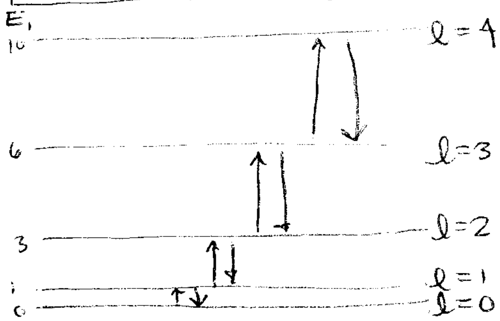
7-64 (a) $E_\ell = \ell(\ell+1)\hbar^2/2I$



$E_0 = 0$ $\quad E_2 = \frac{2(3)}{2}E_1 = 3E_1$

$E_1 = \hbar^2/I$ $\quad E_3 = \frac{3(4)}{2}E_1 = 6E_1$

$E_4 = \frac{3(4)}{2}E_1 = 6E_1$

ALLOWED TRANSITIONS HAVE

$\Delta\ell = \pm 1$

(b) $\Delta E = E_\ell - E_{\ell-1} = \frac{[\ell(\ell+1)-(\ell-1)\ell]}{2I}\hbar^2 = \frac{\ell\hbar^2}{2I}(\ell+1-\ell+1) = \frac{\ell\hbar^2}{I}$

SINCE $E_1 = \hbar^2 I$, $\Delta E = \ell E_1$.

(c) $E_1 = \hbar^2/I = \frac{2\hbar^2c^2}{m_pc^2r^2} = \frac{2(197.3\text{ nm eV})^2}{(938\cdot 10^6\text{eV})(.074\text{nm})^2} = \boxed{.015\text{eV}}$

(d) $\Delta E_{1\to 0} = E_1 = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{.015\text{eV}} = \frac{1240\text{ nm eV}}{.015\text{ eV}} = \boxed{8.2\cdot 10^{-5}\text{m}}$

PROBLEM 2 (DINE SPECIAL)

(a) $|\vec{J}| = \hbar\sqrt{j(j+1)}$ THE $\ell=0$ STATE HAS ONLY 1 POSSIBLE j VALUE:

$\ell=0, s=1/2 \Rightarrow j=1/2$ THEN $J = \sqrt{\frac{3}{4}}\hbar$.

$\ell=1$ STATE HAS 2 POSSIBLE VALUES : $j = 1/2, 3/2$

THEN $\boxed{J = \sqrt{\frac{3}{4}}\hbar, \sqrt{\frac{15}{4}}\hbar}$

(b) $\langle\vec{S}\cdot\vec{L}\rangle = \frac{1}{2}\{\langle J^2\rangle - \langle L^2\rangle - \langle S^2\rangle\} = \frac{\hbar^2}{2}\{j(j+1) - \ell(\ell-1) - s(s-1)\}$

$s=1/2 \Rightarrow \langle\vec{S}\cdot\vec{L}\rangle = \boxed{\frac{\hbar^2}{2}[j(j+1) - \ell(\ell-1) + 1/4]}$

(c) $\ell=0$ STATES : NO SPLITTING. $\langle\vec{S}\cdot\vec{L}\rangle = \frac{\hbar^2}{2}[\frac{3}{4} - 2 + \frac{1}{4}] = -\hbar^2/2$

$E_{1/2} = \frac{1}{2m^2c^2}\frac{1}{r}\frac{dV}{dr}\left(-\frac{\hbar^2}{2}\right) \approx \frac{-V(\hbar^2c^2/2)}{2(.511\text{MeV})^2a_0^2} = \frac{-V(197.3\text{ nm eV})^2}{4(.511\text{MeV})^2(.1\text{nm})^2} \approx \boxed{-V\cdot 10^{-6}}$

(IF V IS ON THE ORDER OF, SAY, 10 eV, THIS GIVES $\approx 10^{-5}$eV)

$\ell=1$ STATES: SPLIT INTO 2 VALUES $\langle\vec{S}\cdot\vec{L}\rangle = -\hbar^2/2, \hbar^2$

$E_{j=3/2} = \frac{1}{2m^2c^2}\frac{1}{r}\frac{dV}{dr}(\hbar^2) \approx \frac{+V(\hbar^2c^2)}{2(.511\text{MeV})^2a_0^2} = \frac{V(197.3\text{ nm eV})^2}{2(.511\text{MeV})^2(.1\text{nm})^2} \approx \boxed{V\cdot 10^{-5}}$

(ON THE ORDER OF 10^{-4} eV IF $V \sim 10$ eV)

SO THE SPLITTING, $E_{j=3/2} - E_{j=1/2} \approx 10^{-4}$eV

PROBLEM 3 (DINE SPECIAL) ENERGY OF 1S STATE $\approx Z^2(-13.6\text{eV})$ FOR ELEMENT WITH Z PROTONS.

URANIUM HAS 92 PROTONS SO TAKE

$$\text{ENERGY REQUIRED} \approx 92^2(14\text{eV}) \approx 1\ 10^5\text{eV}$$

PROBLEM 4 (NEUTRON STAR)

$$\frac{N}{V} = \frac{4\pi}{(2\hbar\pi)^3}\int_0^{E_F} m(2mE)^{1/2} n(E)\,dE$$

AT THE LOWEST ENERGY, THE DISTRIBUTION $n(E)$ IS FLAT - ALL STATES UP TO $E=E_F$ ARE EQUALLY FILLED.
THERE ARE 2 PARTICLES PER STATE, SO WE PICK UP A FACTOR OF 2:

$$\frac{N}{V} = \frac{4\pi}{(2\pi\hbar)^3}\int_0^{E_F} m(2mE)^{1/2}(2)\,dE = \frac{2\sqrt{2}\, m^{3/2}\, 4\pi}{h^3}\left[\frac{2}{3}E_F^{3/2}\right]$$

$$\text{SOLVE FOR } E_F = \left(\frac{3\rho h^3}{16\pi\sqrt{2}\, m^{3/2}}\right)^{2/3} \qquad \rho = 10^{39}/\text{cm}^3 = 10^{18}/\text{nm}^3$$

$$mc^2 \approx 10^9\text{eV}$$

$$E_F = \left[\frac{3(10^{18})(1240)^3}{16\sqrt{2}\pi(10^9)^{3/2}}\right]^{2/3}\text{eV} = \boxed{1.9\cdot 10^8\text{eV}}$$

9.3 NET ENERGY $= E_{ionization} - E_{affinity}$

(a) $E_{NET} = 3.89\text{eV} - 3.40\text{eV} = .49\text{eV}$

(b) $E_{NET} = 5.39\text{eV} - 3.06\text{eV} = 2.33\text{eV}$

(c) $E_{NET} = 4.18\text{eV} - 3.36\text{eV} = .82\text{eV}$

9.5 (a) $-\frac{ke^2}{r} = -\frac{(8.98E9)(1.602\cdot 10^{-19}C)^2}{.267E-9}\cdot\frac{\text{eV}}{1.602\cdot 10^{-19}\text{J}} = \boxed{-5.39\text{eV}}$

(b) $E_{ion} = E_{IONIZATION} - E_{AFFINITY} = 4.18\text{eV} - 3.62\text{eV} = .56\text{eV}$

$E_{DISSOC.} = -U(r) = -E_{ion} + \frac{ke^2}{r} - E_{ex} \approx -.56\text{eV} + 5.39\text{eV} = \boxed{4.83\text{eV}}$

(c) $E_{DISSOC.} = 4.37\text{eV} \overset{\text{set}}{=} 4.83\text{eV} - E_{ex} \Rightarrow E_{ex} = \boxed{.46\text{eV}}$

$\boxed{9\text{-}10}$ H,S   S HAS 4 electrons in valence shell, so it requires 2 MORE TO FILL THE ORBITAL: $\boxed{H_2S}$

H,Te: Tellurium HAS 4 VALENCE e^- $\Rightarrow$ $\boxed{H_2Te}$

H, P: Phosphorous HAS 3 VALENCE e^- $\Rightarrow$ $\boxed{H_3P}$

H, Sb: Antimony HAS 3 VALENCE e^- $\Rightarrow$ $\boxed{H_3Sb}$

$\boxed{9\text{-}11}$ (a) KCl: ALKALI METAL + HALOGEN $\Rightarrow$ MOSTLY IONIC

(b) O_2: IDENTICAL ATOMS $\Rightarrow$ COVALENT

(c) CH_4: HYDROCARBON $\Rightarrow$ MOSTLY COVALENT

$\boxed{9\text{-}21}$ $I = \mu r_0^2$ $\mu = m/2$ FOR IDENTICAL ATOMS

$m_{oxygen} = 16u$ WHERE $1u = 931.5\ MeV/c^2$

$$E_{or} = \frac{\hbar^2}{2(m/2)c^2r_0^2} = \frac{(\hbar c)^2}{16\,(931.5\cdot 10^6 eV)(.121 nm)^2} = \frac{197.3^2\ eV}{(16)(.121)^2(931.5\cdot 10^6)}$$

$$= \boxed{1.78\cdot 10^{-4} eV}$$

$\boxed{9\text{-}26}$ (a) $2\pi f = \sqrt{K/\mu} \Rightarrow K = 4\pi^2\mu f^2$

FIND μ: $E_{or} = 1.32\cdot 10^{-3}eV = \hbar^2/2\mu r_0^2 \Rightarrow \mu = \hbar^2/2E_{or}r_0^2$

SUBSTITUTE INTO $K = 4\pi^2 f^2\left(\frac{\hbar^2}{2E_{or}r_0^2}\right)\frac{c^2}{c^2}$

$$= \frac{4\pi^2(8.97\cdot 10^{13}\tfrac{1}{s})^2}{(3\cdot 10^8 m/s)^2}\frac{(197.3 nm\cdot eV)^2}{(.127nm)^2\, 2(1.32\cdot 10^{-3}eV)} = 3.2\cdot 10^{21}\frac{eV}{m^2}$$

$$= (1.602\cdot 10^{-19} J/eV)(3.2\cdot 10^{21} eV/m^2) = \boxed{517\ N/m}$$

(b) $$K = \frac{2\pi^2(6.93\cdot 10^{12}\tfrac{1}{s})^2(197.3nm\,eV)^2(1.602\cdot 10^{-19}J/eV)}{(3\cdot 10^8 m/s)^2(.294nm)^2(9.1\cdot 10^{-6}eV)} = \boxed{83\frac{N}{m}}$$