LETTERS

Testing

On November 18 the Western Pennsylvania Section of the American Association of Physics Teachers discussed the article by Banesh Hoffmann ("Testing", *Physics Today*, October 1961, p. 38). Our conclusions may be summarized as follows:

Question #64: "Colorless" glass implies no differential absorption at different wave lengths. Since the real and imaginary portions of the dielectric constant are connected by a pair of reciprocal integral equations, the imaginary component, which determines the ordinary index of refraction, can vary only if differential absorption exists. Therefore, the "colorless" glass prism would produce *no spectrum* because it has *no dispersion*. (*C*) is therefore the very best answer as to why *real* glass prisms can produce a spectrum from white light. Question No. 64, *as it is phrased*, is the question with *no correct answer*.

Question #54: (1) We equated "matter" with mass readings obtained by weighing. A weight scale does not read rest mass, but relativistic mass, including any radiant energy trapped in the object being weighed, cf., Harry Lustig, "The Mössbauer Effect", *Am. J. Phys.*, **29**, 1 (1961). The contents of a container are weighed because molecules striking the bottom of the container have fallen through a gravitational potential and have greater relativistic mass and momentum than the ones striking the top of the container. Likewise, the radiation striking the bottom of the container has fallen through a gravitational potential and has been shifted toward the violet (higher frequency) so that it has greater relativistic mass and momentum than radiation striking the top of the container.

Because of the spark advance of an automobile engine and the speed of the reaction, "burning of gasoline" is complete before the start of the power stroke. The reaction is therefore one at nearly constant volume, with so short a duration that any heat conduction loss is compensated by the slight compression. Therefore (*E*) is a true answer. The energy transferred out of the system on the power stroke comes from the conversion of relativistic mass.

(2) Regarding (*A*) "reduction", over half the group concurred that

(a) Equations of the form

$$2H_2 + O_2 \rightarrow 2H_2O$$
$$C + O_2 \rightarrow CO_2$$
$$C_8H_{18} + 25\ O_2 \rightarrow 8CO_2 + 9H_2O$$
$$2Mg. + O_2 \rightarrow 2Mg.O$$

which start with covalent or metallic bonds and end with covalent bonds should be called "oxidation" and distinguished from reactions of the form $CuO + H_2 \rightarrow Cu + H_2O$ which are "reduction". This in no way invalidates the treatment of both types of reaction together under the heading "oxidation-reduction".

(b) Where valence changes are involved it seems preferable to speak of an increase in positive valence as "oxidizing", and an increase in negative valence as "reducing". This leaves the words "oxidation" and "reduction" free to retain their historical and important meanings as designations of the above-mentioned different types of reactions. This terminology is completely compatible with the usual specification of H_2 in the "reduction equation" as the "reducing agent" or H_2O in its reverse reaction as the "oxidizing agent". Our available supply of words is too small to permit squandering them. Question No. 54 is the question with two correct answers.

Question #65: (1) We would not accept a substitution of "metallic atoms in a vapor" for the stated "metal". Consequently "work function" of the metal is the governing consideration, and the change of intervening medium from the vacuum of the photoelectric effect to the electrolyte of the electrochemical series does not alter work function differences between different metals. Consequently (*C*) is the correct answer both because it emphasizes the energy considerations and because it gives a true answer even when members of different groups of the periodic table are compared, which none of the other answers will invariably do.

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More on Testing

On reading the article on testing in the October *Physics Today*, it occurs to me that item 65 can be criticized on grounds more fundamental and trenchant than Dr. Hoffmann's. Briefly, the root difficulty appears to be that the person who wrote the test item did not understand the nature of the photoelectric effect in solid metals, which is what the *question* deals with. The *answers*, however, are aimed at the problem of liberating an electron bound to a specific atom. The outer electrons in a metal are, roughly speaking, not bound to a specific atom, but circulate freely throughout the sample. Thus, when one looks at what is really happening inside a metal, all the answers are wide of the mark, and in particular the desired answer (*B*) is mainly nonsense.

Incidentally, it is too generous to assume, as Dr. Hoffmann does, that the test-maker was interested in individual atoms, as in the gaseous state. "Photoelectric effect" commonly implies the solid state. No experienced test-maker would have reinforced this impression by referring to "potassium metal" and "lithium metal" in the question if what he had in mind was potassium vapor or potassium gas.

I know from my own experience that occasional defective items are unavoidable—although, if Dr. Hoffmann's figure of 5% defective items in Educational Testing Service tests is correct, this would be high for items that may test some hundreds of thousands of students. What I find more distressing than ETS's error is their response to Dr. Hoffmann's criticism (*Harper's Magazine*, March 1961). This is contained in their "Explanation of Multiple-Choice Tests", the relevant portions of which are quoted in Dr. Hoffmann's article, and of which ETS kindly sent me a copy. ETS's explanation of this test item begins: "The technical terms must be considered in studying this question." Indeed, this is correct, but the next sentence displays the identical misunderstanding of the technical terms that motivated the test maker: "The photoelectric effect is exhibited by an element if, in atoms of the element, an electron is so loosely bound that visible light provides enough energy to free that electron from its atom." This belief that a photoelectron is liberated from a specific atom also permeates the rest of the explanation. (The additional misapprehension