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Paper 3 Section A Data Response (4)

At 25 °C iron pentacarbonyl, $Fe(CO)_5$, is a, straw-coloured liquid with a pungent odour. It can react with chlorine to give $Fe(CO)_4Cl_2$.

One of the uses of iron pentacarbonyl is to make nanotubes. When $Fe(CO)_5$ is heated at 1400 K in the presence of carbon monoxide at high pressure it reacts to form nanoparticles of iron.

$Fe(CO)_5(g) \longrightarrow Fe(s) + 5CO(g)$

These iron nanoparticles provide a nucleation surface for the transformation of carbon monoxide into carbon during the growth of the nanotubes (CNT).

$x CO(g) \longrightarrow CNT(s) + \frac{1}{2}x CO_2(g)$

where *x* is typically 6000 giving a carbon nanotube containing 3000 carbon atoms.

(a) Comment on the fact that iron pentacarbonyl is a liquid under standard conditions (its melting point is - 21 °C and its boiling point is 103 °C). ***[1]***

(b) Deduce the geometric shape of a molecule of iron pentacarbonyl. ***[1]***

(c) (i) Draw the Lewis structure of carbon monoxide. ***[1]***

(ii) Use the concept of formal charge to explain why iron bonds to the carbon atom of the carbon monoxide molecules rather than the oxygen atom. ***[2]***

(d) (i) Use oxidation states to show whether iron pentacarbonyl is oxidized or reduced when it reacts with chlorine. ***[1]***

(ii) Deduce all the possible structures for $Fe(CO)_4Cl_2$. ***[2]***

(e) Assuming the carbon dioxide in the above process is lost to the atmosphere and the iron produced is discarded, calculate the atom economy of the reaction assuming it gives 100% yield of carbon nanotubes. ***[2]***