

HL Answers to First row d-block elements questions

1. A transition element contains an incomplete d sub-level in one or more of its oxidation states. Scandium the element does contain one d electron but it only forms scandium(III) compounds with the electron configuration of argon so its compounds contain no d electrons. Zinc loses the two 4s electrons to form zinc(II) compounds. Zn^{2+} has a full 3d level so compounds of zinc(II) do not contain an incomplete d sub-level.
2. All transition elements except chromium and copper contain two 4s electrons. They lose these to form the 2^+ ion. Chromium and copper can also lose one of their 3d electrons (in addition to the 4s electron) to form a 2^+ ion. Copper has the configuration $[\text{Ar}]4s^13d^{10}$. Because the full 3 d level gives some stability copper can form the Cu^+ ion by just losing its one 4s electron.
3. Copper(I) contain a full 3d sub-level and scandium(III) contains no d electrons so no electronic transitions between split d levels are possible. Copper(II) contains nine d electrons and iron(III) five d electrons. In these compounds the 3d orbitals are split and the energy of the electron transitions between the split levels corresponds to the frequency of light in the visible region.
4. In $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ the 3d sub-level is split into two by the water ligands. A d electron can absorb energy as it is promoted from the lower to the higher split level. The colour of the light transmitted is the complementary colour to the light absorbed. In $[\text{Fe}(\text{CN})_6]^{3-}$ the cyanide ligands cause the amount of splitting to be different so a different wavelength of light is absorbed and the complementary colour transmitted is different to $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$.
5. From the Lewis structure of carbon monoxide it can be seen that both carbon and oxygen possess a non-bonding pair of electrons. The non-bonding pair of electrons on the carbon atom enables it to function as a ligand by forming a coordinate bond with the transition metal atom or ion. Methane does not contain a non-bonding pair of electrons so it cannot function as a ligand (Lewis base).
6. (a) (hydrogen peroxide) manganese(IV) oxide, $\text{MnO}_2(\text{s})$.
 (b) (Haber process) iron, $\text{Fe}(\text{s})$.
 (c) (catalytic converter) platinum, $\text{Pt}(\text{s})$, or palladium, $\text{Pd}(\text{s})$, (or rhodium, $\text{Rh}(\text{s})$).
 (d) (Contact process) vanadium(V) oxide, $\text{V}_2\text{O}_5(\text{s})$.