PHYSICS

Magic Atomic Numbers

Ancients considered 3 and 7 as magic and mysterious, but scientists have their own mysterious numbers—50, 82, 126 and 152. Some of these tell which elements will fission.

By HELEN M. DAVIS

➤ MAGIC NUMBERS are appearing in sober scientific papers. By using them, physicists hope to penetrate more and more closely into the secrets of atomic structure.

Mystery-loving priests of ancient religions taught that 3 and 7 have magic properties. To modern scientists the magic numbers are 50, 82, 126 and, more recently, 152.

The modern magic numbers have to do with the arrangement in space of particles inside the atomic nucleus. These particles are so unthinkably small that there is no mechanism by which we can hope to see them. There is even doubt that they have material substance. But they occupy space, nevertheless.

And, just as seven pennies assume the shape of a ring of six around one central penny when they are pushed together on a flat surface as closely as they will go, so protons and neutrons inside the nucleus arrange themselves in rings or "shells" that tend to stay in a definite pattern.

Although the physicist's imaginary picture of the atom is copied from our solar system, where a large central sun is ringed by the orbits of relatively tiny planets, the nucleus, the center of this miniature solar system, seems to have no such roomy space.

Tightly Packed Nucleus

In the nucleus, as scientists picture it, protons and neutrons are packed into a small volume. Instead of spreading out, as each successive element adds to the number of subnuclear particles, the nucleus seems to become more crowded.

Protons and neutrons play different roles in the make-up of the atom. The number of protons in the nucleus determines the kind of matter the atom forms, whether hydrogen, uranium, iron, carbon or any other of the 101 kinds of elements now known. The number of protons determines the atomic number.

The number of neutrons in the nucleus determines the atomic weight or mass. Uranium 233, 235 and 238 differ in atomic weight, while the atomic number for all of them is 92. The name isotope is given to forms of the same element differing in atomic weight.

Inside the nucleus of ordinary uranium are packed 92 protons and 146 neutrons. They seem to be arranged in concentric "shells" which have a complex symmetry.

The greatest early contribution to understanding the theory of atomic structure was made about 1860 by the Russian chemist, D. Mendeleev, just honored by having element 101 named for him. Mendeleev recognized that the differences between the chemical properties from one element to the next, when they are arranged in the order of their atomic weights, recur in regular fashion.

After completing a series of different elements, the properties are repeated in the following series. So regular is this repetition of properties that Mendeleev could and did predict with great accuracy the properties of undiscovered elements to fill all the gaps in the periodic table of the elements which he constructed.

Although, since Mendeleev's time, new families of elements completely outside his original scheme have been discovered, these have proved his periodic law by fitting into the table in a completely regular way.

The chemical properties on which Mendeleev's table is based belong to the outer rings of planets in the atomic solar system. As new knowledge is gained about the particles that make up the atomic nucleus, chemists are interested to discover that they, too, have periodic variation.

Recent study of all the radioactive forms of the elements has forced upon scientists the belief that such nuclear properties as the radioactive decay rate, and even the relative abundance of the elements on earth, depend on the arrangement of protons and neutrons inside the atomic nucleus.

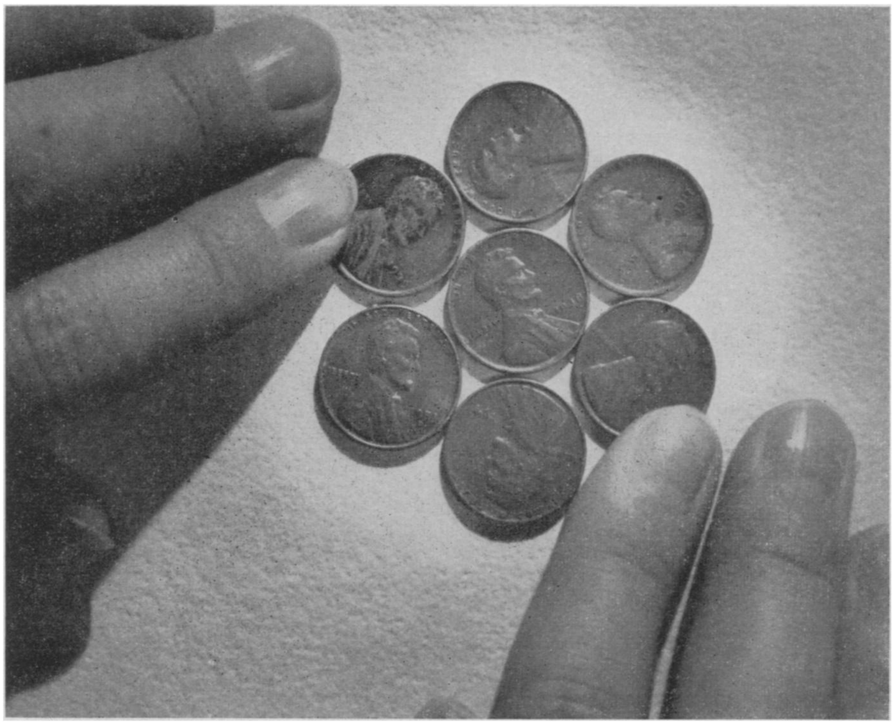
As the periodic table filled, with the discovery of new elements, the mysterious absence of some elements became evident.

Some Combinations Stable

During the past 59 years, since the discovery of radioactivity, as the nuclear make-up of the elements has gradually been worked out, a relationship has been glimpsed between gaps in the list of isotopes of the elements and certain numbers of protons and neutrons in the nucleus.

Some number combinations seem to produce isotopes that are especially stable, or have long radioactive lives. Other combinations seem to be unfavorable to the formation of stable elements.

Dodging the question "why?", physicists and chemists describe the combinations that produce unusual stability as "magic numbers."



SEVEN PENNIES—These pennies illustrate one reason why priests of old considered 7 a magic number. Try to get more than six coins arranged around the center one. Similarly, inside the atomic core particular numbers have meanings not yet understood.

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Shrewd guessing connects the numbers with the geometry of space within the nucleus. Both protons and neutrons have their own patterns into which they fit in this crowded space.

In the larger spheres of influence outside the atomic nucleus, the chemical properties of the elements depend upon the number of electrons filling the possible orbits. Chemical valence, the power by which one atom combines with another to make up all the infinite variety of materials in the universe, is measured by the number of orbits that lack their complement of electrons.

An atom with all its orbits filled belongs to the class of chemically inert gases that form no compounds.

An analogous stability is imagined for the nuclei with "magic numbers." The particles "prefer" certain forms. They do not assume other arrangements, perhaps in the same way that the inert elements do not form compounds.

The laws of atom formation, as they have come to be understood, prevent two electrons circulating in the same orbit at the same time, unless they spin in opposite directions.

Analogous to "Closed Shells"

More than two electrons cannot share an orbit at all, and the number of orbits which can occupy the space a certain distance from the nucleus is strictly limited. Each group of orbits may be thought of as comprising a "shell" at a certain distance around the nucleus.

A "magic number" may correspond to a similar "closed shell" inside the nucleus. Closed shells for both protons and neutrons have been detected.

Picture analogies in subnuclear realms are not exact, and are far from satisfactory. Physicists point out that these fast-moving entities are at the same time waves and particles, and that it is impossible to be certain where they are at any definite moment. Yet the picture of the "closed shell" is useful if it is not taken too literally.

As evidence of the stability of the magic number 50 for protons, tin, with atomic number 50, has more isotopes than any other element.

Lead, end-product of all radioactive transformations, is doubly a magic number element, for it has 82 protons and one of its isotopes is possessed of 126 neutrons. Both of these numbers are characteristic of special stability.

Number 152 is the latest magic number to appear from subnuclear research. Dr. Glenn T. Seaborg of the University of California states that it seems to measure a new stable subnuclear configuration.

Subtract the atomic number from the atomic mass of one of the man-made isotopes of a transuranium element, and if the remainder is greater than 152, beware! Such a nucleus will explode in spontaneous fission, with a shower of neutrons. Fermium 256, a form of the new element 100, is such an isotope.

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MEDICINE

Snakeroot Drug Helps Itchy Skin

➤ ITCHY SKIN DISEASES, particularly if there is a prominent mental factor involved, can be relieved by a drug from the old snakeroot remedy of India, *Rauwolfia serpentina,* Dr. Richard J. Ferrara of Detroit and Dr. Hermann Pinkus of Monroe, Mich., report in *Archives of Dermatology* (July).

The drug they used is called alseroxylon (Rauwiloid). It relieved itching and had a calming effect in 35 of 36 patients.

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