letters

My personal conclusions have been reinforced by the most recent NEA research report[1] on teacher supply and demand which concludes that

> ". . . the teacher supply is generally adequate, but shortages of beginning teachers are expected to continue in secondary school mathematics, special education, vocational-technical courses, industrial arts and some secondary school sciences."

One of the most interesting aspects of the report is that the authors considered the number of science teachers to be in "short supply" and projected a shortage of 2592 for the 1970–71 year. In the field of mathematics the demand was even greater with a projected national shortage of 3900 teachers and the report that 13 of the largest 67 school systems were having "extreme difficulty" in filling mathematics positions. It is of further interest that 7 of the 67 systems had found it necessary to employ "persons with substandard qualifications" in sciences, and 10 systems had the same problem in mathematics.

Although the results of the NEA survey for the 1971–72 year will not be available until August, our limited experiences, described above, indicate that the needs described in the NEA report had not yet been fully met by this spring.

An important lesson that might be learned from the data presented in the NEA report is that the talents of physicists may often be most valuable to secondary schools in meeting their needs in mathematics education. The importance of this lesson is reinforced by the relatively small number of schools whose demands can justify an instructor who teaches physics full time and by the intensity of the economic problem for physicists whose backgrounds are closely associated with mathematics.

Even when the numerical shortages end, there will continue to exist a challenge for the improvement of the quality of secondary-school science and mathematics education and a large number of openings will continue to be filled each year on a competitive basis.

Although I would not presume to speak for the University of Wyoming, I do think that McConnell's long-distance judgment that their program may be "self serving" may reflect in part the tremendous stress that the present economic crisis has brought to bear on all of us.

Reference

1. "Teacher Supply and Demand in Public Schools," Research Report 1970-R14, National Education Association, Washington, D.C. (1970).

Robert Beck Clark
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Clock paradox rebuttals

The article in the September issue (page 23) by Mendel Sachs on the clock paradox has evoked a flood of letters to the editor, many of which take issue with the author's position on the basis of theory or experimental evidence. We have already received more letters than we can publish. A representative sampling will appear in this department in the near future.

—Editor

Scales of ionicity

A most interesting paper, "The Chemical Bond and Solid-State Physics" (February, 1970, page 23 by J. C. Phillips) was recently discussed by Linus Pauling (February 1971, page 9). I would like to add a further comment on the ionicity of chemical bonds, an important topic to chemists and physicists alike.

Phillips defines a scale of ionicity, f_i, for binary solid compounds, AB, as

$$f_i = C^2/(E_h{}^2 + C^2) \qquad (1)$$

where C is the average ionic energy gap and E_h the covalent energy gap. The total energy gap is given by $E_g{}^2 = E_h{}^2 + C^2$, and E_g and E_h are evaluated from spectroscopic data. The values of f_i so calculated are shown to accurately divide AB solids into those with 4-fold coordination ($f_i < 0.785$) and those with 6-fold coordination ($f_i > 0.785$).

If a simple molecular orbital calculation is made for an *isolated* AB molecule, containing a pair of valence electrons, an energy gap between the bonding MO and the antibonding MO can also be calculated. The wave function is taken as

$$\Phi = (\Psi_B + \lambda\Psi_A)/(1 + \lambda^2)^{1/2} \qquad (2)$$

and, ignoring overlap,

$$E_g{}^2 = (q_B - q_A)^2 + 4\beta^2 \qquad (3)$$

where q_B is the coulomb integral on atom B, the β is the exchange integral between A and B.

Clearly $(q_B - q_A)$ corresponds to the ionic energy gap and β^2 to the covalent energy gap, as used by Phillips. However, if we now calculate the ionicity of the bond, as defined by the net charges on A and B,

$$f_i' = (1 - \lambda^2)/(1 + \lambda^2)$$
$$= (q_B - q_A /[(q_B - q_A)^2 + 4\beta^2]^{1/2} \qquad (4)$$

This ionicity, which has a clear meaning within the limitations of the model, is the square root of the ionicity given by Phillips.

Obviously the ionicity scale, f_i', will also divide the binary solids into four-fold and six-fold coordination, except that the critical ionicity is now $f_i' = 0.886$. Values of ionicity can be recalculated from all of Phillips's f_i values. The new numbers are all higher than before, but still appear reasonable.

There is no reason, of course, why both f_i' and f_i cannot be true scales, since they are simply related to each other. Consider, however, the intuitive meaning of ionicity, (agreed to by Phillips as well) as the fraction of time spent by the valence electrons in the configuration A^+B^-, as compared to A:B. This meaning is much more closely related to f_i' than to f_i. This suggests that a better scale of ionicity is given by

$$f_i' = C/(E_h^2 + C^2)^{1/2} \qquad (5)$$

than by equation 1.

Ralph G. Pearson
Northwestern University
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The author comments: Pearson's points are well taken. Because of space considerations, my article in *physics today* could not explore analogies with standard chemical theories, such as the Hückel theory or the Coulson valence-bond theory. In a much longer article [Rev. Mod. Phys. **42,** 317–356 (1970)] some of these analogies are examined quantitatively, especially those following from Pearson's equation 2, and I hope that this article will show that I was aware of these analogies.

Following Coulson in section 3 of the longer article I was able to evaluate $(1 - \lambda^2)/(1 + \lambda^2)$ in Pearson's equation 4, but I obtained a different result than he does. This is because Coulson used Moffit's method to treat charging effects self-consistently. When this is done, one finds that $(1 - \lambda^2)/(1 + \lambda^2)$ is just equal to $1 - N/4$ to lowest order for any $A^N B^{8-N}$ compound, *independent* of A and B. This approach would predict that all II–VI compounds have nearly the same ionicity, and thus could not be used to predict which II–VI compounds (such as MgO) have the rocksalt structure, and which (like ZnO) have covalent, four-fold coordinated structures.

The path that I have taken follows Pauling much more closely than it does Coulson, and places greater emphasis on observable quantities like heats of formation and interatomic forces than it does on charge exchange. The latter is important for molecular reactions, but it is less useful in discussing crystalline properties. I have preferred to avoid it, rather than introduce an additional arbitrary element into the theory.

J. C. Phillips
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Murray Hill, N. J.

More on job picture

In the May issue, (page 23) Murray Gell-Mann observes that "science and technology are being underutilized in a wide variety of immediate civilian tasks of great social importance. . ." He then concludes the paragraph with: "I think, as long as these jobs are being neglected, we cannot speak of any overproduction of scientists and engineers."

It is not entirely clear from the context whether it is the scientists and engineers or those who employ them that are neglecting these jobs. If it is the former group and Gell-Mann has some as yet unpublished list of employers who are quietly seeking scientists and engineers to "employ humane rationality," then I certainly would appreciate a preprint. However, if it is the employers who are neglecting these jobs, then I find it absolutely incredible that his conclusion directly follows a sentence containing the expression "humane rationality."

In the latter case, I suggest that the physics community would do well to take Gell-Mann's advice and apply humane rationality to its own employment crisis. Even physicists are subject to the economic laws of supply and demand. During the years of shortages of physicists, the physics community responded magnificently by increasing supply to meet demand, closing the "critical gap" in ten years or less. Now in years of surplus we hear many physicists talking of somehow increasing demand to meet supply. Yet, none has come forth with an effective way of *making* an employer hire a physicist. The physics community is not the first segment of our economy to discover that it holds considerable influence on supply but almost none on demand.

Frank D. Feiock
San Diego, California

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Since my letter appeared in March (page 9) I have unwittingly become a storm center in the current controversy, and I ask this opportunity to defend myself. I have received well over 200 letters since March. About 80% of them were from unemployed physicists who felt that I could help them find employment. To them I regretfully say that I am sympathetic but not a miracle worker. I cannot help you.

Most of the remaining letters were from certain people in industry and the academic community who, I presume, have a vested interest in maintaining present PhD production. Many of these letters attacked me personally and some even called for my resignation.

There were generally two categories of errors in these letters. The first type consisted of elaborating a particular case of a physicist who successfully

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