Solid State Electronics EC210
AAST – Cairo
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Lec. 10: Hydrogen Potential

Original Lectures repared by:
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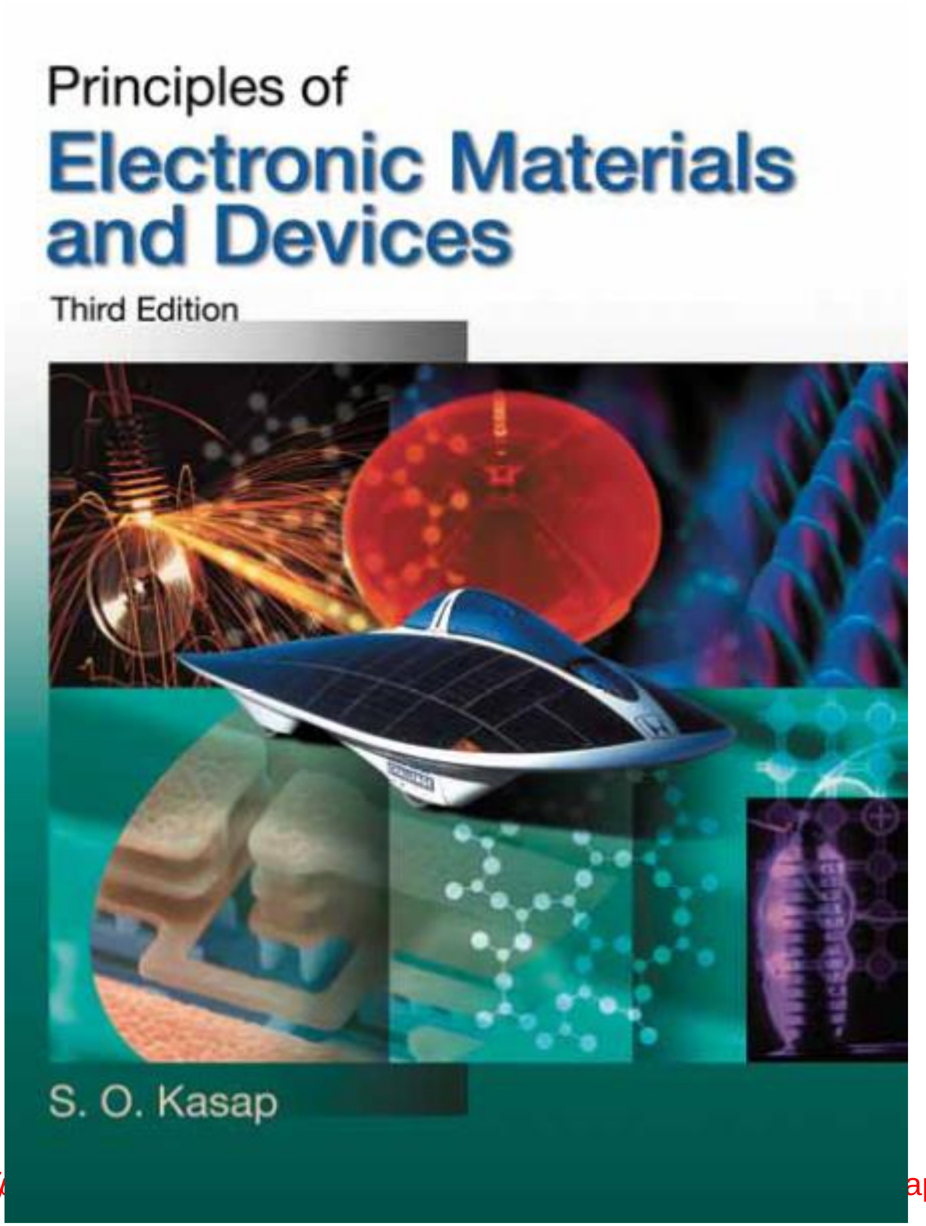
From *Principles of Electronic Materials and Devices, Third Edition*, S.O. Kasap (© McGraw-Hill, 2005)



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From *Princi* … ap (© M … 05)

Pages

P. 231-234: Hydrogen Atom

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Outline

- Energy Levels in Hydrogen
- Overlap of Hydrogen Atom potential and wavefunction
- Band Theory using Hydrogen

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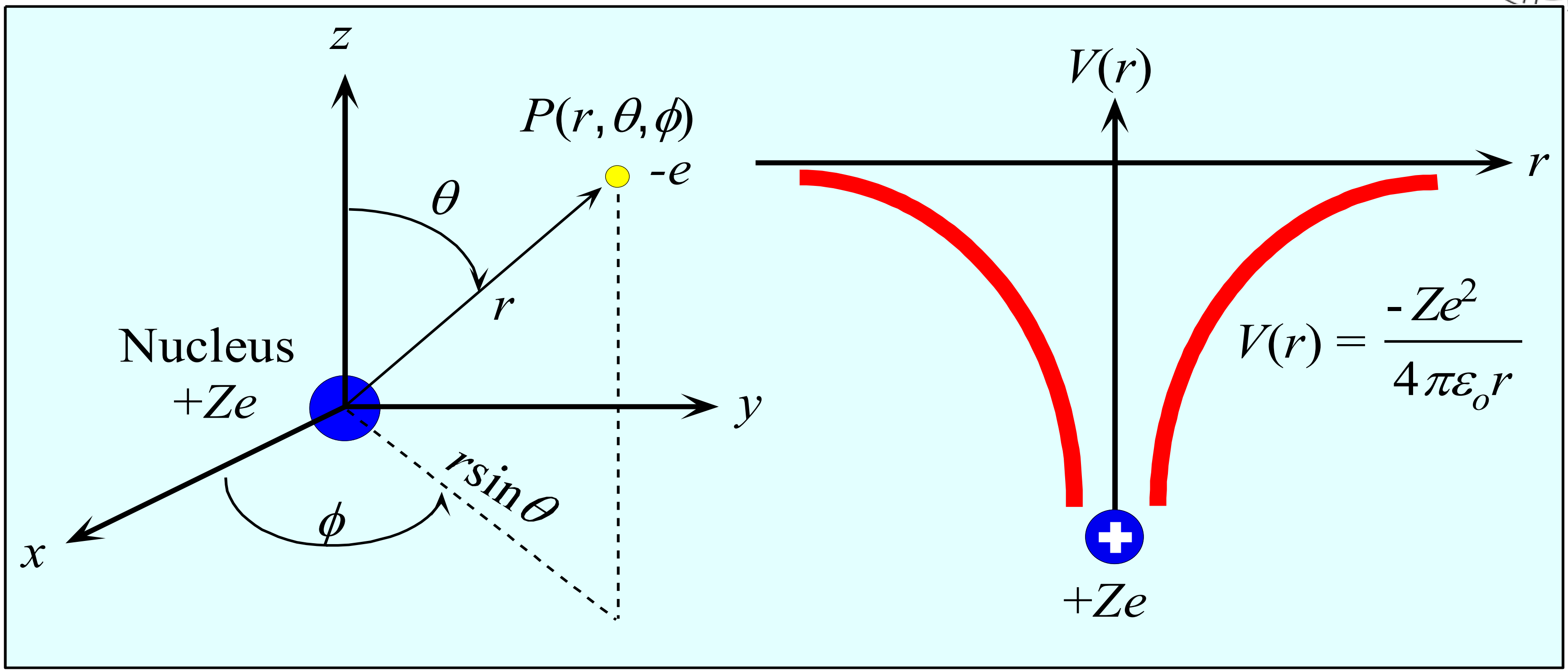
Hydrogen Potential Well



The electron in the hydrogenic atom is attracted by a central force that is always directed towards the positive nucleus. We therefore use spherical coordinates centered at the nucleus to describe the position of the electron. The *PE* of the electron depends on r only.

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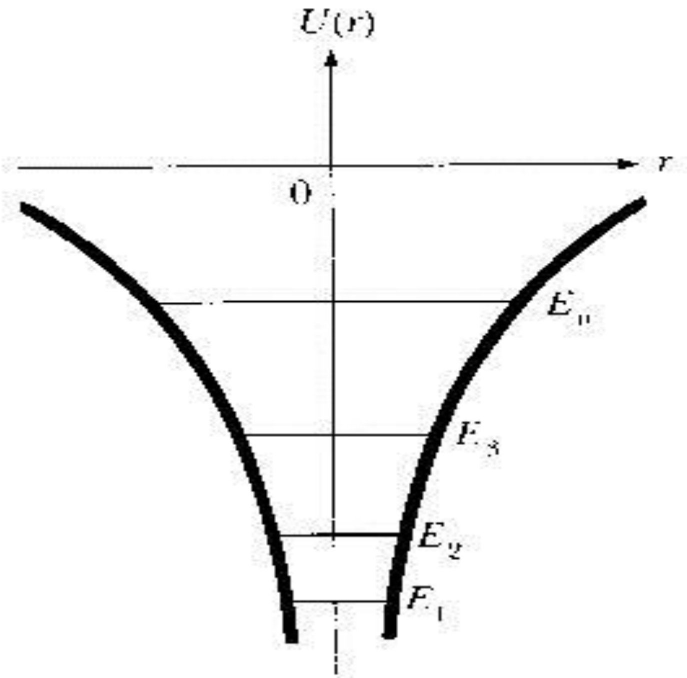
Discrete Energy Levels

This is a "Potential Well" where Schrodinger equation has solution inside it (like in 1-D box) and outside it (like in barrier tunneling)

i.e. It has discrete energy levels and finite wavefunctions



$$U(r) = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

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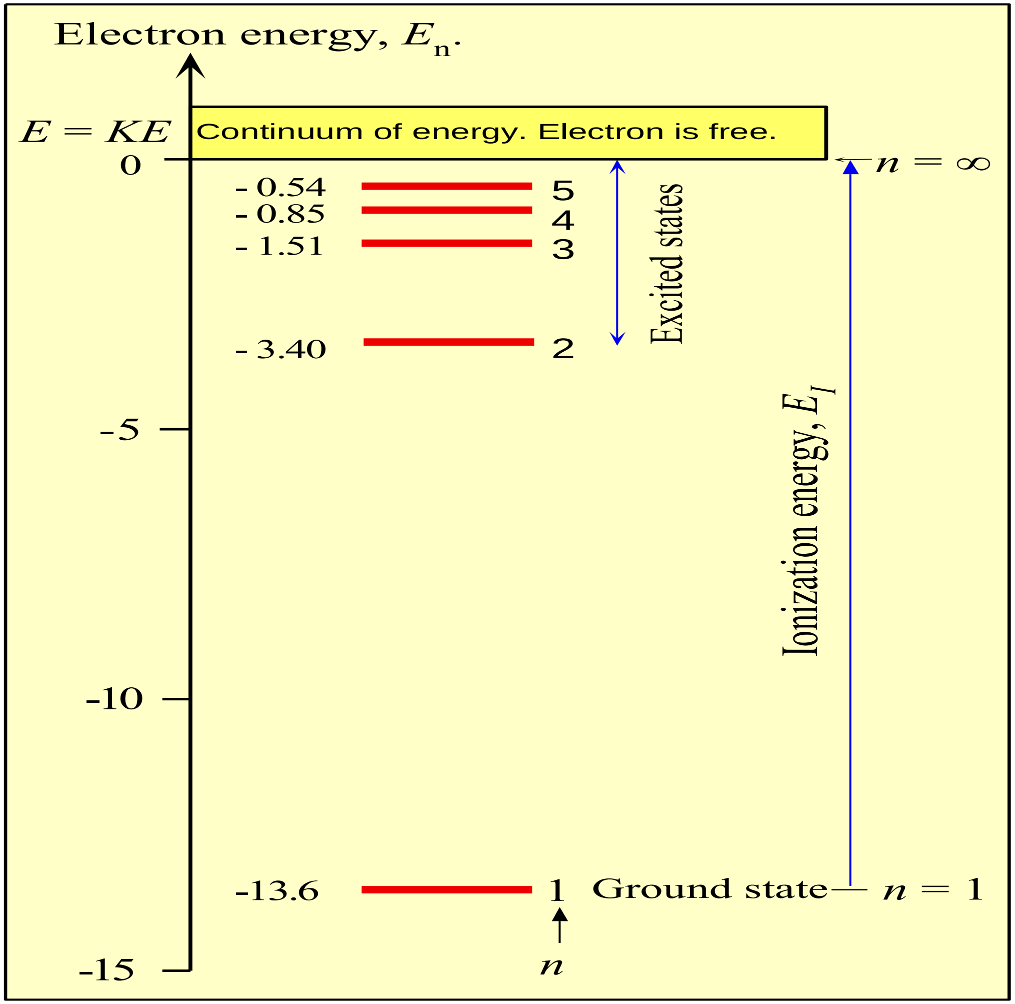
Energy Levels for H-atom:
Depends on *Principal Quantum Number*

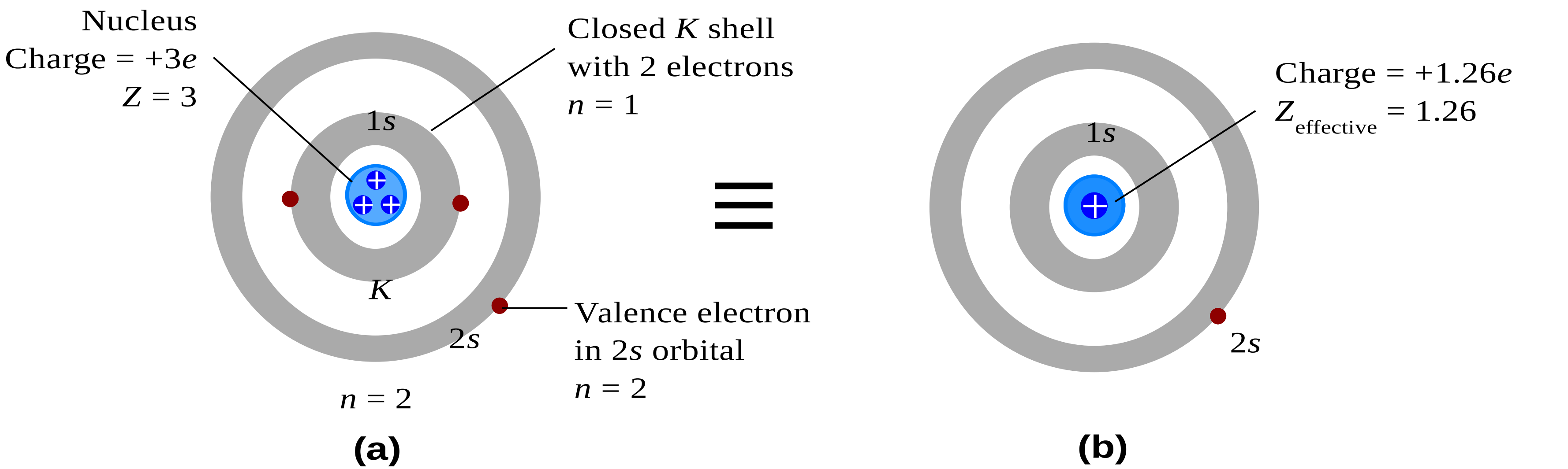
$$E_n = -\frac{Z\,E_1}{n^2}$$

$$E_1 = \frac{me^4}{8\epsilon_o h^2}$$



From *Principles of Electronic Mate* The energy of the electron in the hydrogen atom (Z = 1)

$Z_{Effective}$: (1.26 for Li)



The Li atom has a nucleus with charge +3e, 2 electrons in the K shel, which is closed, and one electron in the 2s orbital.
(b) A simple view of (a) would be one electron in the 2s orbital that sees a single positive charge, Z=1

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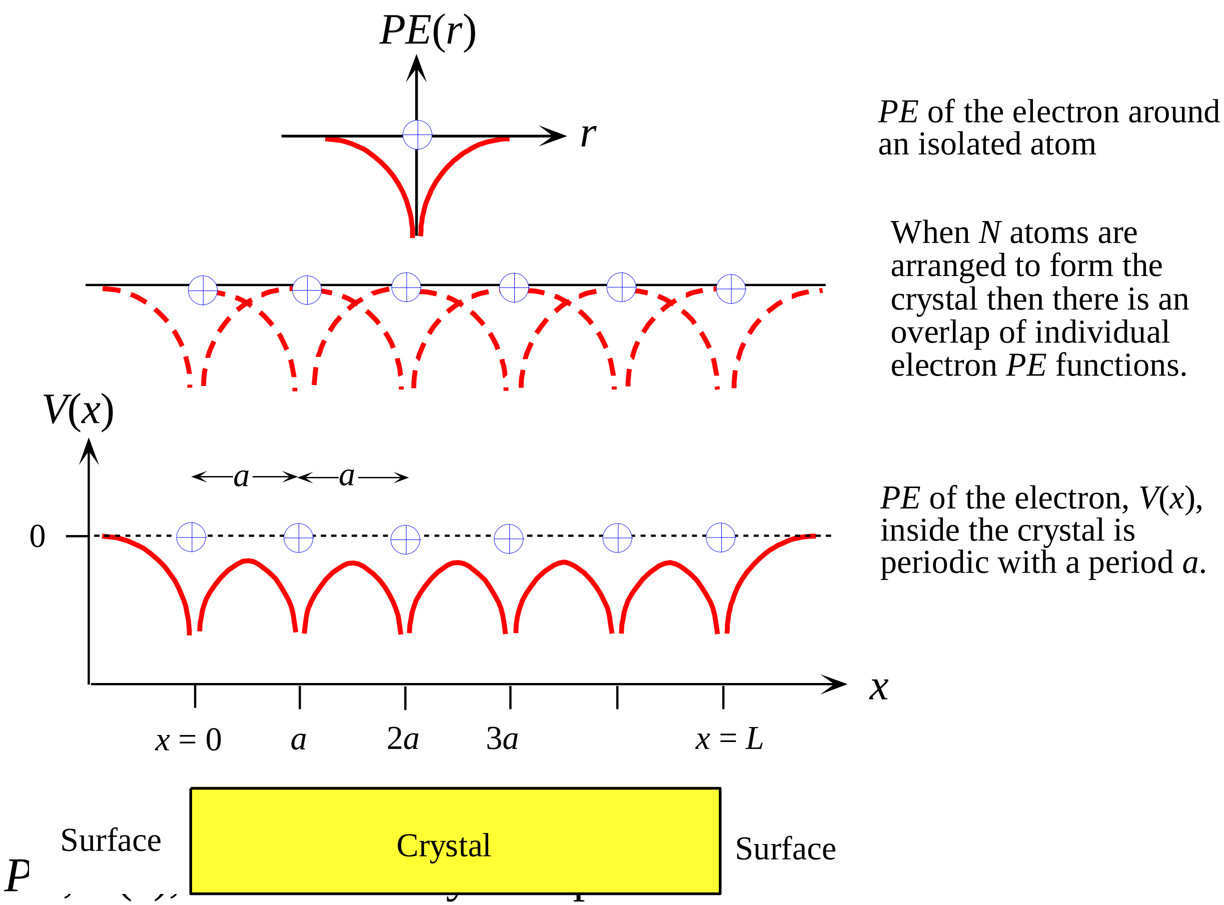
Superposition of Coulomb Potential for N-Atoms



The electron P

periodicity as that of the crystal, *a*. Far away outside the crsytal, by choice, $V = 0$ (the electron is free and $PE = 0$).

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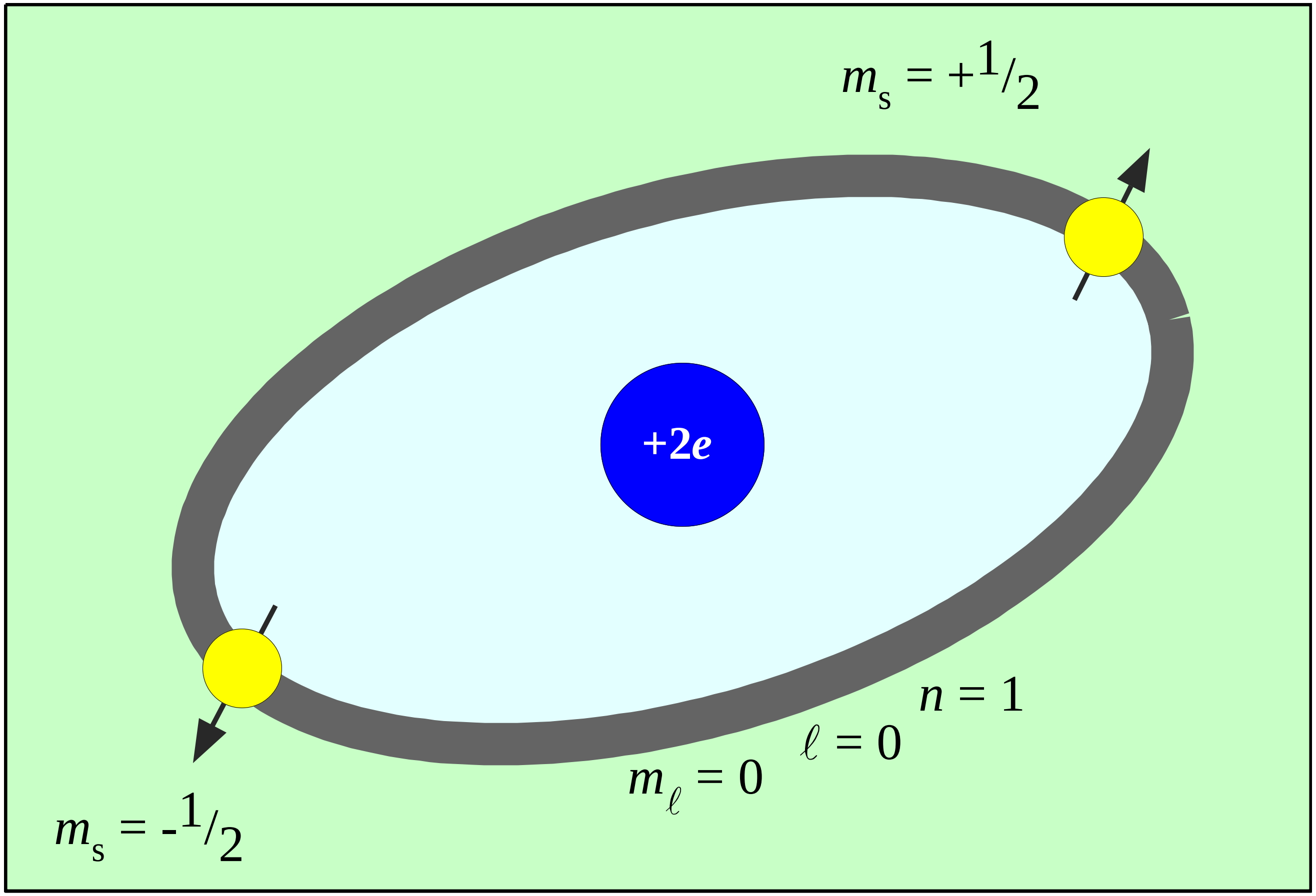
Paired Spins



Paired spins in an orbital.

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Pauli's Exclusion Principle:

No two electrons can have the same four quantum numbers within the same system

Table 3.3 The four quantum numbers for the hydrogenic atom

n	Principal quantum number	$n = 1, 2, 3, \ldots$	Quantizes the electron energy
ℓ	Orbital angular momentum quantum number	$\ell = 0, 1, 2, \ldots (n-1)$	Quantizes the magnitude of orbital angular momentum L
m_ℓ	Magnetic quantum number	$m_\ell = 0, \pm 1, \pm 2, \ldots, \pm \ell$	Quantizes the orbital angular momentum component along a magnetic field B_z
m_s	Spin magnetic quantum number	$m_s = \pm \frac{1}{2}$	Quantizes the spin angular momentum component along a magnetic field B_z

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