electron's orbit → magnetic dipole

(DRAW B FIELD)

Magnetic dipole experiences TORQUE in a magnetic field



Potential energy $U = -\bar{\mu}\cdot\bar{B}$

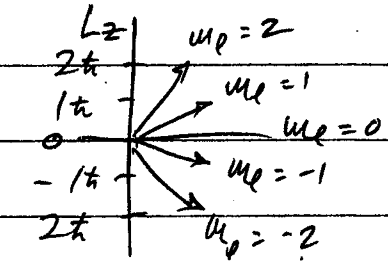
Zeeman effect: energy levels SPLIT by $\Delta U = \mu_B B$

$\frac{40\text{-}2}{1005}$ Orbital angular momentum QUANTUM NUMBER $l = 0, 1, \ldots, (n-1)$

magnetic quantum number m_l indicates DIRECTION of l

Orbital angular momentum $L = \sqrt{l(l+1)}\,\hbar$

For B_z, $L_z = m_l \hbar$

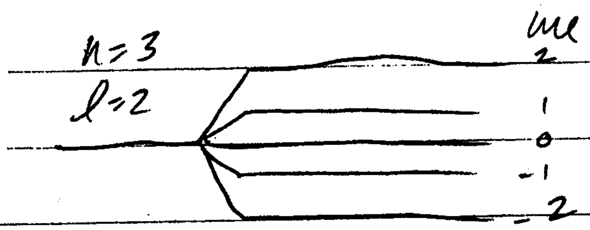


If $l = 2$, then m_l can be $0, \pm 1$, or ± 2.

Do $\frac{40\#46}{1027}$

45. (I) Verify that the Bohr magneton has the value $\mu_B = 9.27 \times 10^{-24}$ J/T (see Eq. 40–12).

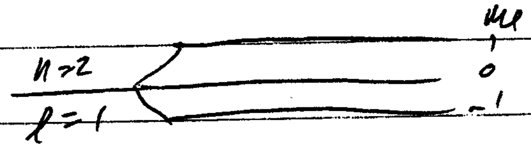
46. (II) Suppose that the splitting of energy levels shown in Fig. 40–4 was produced by a 2.0-T magnetic field. (*a*) What is the separation in energy between adjacent m_l levels for the same l? (*b*) How many different wavelengths will there be for 3d to 2p transitions, if m_l can change only by ± 1 or 0? (*c*) What is the wavelength for each of these transitions?



(a) $U = -\mu_z B = -\mu_B m_e B$

$\Delta U = \Delta m_e \mu_B B$

$=$



b) Transitions are allowed from $\Delta m_e = 0, \pm 1$

$\frac{40\text{-}2}{1005}$

c) $\frac{1}{\lambda_0} = R\left[\frac{1}{n^2} - \frac{1}{n'^2}\right] =$ $n = 2,\ n' = 3$

$E = \frac{hc}{\lambda}$, $\frac{dE}{d\lambda} = hc \frac{d}{d\lambda}(\lambda^{-1}) =$

$\Delta E = \frac{hc}{\lambda} \frac{\Delta\lambda}{\lambda}$

$E_0 = \frac{hc}{\lambda_0}$

$E_+ = \frac{hc}{\lambda_0 - \Delta\lambda}$

$E_- = \frac{hc}{\lambda + \Delta\lambda}$

39-3
981

Heisenberg Uncertainity principle

Uncertainity in position $\Delta x \approx \lambda$ of light used to look at particle.

Photon can change particle's momentum by $\Delta p \approx \frac{h}{\lambda}$

$$\Delta x \Delta p \approx \underline{\qquad\qquad}$$

$$\Delta x \Delta p \gtrsim \hbar = \frac{h}{2\pi}$$ Do $\frac{\#7}{1000}$

The more precisely we measure position (with light of small λ) the less precisely we can know momentum.

Time uncertainty $\Delta t \approx \frac{\Delta x}{c} \approx \frac{\lambda}{c}$ (travel time of photon across object)

Photon can change particle's energy by $\Delta E \approx \frac{hc}{\lambda}$

$$\Delta E \, \Delta t \approx \underline{\qquad\qquad}$$

$$\Delta E \, \Delta t \approx \hbar$$ Do $\frac{\#9}{1000}$