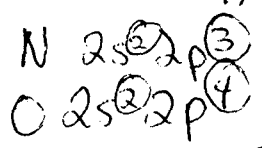
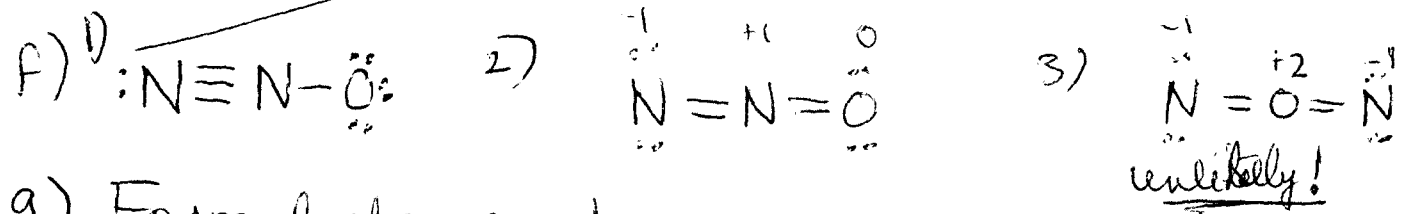


Vraag 1: Consider the following molecule N_2O

e) $2 \times 5 + 1 \times 6 = 16$ valence



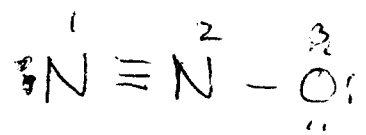
- 1) Octet rule = $8e^-$ around atoms
- 2) minimize formal charge on each atom



g) Formal charge = charge an atom would have if the bonding were perfectly covalent in the sense that the atom had exactly a half-share in the bonding electrons.

$$F.C. = V - (L + \frac{1}{2} B)$$

- V = # of valence electrons
- L = # of electrons present on the bonded atom as lone pairs
- B = # of bonding electrons on the atom



$$F.C. \text{ on } 1 = 5 - (2 + \frac{1}{2}(6)) = 0$$

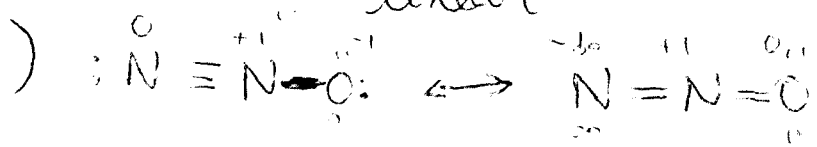
$$F.C. \text{ on } 2 = 5 - (0 + \frac{1}{2}(8)) = +1$$

$$F.C. \text{ on } 3 = 6 - (6 + \frac{1}{2}(2)) = -1$$

h) VSEPR = Valence shell electron pair repulsion



k) polar, permanent dipole.

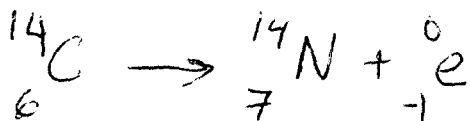


Vraag 2

Carbon from the remainings of a tree with a radioactivity of 5000 disintegrations per hour for 20 grams of material. 1 gram of a living tree gives 1000 disintegrations per hour. The half life of carbon-14 is 5000 years.

a) What causes the radioactivity of carbon, and how can we determine the age of old materials from its level of radioactivity?

→ ${}^14_6\text{C}$ is neutron rich, can be made more stable by ejecting a β particle, which reduces the n/p ratio as a result of the conversion of a neutron into a proton:



→ A radioactive nucleus decays at a certain rate, with a certain ~~given by its~~ activity = $\frac{\# \text{ of nuclear disintegrations}}{\# \text{ of time}}$

$$\text{Activity} = \text{rate of decay} = k \times N$$

k = decay constant

N = # of disintegrations

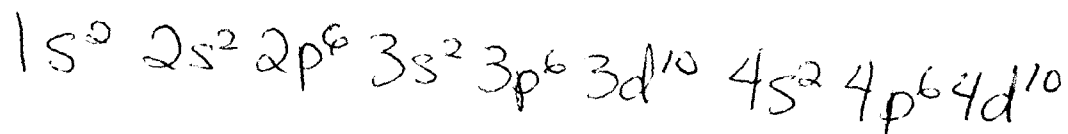
$$N = N_0 e^{-kt}$$

Assuming the activity is the same for an original and an ancient sample, knowing the $\frac{1}{2}$ -life of the original sample,

$$\Rightarrow t = \frac{-1}{k} \ln\left(\frac{N}{N_0}\right) \rightarrow t = \frac{-t_{1/2}}{\ln 2} \ln\left(\frac{N}{N_0}\right)$$

Vraag 3

a) Give the partitioning of electrons with principal quantum number $n=4$ in their subshells and orbitals, including the # of electrons in every subshell



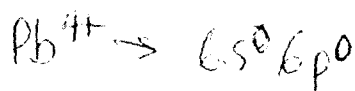
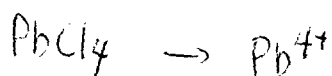
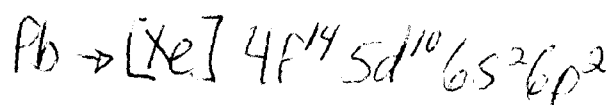
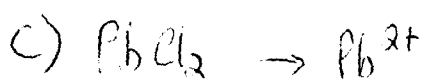
b) Why is a 2p orbital higher in energy than a 2s orbital

- an s-electron ^{of any shell} can be very close to the nucleus (ie. it can penetrate through the inner shells)

- The wave function of a p-electron vanishes at the nucleus, so a p-electron penetrates less than an s-electron.

⇒ p-electron is more effectively shielded from the nucleus and thus experiences a smaller effective nuclear charge than an s-electron

- an s-electron is bound more tightly than a p-electron and has a slightly lower (more negative) energy.



b) How old is the tree trunk?

Express the disintegration rate in #disintegrations/hour/gram

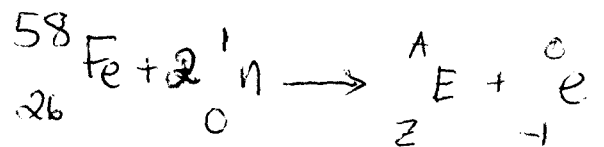
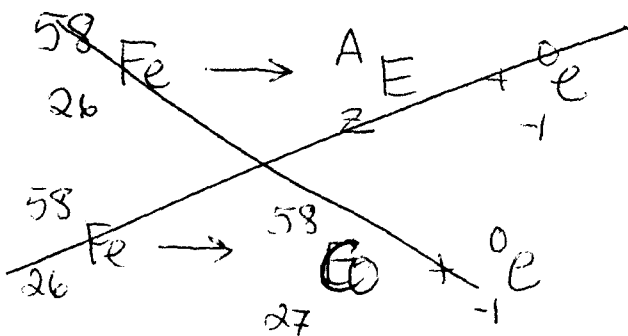
$$N = \frac{5000 \text{ disint.}}{\text{hour}} \times \frac{1}{20 \text{ grams}} = 250$$

$$N_0 = 1000$$

$$t = \frac{-t_{1/2}}{\ln 2} \ln \left(\frac{N}{N_0} \right)$$

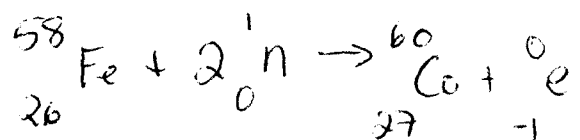
$$t = \frac{-5000 \text{ years}}{\ln 2} \left(\ln \left(\frac{250}{1000} \right) \right) = -10000 \text{ years}$$

c) Give the equation for β -decay of Fe-58 after collision with 2 neutrons



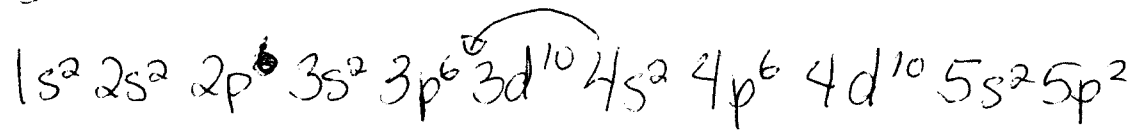
$$A = 58 + 2 = 60$$

$$Z = 26 + 1 = 27$$

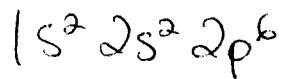


d) Give the groundstate electronic configurations of
Sn, O^{2-} , Cr^{2+}

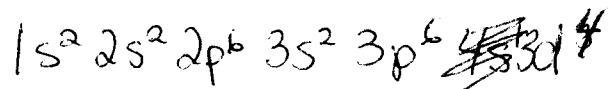
Sn \rightarrow 50 electrons



$O^{2-} \rightarrow$ 8 + 2 electrons = 10



$Cr^{2+} \rightarrow$ 24 - 2 electrons = 22



Vraag 4: In infrared (IR) spectroscopy, it is normal to express the energy in terms of ν/c , in wave-numbers cm^{-1} (inverse centimetres)

a) If an absorption is found at 2143 cm^{-1} , what is the frequency of the radiation?

$$\text{Wave number (cm}^{-1}\text{)} = \frac{\nu \text{ (s}^{-1}\text{)}}{c \text{ (cm} \cdot \text{s}^{-1}\text{)}}$$

$$\nu = (2143 \text{ cm}^{-1}) (3 \times 10^{10} \text{ cm} \cdot \text{s}^{-1})$$

$$\nu = 6.43 \times 10^{13} \text{ Hz}$$

b) Give the energy of this absorption in joules.

$$E = h\nu = (6.626 \times 10^{-34} \text{ J} \cdot \text{s}) (6.43 \times 10^{13} \text{ s}^{-1})$$

$$= 3.9 \times 10^{-20} \text{ J}$$

c) Give as complete a description of IR spectroscopy.
Mention which properties of a material are measured and which atomic parameters are important.

• IR spectroscopy measures the vibrations of bonds in molecules.

- stretching
- bending

• the vibrational frequency, ν , of a bond between two atoms A and B of masses m_A and m_B is given by

$$\nu = \frac{1}{2\pi} \sqrt{\frac{k}{\mu}}, \quad \mu = \frac{m_A m_B}{m_A + m_B}$$

• The number of ways a molecule can vibrate depends on the number of atoms N ;

There are $3N - 6$ ways for a non-linear molecule
 $3N - 5$ " " " linear molecule

→ $\tilde{\nu}$ = wavenumbers (cm^{-1}). (c , speed of light $\cdot \text{cm} \cdot \text{s}^{-1}$)

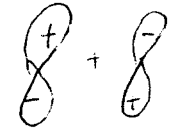
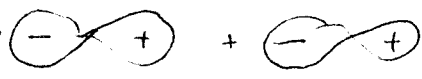
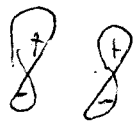
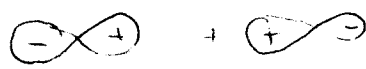
The energy of a vibration is given by, $E = h\nu$.

d) $\text{Cr} \rightarrow 8 \times \frac{1}{8} = 1$

$\text{Cl} \rightarrow 2 + 4\left(\frac{1}{2}\right) = 4$



Vraag 5

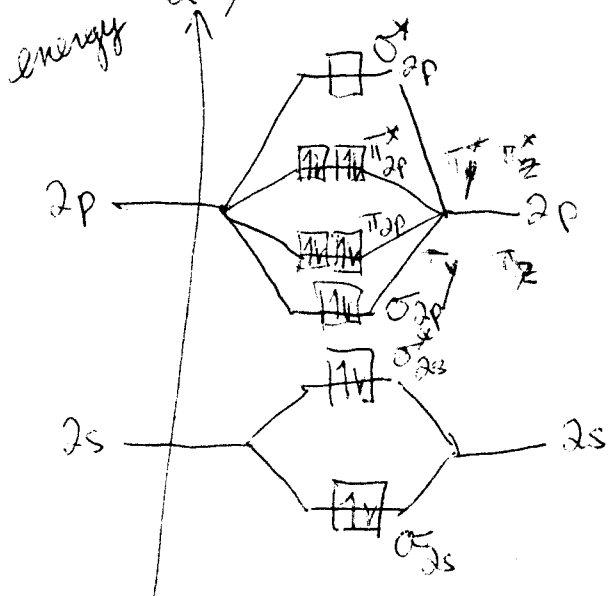
- a) A = π^* antibonding ~~π^*~~ , $(+p_x, -p_x)$ $(+p_y, -p_y)$ 
- B = σ^* antibonding $(p_x, p_x) \rightarrow$ 
- C = π bonding (p_y, p_y) 
- D = σ -bonding $(p_x, p_x) \rightarrow$ 

b) Remember the energy diagram for O_2 , werkcollege 3, vraag 3B, for p orbitals, the order of bonding is:

is: σ_{2p} -bonding $<$ π_{2p} -bonding $<$ π_{2p}^* -antibonding $<$ σ_{2p}^* -antibonding

D $<$ C $<$ A $<$ B

c) In F_2 , there are $2 \times 2s^2 2p^5 = 14$ electrons



Only σ_{2p}^* , B, is empty. The other orbitals are full.

p. 119, figure 3.32