Vicky Wong

The Chemistry of the Noble Gases

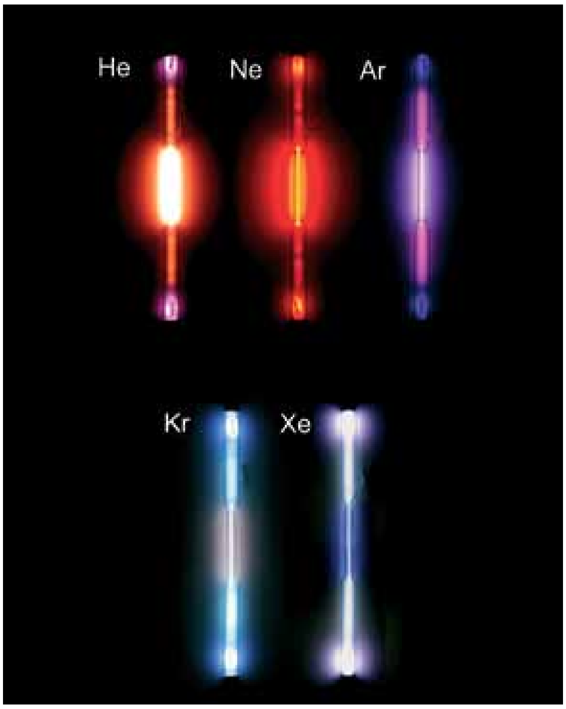
1	2											3	4	5	6	7	0
							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
N	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							

Alkali metals *Halogens*
Transition metals *Noble gases*

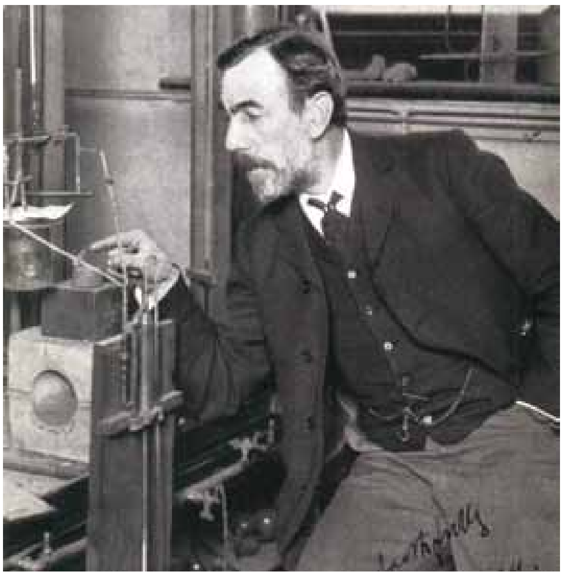
Group 0 or 8 of the periodic table contains the Noble gases: helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn). This group was the last of the periodic table to be discovered due to their unreactivity.

Nobel prizes are awarded each year for physics, chemistry, physiology or medicine, literature and for peace. They are very prestigious international awards.

The periodic table had not allowed for a group of elements between the halogens and the alkali metals so their discovery came as a complete surprise. The first to be found was argon, in 1895 by William Ramsay and Lord Rayleigh. This was so unexpected that it was suggested by a number of eminent scientists, including Mendeleev, that it was a new sort of nitrogen, N_3. Within three years, Ramsay and his co-workers had also found helium, neon, krypton and xenon by using fractional distillation to separate out liquid air into several components. They showed that these gases are monatomic (consist of only one atom) and unreactive. Ramsay and Lord Rayleigh were both awarded Nobel prizes for their discoveries.

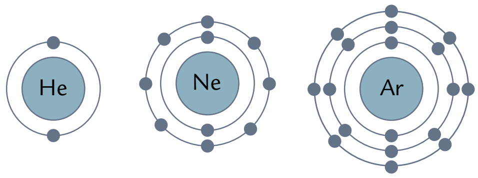


When an electric current is passed through the noble gases, each glows with a distinctive spectrum of colours.



William Ramsay

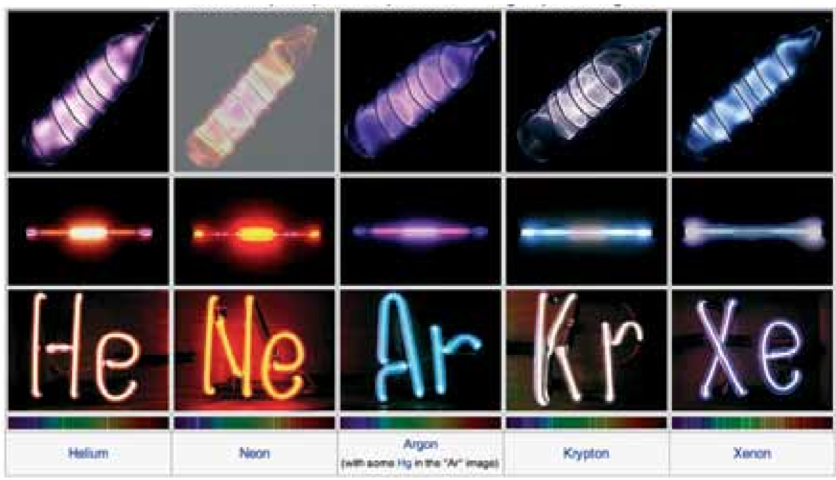
In 1913, Rutherford and Bohr published their theories on the structure of the atom and electronic configurations. We still use these theories today to explain the chemical properties of elements. It was noted early on that the noble gases were especially stable and this was linked to their electron configurations. Chemical properties of other atoms were related to the gain or loss of electrons from the configuration of the nearest monatomic gas. These theories were incredibly successful in predicting and explaining patterns of chemical behaviour. But partly as a result of them, the noble gases came to be thought of as completely inert and unreactive – chemists thought that they could *not* react.



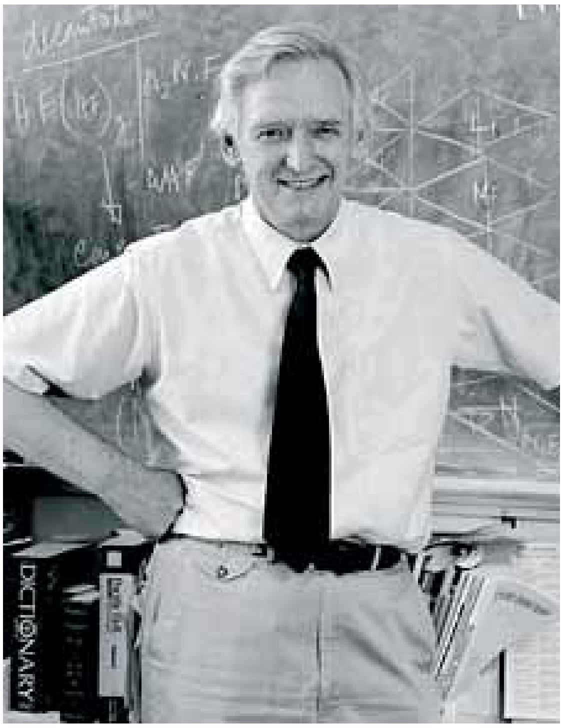
Electron configurations of the first 3 elements of group 0 or 8

Changing ideas

However, even as early as 1916, it was noted that xenon was the most likely to chemically combine and that it would probably be with fluorine or oxygen. A few attempts were made to react xenon and fluorine, but without success. Chemists generally held that all noble gases were completely inert to chemical combination.



Colours and spectra (bottom row) of electric discharge in noble gases



Neil Bartlett, professor of chemistry at the University of California, Berkeley.

That changed when a chemist called Neil Bartlett, who was originally from England but was working in Canada, tried something different. He had been working on compounds of platinum and fluorine and speculated that these may be reactive enough to combine with xenon. He was right. In 1962 he announced that he had made the first compound of xenon – with platinum and fluorine. Its chemical formula was complex and he had probably made a mixture rather than a pure compound – but he had offered the first proof that compounds could be prepared from a noble gas. Since he showed that it could be done, more than 100 compounds of xenon have been prepared including oxides, acids and salts. Even compounds with xenon bonded to hydrogen, sulfur and gold have been made, although most are stable only at very low temperatures.

Crystals of xenon tetrafluoride – this was the first compound of xenon in which it was combined with only one other element.

Following Neil Bartlett's success, other compounds of noble gases followed; radon fluoride in 1962 and krypton difluoride in 1963. In spite of the success in forming compounds of three of the noble gases, opinion remained among chemists that the other gases were inert and would not form compounds.

It took until 2000 before the first compound of argon was announced. It has the formula HArF and is called argon fluorohydride. It was made by a team of Finnish chemists by freezing a mixture of argon and hydrogen fluoride onto caesium iodide at -265°C and exposing the mixture to UV radiation. They clearly identified the new compound and showed that the argon had formed bonds, but on warming it reverts back to argon and hydrogen fluoride.

At present, no compounds are known of neon or helium and they are considered to be completely inert and unreactive. However, this is what chemists thought of the other noble gases too – until they made compounds with them!

Vicky Wong is Chemistry editor of Catalyst.