CHEMISTRY 1A (CHEM1101) - November 2009

2009-N-2

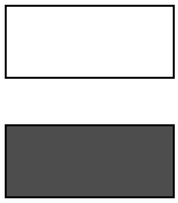
- $^{83}_{37}\text{Rb} \rightarrow ^{83}_{36}\text{Kr} + ^{0}_{+1}e$ (positron decay)

  $^{83}_{37}\text{Rb} + ^{0}_{-1}e \rightarrow ^{83}_{36}\text{Kr}$ (electron capture decay)

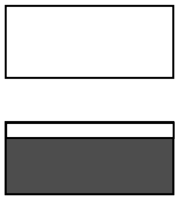
  6.76×10^{14} Bq

  600 days (to 1 sig fig)

2008-N-3

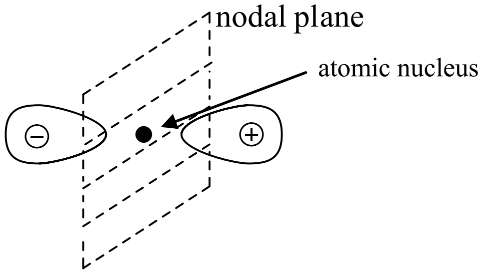
- 

  The band gap in pure Si (between the full valence band and the empty conductance band) is large. Normal thermal energy does not give the electrons enough energy to make the jump and so Si is an insulator.

  Si doped with Al

  Replacing some Si atoms with Al (or other Group 13 element), means that the valence band will not be completely occupied with electrons. The gaps act as positive holes and allow the material to act as a semiconductor of the p-type.

- 

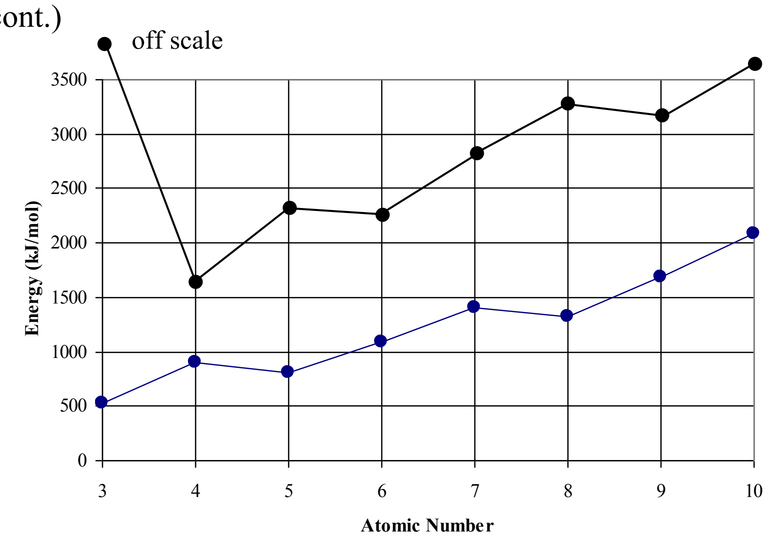
2009-N-4

- The general trend of an *increase* in ionisation energy across the period is due to the increase in effective nuclear charge (Z_{eff}). The electrons feel a greater pull from the nucleus as Z_{eff} increases. This leads to a decrease in the size of the atom and an increase in the energy required to remove an electron.

  First anomaly - the *decrease* in ionisation energy in going from Be (at. no. 4) to B (at. no. 5). Be has an electron configuration of [He] $2s^2$ while B has a configuration of [He] $2s^2\,2p^1$. Due to shielding in a multi-electron atom, the $2p$ orbital is higher in energy than the $2s$ orbital and thus any electron in the $2p$ orbital is held less tightly than those in the $2s$ orbital. B therefore has a lower ionisation energy than Be despite having a higher nuclear charge.

  Second anomaly - another (slight) drop in ionisation energy going form N (at. no. 7) to O (at. no. 8). There are only three p orbitals, so the next electron to go into one of the p orbitals must pair up. Paired electrons in the same orbital are higher in energy than electrons with parallel spins in different orbitals so O has a lower ionisation energy than N.

2009-N-4 (cont.)



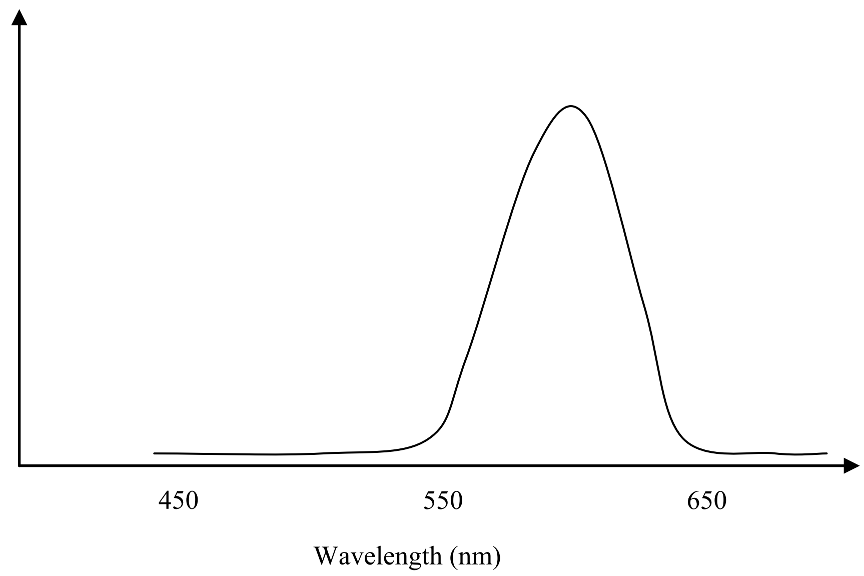
The second ionisation of Li is > 7000 kJ mol^{-1} as a core electron is ionised. The second ionisations of the other elements follow the same trends as the first ionisations (for exactly the same reasons), but displaced one atomic number to the right and at a slightly higher energy (as Z_{eff} is greater).

2009-N-5

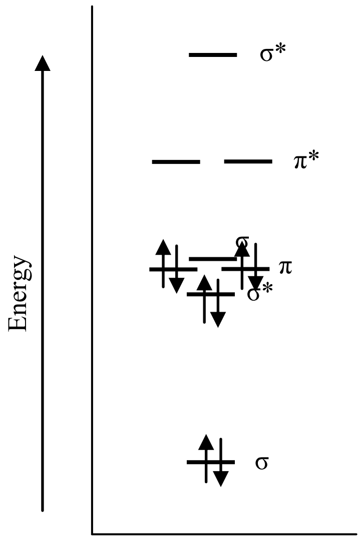
- copper and zinc

2009-N-6

- carboxylic acid, ether, amine, aromatic ring



2009-N-7

- 

  2

  3

2009-N-8

- 0.273 M

2009-N-9

- exothermic

  –56.2 kJ mol^{-1}
- >

  >
- Pentane. It has more bonds and can therefore take on more conformations so has the higher entropy (disorder).

2009-N-10

- Assume 1 mol of reactants at initial temperature of 25 °C. Need to show that ΔH for the reaction is greater than the amount of energy required to melt 2 mol of Fe + heat all the products (2 mol of Fe + 1 mol of Al_2O_3) to the m.p. of Fe.

  $\Delta H = \sum\Delta_f H(\text{products}) - \sum\Delta_f H(\text{reactants})$

  $= \Delta_f H(Al_2O_3) + 2\Delta_f H(Fe) - (2\Delta_f H(Al) + \Delta_f H(Fe_2O_3))$

  $= -1676 + 2 \times 0 - (2 \times 0 - 824)$

  $= -852$ kJ mol^{-1}

2009-N-10 (cont.)

ΔH to heat 2 mol of Fe to its m.p.

$$\Delta H = 25 \text{ J K}^{-1} \text{ mol}^{-1} \times (1535\text{–}25) \text{ K} \times 2 \text{ mol} = 75.5 \text{ kJ}$$

ΔH to heat 1 mol of Al_2O_3 to m.p. of Fe

$$\Delta H = 79 \text{ J K}^{-1} \text{ mol}^{-1} \times (1535\text{–}25) \text{ K} \times 1 \text{ mol} = 119 \text{ kJ}$$

ΔH to melt 2 mol of Fe

$$\Delta H = 14 \text{ kJ mol}^{-1} \times 2 \text{ mol} = 28 \text{ kJ}$$

Total energy required to melt the iron = 75.5 + 119 + 28 = +222.5 kJ

2009-N-11

- 366 mmHg

  49.5 °C

2009-N-12

- –3260 kJ mol^{-1}

2009-N-13

- –0.95 V 8.5×10^{-17}
- N_2 dispersion

  CH_3Cl dipole-dipole and dispersion

  SO_2 dipole-dipole

  H_2O hydrogen bonding

2009-N-14

- $N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \quad \Delta H = +180 \text{ kJ mol}^{-1}$

  The formation of NO(g) is endothermic, so it is favoured at the high temperatures that exist in the car engine. The high temperatures also speed up the reaction.

  It reacts with oxygen in the atmosphere to give $NO_2(g)$.

  $$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

- 0.422 V