d -Block Elements

General Features

The d-block elements are located between Group II and Group Ill in the Periodic Table.

They are so called because a d-subshell is being filled. Here only the first row, from scandium to zinc, will be considered.

Appearance

Most of the d-block elements are considered to be metals, with a common lustrous metallic appearance.

General Reactivity

These elements have d electrons in their valence shells, and this gives them different charactenstics to other metals in the Periodic Table. They each exist in several oxidation states except scandium and zinc; many of their compounds are coloured; and they readily form complexes by acting as Lewis acids.

Occurrence and Extraction

The first six elements, scandium to iron, occur mainly as the oxides in various mineral deposits. The most abundant of these is iron, found chiefly in magnetite and haematite, both commonly known as iron ore. The remainder of the elements occur mainly as sulphides such as zinc blende.

Each element is extracted from the appropriate mineral by various extraction methods. The extraction of iron, however, is of immense importance as steel - basically a mixture of iron and carbon - is used in greater quantities world-wide than any other metal. Steel is produced from iron ore in 2 main stages:

(1) a blast furnace produces impure iron from iron ore

(2) the impure iron is then purified and alloyed with other metals to produce steel.

Physical Properties

All these elements are hard, rigid and have good thermal and electrical conductivities. They have high melting and boiling points.

Chemical Properties

The chemistry of the d-block elements is governed by the fact that most exhibit several oxidation numbers. This is because the energies of all the d electrons is very similar. The d electrons also confer properties on these elements not found elsewhere:

- they easily form complexes

- their complexes are often coloured

- some complexes are paramagnetic

- they make good catalysts.

The chemical properties of these elements and their many complexes is extensive, and not suitable for further study here.

Oxidation States

As stated earlier, most of the d-block elements exist in several oxidation states - for example, the oxidation number of iron can be 0, +2, +3 and +6. The widest range of oxidation numbers is for manganese, which has a lowest oxidation number of 0 and a highest oxidation number of +7. There are general tendencies concerning the oxidation numbers:

(a) the 1st and last elements, scandium and zinc, have only 1 oxidation number.

(b) all the elements except zinc can have oxidation number +3

(c) all the elements except scandium can have oxidation number +2

(d) from scandium to manganese, the highest oxidation number = the number of 4s electrons + the number of 3d electrons

(e) from manganese to zinc, low oxidation numbers are common.

Industrial Information

The d-block elements are used in many thousands of applications.

Iron is the most widely used element because it is converted to steel, which consists of iron with 0.2 - 1.7% carbon. The addition of carbon hardens the iron and gives it better resistance to corrosion. Special steels can be prepared by the addition of small quantities of other elements - stainless steel contains 18% chromium and 8% nickel. Iron and steel are extensively used in our society.

Other important uses of some of these elements include titanium in aircraft and spaceship manufacture. Titanium is less dense than other d-block elements, and this lightness, coupled with its extra hardness, make it more suitable than aluminium in high-flying aircraft and space vessels:

Chromium is often used for electroplating, and alloyed with nickel to make nichrome - used in electrical components as its electrical resistance hardly varies with temperature.

Copper is used as protective sheeting as it is more resistant to oxidation than other elements. The green patina that forms on exposure to air is copper (II) carbonate, sulphate or chloride. Copper is also used in electrical cables.

Zinc is used in galvanising and in alloys.

Further Information

For further information look up the individual elements.

Data

Atomic Radius/nm

Sc	0.160	**Y**	0.177	**La**	0.187
Ti	0.144	**Zr**	0.159	**Hf**	0.156
V	0.131	**Nb**	0.142	**Ta**	0.143
Cr	0.124	**Mo**	0.136	**W**	0.137
Mn	0.136	**Tc**	0.135	**Re**	0.137
Fe	0.124	**Ru**	0.132	**Os**	0.133
Co	0.125	**Rh**	0.134	**Ir**	0.135
Ni	0.124	**Pd**	0.137	**Pt**	0.137
Cu	0.127	**Ag**	0.144	**Au**	0.144
Zn	0.133	**Cd**	0.148	**Hg**	0.150