of hydrogen sulphide and hydrogen selenide is evolved and recognized by the characteristic smell. The solution gives the normal reactions for cadmium ions.

Toxicity of cadmium colours

The solubility of cadmium pigments is very low but, in handling these materials, care must be taken to avoid inhalation of dust. Masks should be worn.

A danger arises in welding through films or burning-off paint containing cadmium pigments. This can lead to the formation of toxic cadmium oxide, CdO.

TITANIUM NICKEL YELLOW

This is a very interesting member of the rather limited range of heat-resisting pigments.

It is prepared from the titanium hydroxide precipitate produced in the sulphate process (Chapter 4). The slurry is placed in a vat, treated with salts of nickel and antimony, filtered and calcined. The product is ground and graded.

Properties and uses of titanium nickel yellow

The pigment is a compound of titanium, nickel and antimony with specific gravity 4·5 and oil absorption 22 to 25. It has a dullish yellow self-colour but gives very bright and clean tints on reduction with white. The fastness to light is very good, even in the pale tints. It is also fast to solvents, paint media, acids and alkalis.

A very valuable property is its fastness to heat; it is stable up to 500°C (932°F). In this respect it rivals the cadmium yellows.

The principal use of this pigment is as a stainer for heat-resisting paints.

YELLOW AND RED OXIDES OF IRON

Natural oxides

Iron oxide is one of the most abundant mineral oxides in the earth's crust. It is widely distributed and has been used as a pigment for many centuries. If the deposits are to be economically workable as pigments they must be of good colour, uniform, free from contamination, and must contain a reasonable quantity of iron oxide. The colours of the natural oxides range from yellow to black, and the impurities are usually silica together with compounds of aluminium and calcium.

Principal ores of iron

1 **Limonites** or hydrated oxides in which the constitution can vary from $2Fe_2O_3.H_2O$ to $Fe_2O_3.4H_2O$. These comprise the yellow ochres, the siennas and the umbers.

Turkey Red is a bright soft pigment with good opacity and tinting strength. Indian Red is deeper, bluer and harder and possesses lower opacity and tinting strength. These properties are developed still further in the Purple Oxides.

These pigments are sometimes used in gloss paints and undercoats. In primers, however, their use is somewhat risky due to the possibility of the presence of sulphate which is extremely difficult to remove by washing. They are fast to light and heat and are insoluble in all oils, resins and solvents. They are also resistant to alkali and acids except boiling concentrated acids, and even here the attack is slow.

Identification tests

Boiling (usually prolonged) with concentrated hydrochloric acid yields a solution showing the usual reactions for ferric ions.

Bauxite residue

The mineral Bauxite, which is one of the chief sources of aluminium, contains appreciable quantities of iron oxide. After extraction of the aluminium, the residue is ground and sold under the name Bauxite Residue. It contains 60 to 70 percent Fe_2O_3, the balance consisting of siliceous matter and possibly traces of alumina.

It is sometimes used in primers for steelwork, as the protective properties appear to be superior to some of the natural red oxides.

RED LEAD (CI Pigment Red 105)

Manufacture of red lead

Red lead is manufactured by calcining litharge (PbO) in an oxidizing atmosphere at about 350°C (662°F). Reaction is slow but cannot be accelerated since decomposition of the red lead takes place below 500°C (932°F). Accurate temperature control is therefore necessary. The reaction can be represented by the equation:

$$6PbO + O_2 \underset{470°C}{\overset{350°C}{\rightleftharpoons}} 2Pb_3O_4$$

The final product always contains some free litharge, the amount of which can be controlled by the degree of oxidation.

Properties of red lead

Red lead is an orange-red pigment with the following physical characteristics:

Specific gravity 8·8	Refractive index 2·42
Oil absorption 7–8	Mean particle size range 3–12 μm

blues. These blues are used in printing inks. In paints the non-bronze potash blues are used since bronziness is unacceptable.

The specific gravity of Prussian Blue is 1·97 and the oil absorption, which is related to particle size, varies from 70 to 160. The extreme fineness of the particles results in a high tinting strength, but the opacity in paint media is poor.

It possesses good lightfastness and is resistant to solvents and resins. In the earlier types of oil paint, Prussian Blue sometimes lost its colour on storage, due, presumably, to reduction to the colourless potassium ferrous ferrocyanide. On exposure of the paint film to the air, however, the original colour was restored by oxidation.

Prussian blue is resistant to mineral and organic acids but is decomposed by alkali (reactions which are the reverse of those of ultramarine blue). It is, therefore, unsuitable for use in paints to be applied to alkaline surfaces such as cement render, concrete or lime plasters.

Mixtures of non-bronze blues with lead chromes constitute the Chrome or Brunswick Greens (*below*). Potash blues were the standard blues for paints until the introduction of the phthalocyanine blues (Chapter 7) and the amount now used is comparatively small.

Identification tests

The reactions with acid (stable) and alkali (decomposed) are generally considered sufficient.

Toxicity of Prussian Blues

Prussian Blue is considered to present a very low health hazard and this is supported by a long history of freedom from ill effects in usage.

Fire risk

This can be a serious hazard. When Prussian Blue burns, the highly dangerous hydrocyanic (prussic) acid can be evolved.

Other varieties of Prussian Blue

Brunswick Blue A reduced blue produced either by precipitation of the Prussian Blue on to a base such as blanc fixe or barytes or by addition of the base to the Prussian Blue suspension before filtration. The blue is then more easily filtered, gives less trouble in drying, and is more readily dispersed. However, the presence of the base is often not desired.

Milori Blue This term is sometimes applied to the best and palest potash blues which are completely devoid of bronze.

Chinese Blue A Prussian Blue with a high bronze lustre.

Cobalt Blue (CI Pigment Blue 28)

Cobalt oxide forms solid solutions with some other metallic oxides. These are highly coloured and possess great resistance to heat, light and chemicals.

6

Black, metallic, and miscellaneous pigments

BLACK PIGMENTS

The bulk of the black pigments used in the modern paint industry consists of elementary carbon (in a fairly pure state as carbon black, lamp black and synthetic graphite or mixed with siliceous matter in natural graphite), black oxides of iron (natural and manufactured) and micaceous oxide of iron.

Carbon blacks (CI Pigment Black 7)

These are derived from petroleum gases and oils and are classed as Channel or Furnace blacks according to the method of production.

Channel black The basis of the channel process is the burning of hydrocarbon gases using specially designed burners in a limited supply of air so that combustion is incomplete and smoky flames result. In the original process (from which the name is derived) the smoky flames impinged on lengths of channel iron on which the carbon was deposited and from which it was removed by scrapers.

In the modern 'gas black' process [1] petroleum oil is used in place of gas and the smoky flames impinge on cooled rollers from which the carbon is removed by scrapers.

The quality of the black can be controlled by the shape of the flame, distance from channel surface, amount of air, and quality of the gas.

When first produced, channel black is very fluffy due to entrained air and gaseous by-products resulting from incomplete combustion. It is therefore compressed or converted to beads by either wet or dry pelletizing.

Wet pelletizing The carbon black is passed into a cylinder fitted with a central rotating shaft to which spokes are attached. Water is added at the same time and the carbon black forms pellets which are then dried.

Dry pelletizing The carbon black particles are caused to adhere together by passing the black slowly through rotating drums.

The efficiency of the channel process is very low and prevention of smoke