Noble gases

Uses

He: (1) Helium is used chiefly in filling lighter-than-aircrafts such as airships, weather balloons etc. Although it is twice as heavy as hydrogen, its lifting power is 92% of that of hydrogen. This small difference in buoyancy is not serious disadvantage in view of reason of safety because unlike hydrogen, helium is non-flammable.

(2) Since helium, unlike nitrogen, is not soluble in blood even under pressure, a mixture of 80% He and 20% O_2 is used, instead of ordinary air, in modern diving apparatus. If air is used as such in the diving apparatus, the nitrogen dissolves in the blood of the diver due to high pressure when he is down in the deep sea. As soon as he comes to the surface, the pressure is released and the dissolved nitrogen escapes. This gives rise to 'Caisson disease' or the 'bends'. A similar He-O_2 mixture is used to assist breathing in asthma and other respiratory diseases.

(3) Helium has also a number of scientific uses, eg. liq. He (bp. 4.2K) is used as a cryogenic fluid to provide low temperatures for studying a number of phenomena which occure near absolute zero. It is also used in gas thermometres required for low temperature measurements.

(4) Helium is also used in providing an inert atmosphere for a number of metallurgical processes, eg in the preparation of reactive metals such as titanium, as well as during welding of magnesium, aluminium, titanium and stainless steel.

Ne: (i) Neon has a characteristic property of giving an orange-red glow in a discharge tube at a low pressure (2 mm) at 1000 volts. It is therefore, extensively used in neon glow lamps for advertising purposes. If mercury vapours are mixed with neon, a glow of blue or green colour is obtained. Various different colours can be obtained according to the composition of gas mixture and the type of glass used.

(ii) Neon has a remarkable property of carrying exceedingly high electric currents even under high voltage. It is therefore, used in safety devices for protecting electrical instruments such as voltmeters, relays and rectifiers, from high voltage.

Ar: (1) Argon is used for filling incandescent metal filament electric bulbs. Its action there is to prevent the volatilisation of the tungsten filament at the high temperature of the lamp.

(2) It is also used to some extent in discharge tubes for illumination purposes instead of neon. Thus a mixture of argon and mercury vapours in discharge tube produces a glow of blue or green colour.

(3) It is chiefly employed in welding and other operations which require absence of nitrogen as well as a non-oxidising atmosphere.

Clathrates of noble gases

Noble gases form a number of compounds in which the gases are trapped within the cavities of crystal lattices of certain organic and inorganic substances. Such compounds are known as clathrates. These are also referred to a cage compounds.

Thus when β-quinol (o-hydroxy benzene) is allowed to crystallise from its solution in water in the presence of a heavier noble gas. (Ar, Kr or Xe) under a pressure of 10-40 atm, the atoms of the noble gas gets trapped within the lattice of quinol crystals. In other words, the crystals obtained are not of quinol, but of a clathrate compound of the noble gas with quinol. The crystals are quite stable and can persist for several years. However when heated or dissolved in water, the gas escapes and quinol remains behind as such.

X-ray examination shows that a crystal of β-quinol is three dimensional network containing several cavities of 4 Å diameter, the quinol molecules being bound together with H-bonds. When β-quinol is allowed to crystallise from its solution in the presence of any foreign atom or molecule of suitable size which can fit in the cavities tightly, a clathrate compound results. The trapped atoms or molecules are unable

to escape easily from the cavities. If the molecules are too small, as those of helium and neon, they are able to escape easily from the cavities. Thus helium and neon do not form clathrate compound with quinol. Argon, krypton and xenon molecules, on the otherhand, are of suitable sizes and form these compounds.

Since three molecules of quinol can form one cavity of 4Å diameter, the composition of these clathrate compounds corresponds to 3 molecules of quinol for every molecule of the noble gas.

Similarly, when water is allowed to freeze in the presence of argon, krypton or xenon, under pressure, the atoms of the noble gas get trapped in the crystal structure of ice yielding clathrate of composition approximating to 5.75 molecules of water for every molecule of the noble gas.