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.

GEORGE WALD

Biological Laboratories,
Harvard University,
Cambridge, Massachusetts

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 pro-