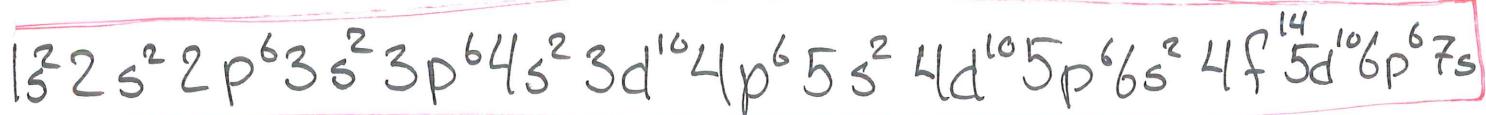


4. The alkalis

4.1 Write down the full electron configuration of Francium $Z=87$.

K	$1s^2$		
L	$2s^2$	$2p^6$	
M	$3s^2$	$3p^6$	$3d^{10}$
N	$4s^2$	$4p^6$	$4d^{10} 4f^{14}$
O	$5s^2$	$5p^6$	$5d^{10} 5f^{14}$
P	$6s^2$	$6p^6$	$6d^{10} 6f^{14}$
Q	$7s^2$	$7p^2$	$7d^{10} 7f^{14}$

Om vi använder alla röda linjer så får vi 88st elektroner. Detta är en för mkt, som vi vet är Fr en alkalinmetall och har endast en elektron i $7s$. Vi får alltså:



Alternativt, kolla periodiska systemet: SMIDIGT

$$Fr = [Rn] 7s = [Hg] 6p^6 7s = [Xe] 4f^{14} 5d^{10} 6s^2 6p^6 7s = [Kr] 3d^{10} \dots$$

Tillslot kommer du att bli klar.

4.3 Calculate the quantum defects.

$3s, 4s, 5s, 6s$

$5.1388\text{eV}, 1.9476\text{eV}, 1.0227\text{eV}, 0.6294\text{eV}$

$$\delta_\ell = n - n^*$$

[quantum defect]

$$\text{Eq 4.1: } E(n, \ell) = -\frac{hcR_\infty}{(n - \delta_\ell)^2}$$

$$\Leftrightarrow (n - \delta_\ell)^2 = -\frac{hcR_\infty}{E(n, \ell)}$$

$$\Leftrightarrow \delta_\ell = \left(\frac{hcR_\infty}{E(n, \ell)} \right)^{\frac{1}{2}} + n = \sqrt{\frac{13.6}{E(n, \ell)}} - n$$

$$3s \Rightarrow n=3, \ell=0 \Rightarrow \delta_0 = -\sqrt{\frac{13.6}{5.1388}} + 3 = +1.37 \quad \cancel{\text{}}$$

$$4s \Rightarrow n=4, \ell=0 \Rightarrow \delta = -\sqrt{\frac{13.6}{1.9476}} + 4 = +1.36 \quad \cancel{\text{}}$$

$$5s \Rightarrow n=5, \ell=0 \Rightarrow \delta = -\sqrt{\frac{13.6}{1.0227}} + 5 = +1.35$$

$$6s \Rightarrow n=6, \ell=0 \Rightarrow \delta = -\sqrt{\frac{13.6}{0.6294}} + 6 = +1.35$$

$$6s \Rightarrow n=6, \ell=0 \Rightarrow \delta = -\sqrt{\frac{13.6}{0.6294}} + 6 = +1.35$$

Medel: 1.3575 .

Vad är en ergin för $8s$?

$$E_{8s} = \frac{-13.6}{(8 - 1.3575)^2} = 0.31\text{ eV}$$

Dette är en högre bindningsenergi än

för väte. $E_{H8s} = \frac{-13.606}{8 - \dots}$

4.4 Estimate the wavelength of laser that excites the $5s^2S_{1/2} - 7s^2S_{1/2}$ transition in rubidium, by simultaneous absorption of two photons with same energy.

Öh, så vi går från 5s till 7s.

Tabell 4.2 $\Rightarrow \Delta E = 3.19$

$$\Delta E = E_{5s} - E_{7s} = \frac{13.6}{(5-3.19)^2} - \frac{13.6}{(7-3.19)^2} = 3.22 \text{ eV}$$

Så energin per foton är $\frac{3.22}{2} = 1.6 \text{ eV}$

$$\lambda = \frac{hc}{1.6 \text{ eV}} = 771 \text{ nm}$$

4.5 Application of quantum defects

a) Calculate the wavelength of the 1s2p-1s3d line in helium and compare it with Balmer- α in hydrogen.

Binding energy

$$\left. \begin{array}{l} 1s2p := 28206 \text{ cm}^{-1} \\ 1s3d := 12214 \text{ cm}^{-1} \end{array} \right\}$$

Hur omvandlar vi cm^{-1} till nm?

$$\lambda = 28206 - 12214 = 15992 \text{ cm}^{-1} =$$

$$= \frac{1 \text{ cm}}{15992} \cdot \frac{1 \text{ m}}{100 \text{ cm}} \cdot \frac{10^9 \text{ nm}}{1 \text{ m}} = 625 \text{ nm}$$

b) Calculate the quantum defects for the configurations in He in the table

$\text{cm}^{-1} \rightarrow \text{eV}$

Algorithm: $1\text{cm}^{-1} = \frac{1}{\text{cm}} \cdot \frac{100\text{cm}}{\text{m}} = \frac{100}{\text{m}}$ (våglängd $^{-1}$)

$$E = \frac{hc}{\lambda} = [\text{Joule}] = \frac{hc}{\lambda e} = [\text{eV}]$$

Alltså:
 $1\text{cm}^{-1} = 1,986 \cdot 10^{23} \text{ J}$

Vi tar fram energierna:

1s2s: $E = \frac{hc}{q} \cdot 100 \cdot \frac{1}{2} = [\text{eV}; \text{cm}^{-1}] = \frac{hc}{q} \cdot 100 \cdot 35250 = 4.37 \text{ eV}$

1s2p: $E = [\text{P.S.S.}] = 3.50 \text{ eV}$

1s3s: $E = 1.77 \text{ eV}$

1s3p: $E = 1.54 \text{ eV}$

1s3d: $E = 1.51 \text{ eV}$

Eller tjs. vi konverterar i eV, men
är i Joules
+ till Joules

Eq 4.1 i elektronvolt: $E_e^* = \frac{Rhc}{(n-\delta_e)^2} = \frac{Rhc}{n^*} \Leftrightarrow n^* = \sqrt{\frac{Rhc}{E_e}}$

$n_{1s2s}^* = 1.76 \Rightarrow \delta_e = 0.24$

$n_{1s2p}^* = 1.97 \Rightarrow \delta_e = 0.028$

$n_{1s3p}^* = 2.77 \Rightarrow \delta_e = 0.23$

$n_{1s3d}^* = 2.997 \Rightarrow \delta_e = 0.0026$

c) Blable. estimate 2nd ionizing energy for 1s4f

$$\text{IE}_2 = - (E' - E_{1s4f}) = 72.24 + \frac{z^2 R^*}{4!^2} = 75.64 \text{ eV}$$

$$4.6 \quad IE = 4.34 \text{ eV}$$

$$\left. \begin{array}{l} 769.9 \text{ nm} \\ 766.5 \text{ nm} \end{array} \right\} \Delta \lambda_{fs} = 3.4 \text{ nm}$$

$$\left. \begin{array}{l} 404.7 \text{ nm} \\ 404.4 \text{ nm} \end{array} \right\} \Delta \lambda_{fs} = 0.3 \text{ nm}$$

$$\left. \begin{array}{l} 344.7 \text{ nm} \\ 344.6 \text{ nm} \end{array} \right\} \Delta \lambda_{fs} = 0.1 \text{ nm}$$

$$E - IE = \frac{hc}{\lambda \cdot e} - 4.34 = \begin{cases} -2.73 \text{ eV} \\ -1.27 \text{ eV} \\ -0.74 \text{ eV} \end{cases}$$

$$\delta_2 = \bar{n} - Z_{eff} \sqrt{\frac{-hcR}{E_{n2}}} = \begin{cases} n_1 - 2.23 \\ n_2 - 3.27 \\ n_3 - 4.28 \end{cases} = \begin{cases} 1.77 \\ 1.73 \\ 1.72 \end{cases}$$

Vi gissar på att vi går till ~~4P~~, ~~5P~~, ~~6P~~. \uparrow

Vi vill ha E_{7p} och ΔE_{7p-4s}

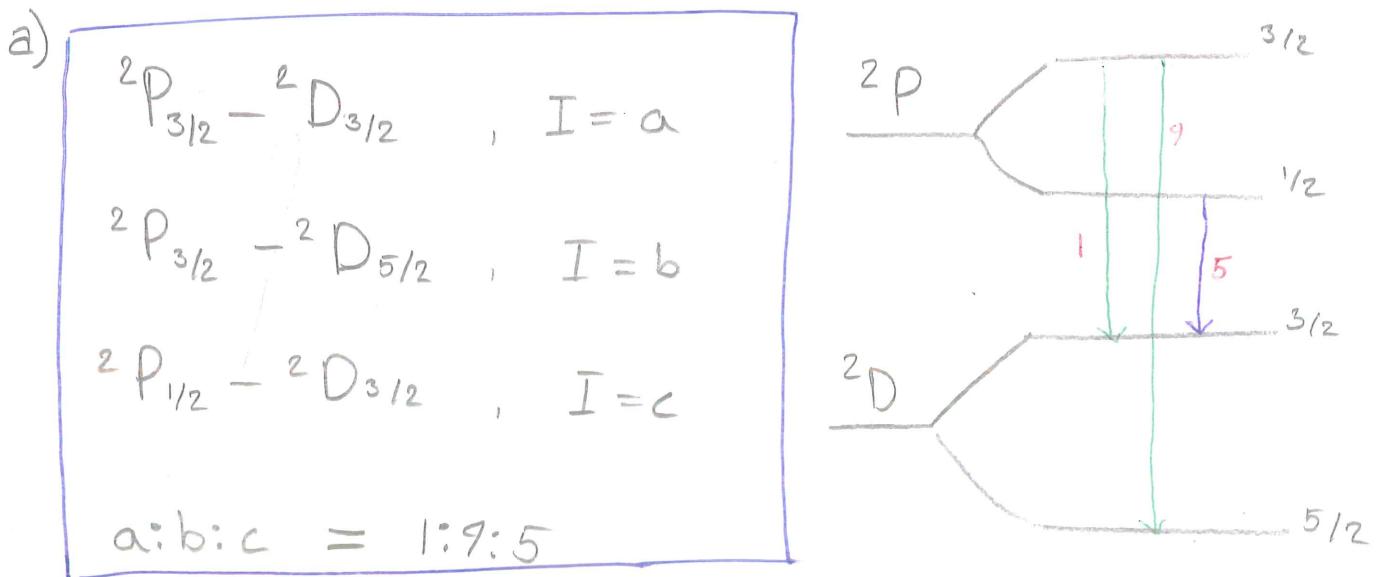
$$E_{7p} = -hcR_\infty \frac{1}{(7-\delta_p)^2} = -0.488 \text{ eV}$$

$$\Delta E_{7p-4s} = -0.488 + (4.34) = 3.85 \text{ eV}$$

$$\lambda_{7p-4s} = \frac{hc}{e \cdot \Delta E_{7p-4s}} = 321.87 \text{ nm} \quad (\text{jag använde inte tillräckligt med siffror tyvärr})$$

$$\Delta \lambda = \lambda \cdot \frac{\Delta E}{E} = 321.87 \cdot \frac{\Delta E_{fs}}{3.85 \text{ eV}} = 0.09 \text{ nm}$$

4.8 Relative intensities of fine structure components.



Show that these intensities satisfy the rule that the sum of the intensities of the transitions to, or from, a given level is proportional to its statistical weight $(2J+1)$

$$^2P_{1/2}: J = \frac{1}{2}, 2J+1 = 2, I: 5$$

$$^2P_{3/2}: J = \frac{3}{2}, 2J+1 = 4, I: 1+9 = 10$$

$$^2D_{3/2}: J = \frac{3}{2}, 2J+1 = 4; I: 1+5 = 6$$

$$^2D_{5/2}: J = \frac{5}{2}, 2J+1 = 6, I: 9$$

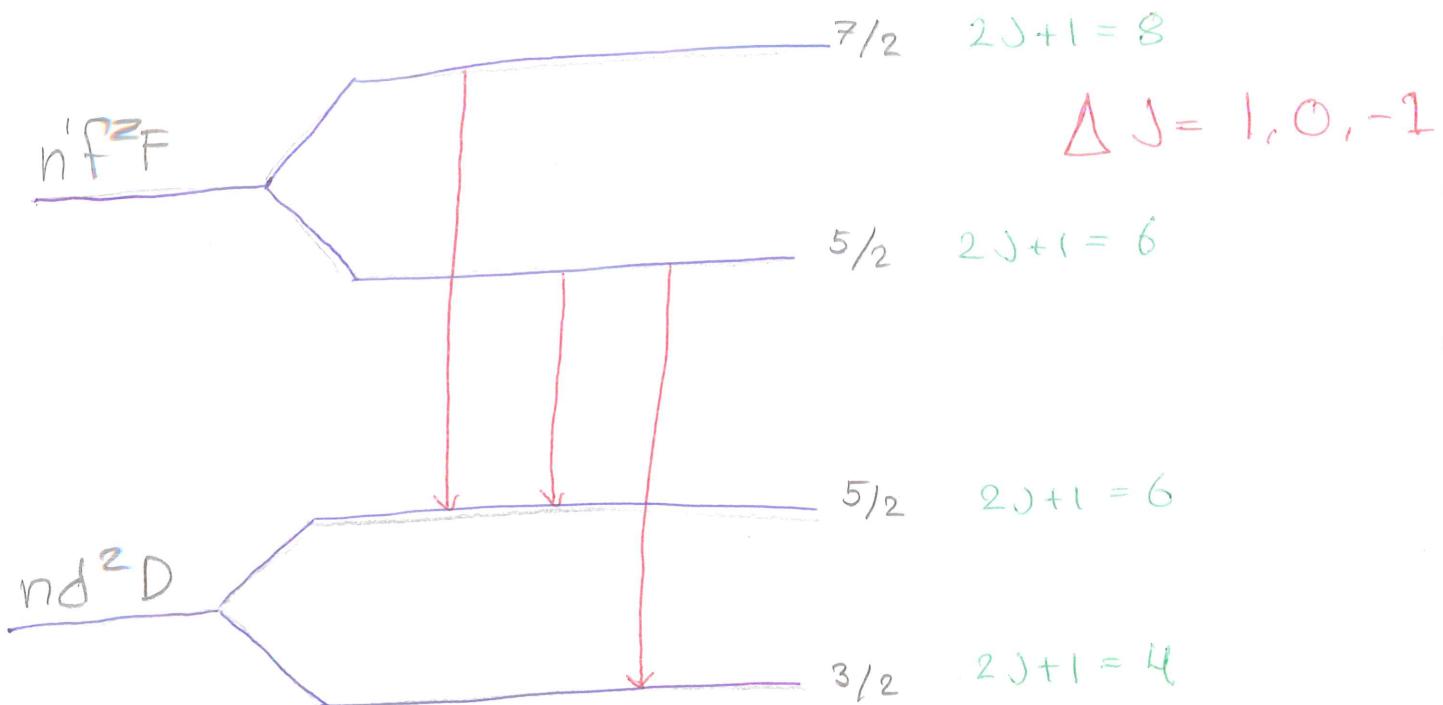
$^2D_{5/2}$	$^2D_{3/2}$
9	1
5	5
1,5	1,5

b) Sketch an energy level diagram

$$nd^2D : L=2, S=\frac{1}{2}, J=\frac{3}{2}, \frac{5}{2}$$

$$n'F^2F : L=3, S=\frac{1}{2}, J=5/2, 7/2$$

Vi har 2 uppsplittringar eftersom de är dubletter



	$^2D_{5/2}$	$^2D_{3/2}$	
$^2F_{7/2}$	a	~	$\frac{a+0}{8}$
$^2F_{5/2}$	b	c	$\frac{b+c}{6}$

$$\frac{a+b}{6} = \frac{0+c}{4}$$

$$b:c = 14:17$$

$$\begin{cases} \frac{a+b}{6} = \frac{c}{4} \\ \frac{a}{8} = \frac{b+c}{6} \end{cases} \Leftrightarrow \begin{cases} 4a + 4b - 6c = 0 \\ 6a - 8b - 8c = 0 \end{cases} \Leftrightarrow \begin{cases} 2a + 2b - 3c = 0 \\ 0 - 14b + c = 0 \end{cases}$$

Svar: 20:1:14