Letters

On the Chemistry of Inert Gases

The report in *Science* [**138**, 136 (1962)] describing the synthesis of xenon tetrafluoride appeared just as I was explaining to my large introductory course in biology (we call it that, though living organisms don't appear until about Christmas) that inert gases have no chemistry. Of course I have had to comment on it, particularly since both the report and the accompanying editorial emphasized only the shattering of former idols, with no suggestion of an explanation. All honor to the men who upset the idols, but now that one has to think again, is there not a reasonably straightforward explanation of such compounds, so that—as with all the best discoveries—their existence should have been anticipated?

The view that an outer shell of eight electrons—as in all the inert gases beyond helium—represents ultimate stability carries also the implication that the maximum number of covalent bonds should be four, filling one *s* and three *p* orbitals. To explain the existence of such familiar compounds, however, as PCl_5 and SF_6 one invokes the principle of the "expanded octet," expanded in these instances by employing *d* in addition to *s* and *p* orbitals. The third period of the periodic system, in which sulfur and phosphorus occur, is closed when the octet is completed (when the *s* and *p* orbitals are filled), as in argon (2–8–8). Yet the third electron shell will eventually hold 18 electrons, as it does in krypton (2–8–18–8), owing to the filling of the five additional *d* orbitals; and elements in the third period can expand beyond the octet by borrowing against this potentiality. No such compounds as PCl_5 and SF_6 appear in the second period, since no *d* orbitals are available. If other elements in the third period can expand beyond an octet on the basis of 3*d* orbitals, why not the inert gas argon that closes the period?

The electronic formula of xenon (atomic number 54) is 2–8–18–18–8. The outermost shell of xenon will eventually go from 8 to 18 electrons, as in radon (atomic number 86: 2–8–18–32–18–8), by filling its five 5*d* orbitals with five additional pairs of electrons. This might be expected, therefore, to offer a bonding possibility. Actually, however, the energies of the 6*s* and 6*p* orbitals are close in this case to those of the 5*d* orbitals, so that any expansion beyond the inert gas structure might be expected to involve hybridization of all three types.

Similarly, compounds of radon might be expected to involve the hybridization of 6*d* and 7*s* orbitals, and compounds of krypton, hybridization of 4*d* and 5*s* (also 5*p*?) orbitals. Indeed, compounds of argon, if such can be prepared, might involve a similar hybridization of 4*s* and 3*d* (also 4*p*?) orbitals rather than 3*d* orbitals alone.

If these are the lines of a correct explanation, it should be exceedingly difficult ever to prepare compounds of helium, in which the single 1*s* orbital is filled and no others are available; or of neon, in which the 2*s* and 2*p* orbitals are filled and no others are available. (In these cases hybridization with orbitals on the next shells is very unlikely because of large energy gaps.)

Obviously I am not the one to say these things; and really I am not saying, but asking them.

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On the Recent Discoveries Concerning Jupiter and Venus

In the light of recent discoveries of radio waves from Jupiter and of the high surface temperature of Venus, we think it proper and just to make the following statement.

On 14 October 1953, Immanuel Velikovsky, addressing the Forum of the Graduate College of Princeton University in a lecture entitled "*Worlds in Collision* in the Light of Recent Finds in Archaeology, Geology and Astronomy: Refuted or Verified?," concluded the lecture as follows: "The planet Jupiter is cold, yet its gases are in motion. It appears probable to me that it sends out radio noises as do the sun and the stars. I suggest that this be investigated."

Soon after that date, the text of the lecture was deposited with each of us [it is printed as supplement to Velikovsky's *Earth in Upheaval* (Doubleday, 1955)]. Eight months later, in June 1954, Velikovsky, in a letter, requested Albert Einstein to use his influence to have Jupiter surveyed for radio emission. The letter, with Einstein's marginal notes commenting on this proposal, is before us. Ten more months passed, and on 5 April 1955 B. F. Burke and K. L. Franklin of the Carnegie Institution announced the chance detection of strong radio signals emanating from Jupiter. They recorded the signals for several weeks before they correctly identified the source.

This discovery came as something of a surprise because radio astronomers had never expected a body as cold as Jupiter to emit radio waves (*1*).

In 1960 V. Radhakrishnah of India and J. A. Roberts of Australia, working at California Institute of Technology, established the existence of a radiation belt encompassing Jupiter, "giving 10^{14} times as much radio energy as the Van Allen belts around the earth."

On 5 December 1956, through the kind services of H. H. Hess, chairman of the department of geology of Princeton University, Velikovsky submitted a memorandum to the U.S. National Committee for the (planned) IGY in which he suggested the existence of a terrestrial magnetosphere reaching the moon. Receipt of the memorandum was acknowledged by E. O. Hulburt for the Committee. The magnetosphere was discovered in 1958 by Van Allen.

In the last chapter of his *Worlds in Collision* (1950), Velikovsky stated that the surface of Venus must be very hot, even though in 1950 the temperature of the cloud surface of Venus was known to be −25°C on the day and night sides alike.

In 1954 N. A. Kozyrev (*2*) observed an emission spectrum from the night side of Venus but ascribed it to discharges in the upper layers of its atmosphere. He calculated that the temperature of the surface of Venus must be + 30°C; somewhat higher values were found earlier by Adel and Herzberg. As late as 1959, V. A. Firsoff arrived at a figure of + 17.5°C for the mean surface temperature of Venus, only a little above the mean annual temperature of the earth (+ 14.2°C) (*3*).

However, by 1961 it became known that the surface temperature of Venus is "almost 600 degrees [K]" (*4*). F. D. Drake described this discovery as "a surprise . . . in a field in which the fewest surprises were expected." "We would have expected a temperature only slightly greater than that of the earth. . . . Sources of internal heating [radioactivity] will not produce an enhanced surface temperature." Cornell H. Mayer writes (*5*), "All the observations are consistent with a temperature of almost 600 degrees," and admits that "the temperature is much higher than anyone would have predicted."

Although we disagree with Velikovsky's theories, we feel impelled to make this statement to establish Velikovsky's priority of prediction of these two points and to urge, in view of these prognostications, that his other conclusions be objectively re-examined.

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References

1. See also the New York *Times* for 28 October 1962.
2. N. A. Kozyrev, *Izv. Krymsk. Astrofiz. Observ.* **12** (1954).
3. *Science News* 1959, 52 (Summer 1959).
4. *Phys. Today* **14**, No. 4, 30 (1961).
5. C. H. Mayer, *Sci. Am.* **204** (May 1961).

Lunar Influence on Precipitation Patterns

I read with much interest the report by Bradley, Woodbury, and Brier [*Science* **137**, 748 (1962)] and the report from Australia by Adderley and Bowen [*ibid.* **137**, 749 (1962)] dealing with possible lunar influence on precipitation patterns. I would like to offer the following as testimony relative to the findings reported.

About 10 years ago I was working on weekly rainfall totals and their effect on corn yields for 15 counties in central Indiana. From folklore I had learned that precipitation was more likely to occur during the week following a new moon and the week following a full moon than at other times, so I proceeded to test this idea. To my amazement I found some agreement. After applying several statistical treatments to the data I produced a short manuscript as well as an outline suggesting some further investigations along this line. I need not relate here the review comments or the outcome of the proposed investigations. In short, the whole matter was dropped.

Best wishes to all the authors in their further investigations.

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