the most deuterated condition toward a more nearly equal concentration of H^1 and H^2, the intensity changes of type (0), (1), and (2) lines are to be associated respectively with 0, 1, and 2, hydrogen replacements per molecule of ND_3. From a measure of the type and amount of intensity drift observed for a given type line, a quantitative estimate was made as to the instantaneous location on the ratio curves. From this position a prediction could be made as to the intensity change to be expected by driving the assumed equilibrium slightly toward NH_3 or ND_3 by addition of a small amount of the appropriate gas. In every instance both the initial change and the rate of the line intensity confirmed the indicated correlation between line type and deutero-hydrogen assignment. The complete assignment of all observed lines by these techniques awaits further work.

Table I lists the lines so far measured. Rough frequency measurements for this preliminary survey were made by means of cavity frequency meters with precision measurements to be made later directly against the NBS frequency standards. Relative intensities expressed, as recorder line-heights, are shown in Table I when intensity measurements were made and are uncorrected for the unknown isotopic abundance. Line intensities in restricted frequency regions were reproducible for a given type line. However, variations of equipment sensitivity with line-height and frequency correspondingly limit the ranges within which these values have significance.

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The Enhanced Photoelectric Emission Effect in Barium Oxide*

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THE activation effect of ultraviolet radiation on the photoelectric emission from BaO recently reported by Dickey and Taft[1] has been studied in this laboratory. Since the reported effect was found for thin films of the oxide, whereas our observations have been made on thermionically active oxide cathode coatings, and since the pronounced wavelength dependence of this effect was not described, it seems desirable to report at this time the results of our study.

Figure 1 (A) shows the spectral distribution of photoelectric emission from a normal sample of pure[2] BaO. This cathode was activated for thermionic emission by drawing current to a movable tantalum anode. A Richardson plot gave thermionic constants of $\varphi = 1.44$ ev and $A = 0.026$ amp/cm^2 °K^2. Maxima in the photoelectiic response curve between $h\nu = 3.6$ and 4.0 ev have been found for all samples, although the exact shape in this region differs. These maxima for BaO were previously reported by Apker[3] and are not unlike the maxima found[4] for KI and attributed to exciton production. Curve B was obtained after allowing 3700A radiation ($h\nu = 3.37$ ev) to fall on the sample for 30 minutes. In the region of the photoelectric threshold, below 1.5 ev, the photoemission was doubled, whereas in the region of the exciting wavelength the increase was only about 30 percent.

Measurement of the photo-current in the ultraviolet region from unactivated samples could not be carried out without the radiation used in this measurement changing the state of photoelectric activation, particularly for photo-emission near the
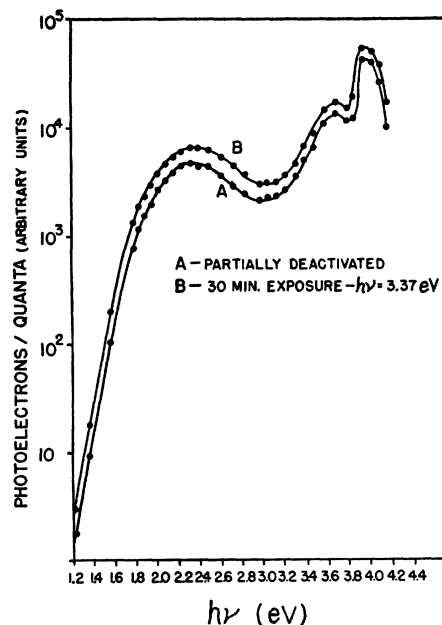

FIG. 1. (A) Spectral distribution of photo-emission from BaO sample. (B) Spectral distribution resulting following 30-minute irradiation at $h\nu = 3.37$ ev.

threshold. An attempt was made to determine the wavelength range over which photoelectric activation could be produced. All ultraviolet wavelengths down to and including 2537A produced the effect as did wavelengths in the visible. A sample in a low state of activity for enhanced photo-emission could be activated by 7000A radiation, whereas a partially activated sample, e.g., that of Fig. 1, could not be activated further by 4000A. Although the relative efficiencies for these activating wavelengths have not yet been investigated thoroughly, it is clear that the efficiency increases with higher energies but that irradia-
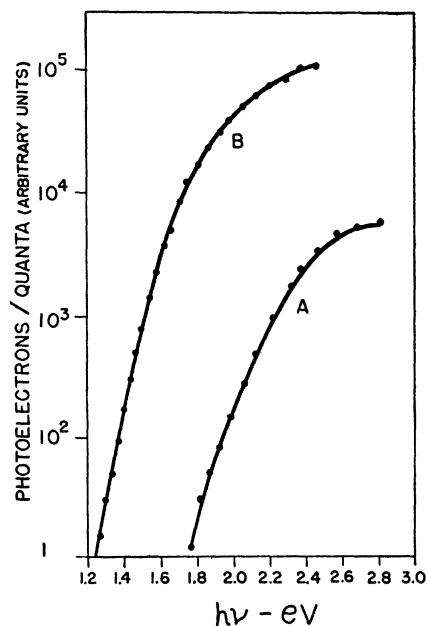

FIG. 2. Spectral distribution of photo-emission from BaO near the threshold, (A) initial unactivated state, (B) after 30 minutes irradiation at $h\nu = 3.37$ ev.

tion in the fundamental absorption band[5] is not required. In order to keep the sample in essentially the same state of activity for photo-emission, all subsequent work on activation and de-activation effects was carried out using photon energies less than 3.0 ev.

Figure 2 shows the enhancement of photo-emission starting from a state (A) which was less active for photo-emission than the sample in Fig. 1(A). Thirty minutes irradiation at $h\nu=3.37$ ev changed the sample to state (B). At $h\nu=1.8$ ev a 1000-fold increase was observed, whereas at $h\nu=2.5$ ev the increase was by a factor of 30. It is apparent that the effect of irradiation is considerably greater near the photoelectric threshold than for higher energies. This feature of the enhanced photo-emission from BaO differs from the effect[4] in KI, in which the increase occurs simultaneously for all wavelengths.

At 300°K the enhancement effect decays slowly with time but at different rates for the various wavelengths, Fig. 3. Wave-
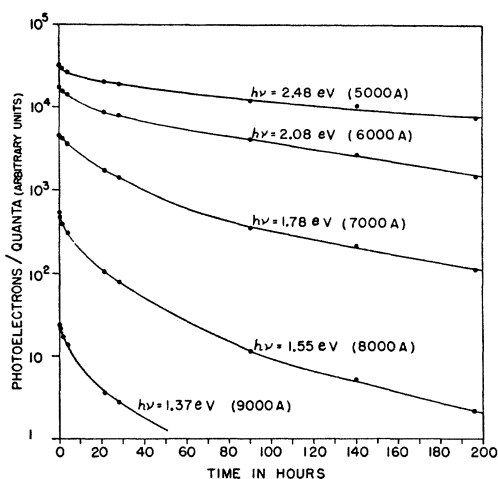

FIG. 3. Decay of enhanced photo-emission from BaO at 300°K at various wavelengths.

lengths near the photoelectric threshold for which the enhancement effect is most pronounced have the greater decay rate. This decay increases rapidly with higher temperatures; at 600°K complete deactivation takes place in 30 minutes. It is apparent that the decay does not have a simple exponential time dependence nor does it seem to obey a second-order reaction law. If one assumes that the decay rate has an initial exponential dependence on E/kT, where E is the activation energy, and uses $1/t$, as a measure of the decay rate, where t is the time required for the photo-current to fall to one-half value, an activation energy may be evaluated. At $h\nu=1.8$ ev this activation energy is 0.92 ev and at $h\nu=2.5$ ev the energy is 1.07 ev.

Although it is perhaps too early to attempt a complete interpretation of this enhanced photo-emission effect, it seems likely that incompletely filled donor levels lying in a region 1 ev below the conduction band together with a few low lying levels above the filled band will account qualitatively for the observed phenomena. This enhanced photo-emission effect has been observed on three BaO cathodes although all of the data presented here are for a single sample.

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Angular Distributions of Neutrons from (α, n) and (d, n) Reactions

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BEFORE interpreting the data of Allen, et al.[1] on the angular distributions of the neutrons from (α, n) and (d, n) reactions, as measured with sulfur detectors, two very important corrections must be applied: (1) a correction for the variation of the solid angle in the center-of-mass system, and (2) a correction for the fraction of the neutrons detectable by a threshold detector at various angles.

The first of these is described by Taschek and Hemmendinger,[2] and their formulas can be used. The second arises as follows. A neutron produced in an (α, n) reaction on element A will have different energies in the laboratory and the center-of-mass systems. These are related by the formula (with the masses in atomic units)

$$E_c = \frac{1}{2}\left[(2E_L)^{\frac{1}{2}} - \left(\frac{M_a}{M_a+M_A}\right)(2E_a/M_a)^{\frac{1}{2}} \cos\theta_c \right]^2. \quad (1)$$

An ideal threshold detector detects all neutrons with E_L greater than its threshold, B. Assuming the neutrons to be emitted with an energy distribution

$$I(E) \propto e^{-E/T}, \quad (2)$$

the total number of neutrons detected is

$$N \approx \int_{E_{min}}^{E_{max}} E e^{-E/T} dE, \quad (3)$$

where

$$E_{min} = \frac{1}{2}\left[(2B)^{\frac{1}{2}} - \frac{M_a}{M_a+M_A} \cdot (2E_a/M_a)^{\frac{1}{2}} \cos\theta_c \right]^2, \quad (4)$$

E_{max} = maximum energy in the center-of-mass system.

On integrating (3) and assuming that $E_{max} \gg T$, we find that

$$N \approx (E_{min}+T) \exp(-E_{min}/T). \quad (5)$$

Use of (4) in (5) gives a large correction factor in many cases. As an example, Fig. 1 shows the correction to the intensities at 90° and 180° with respect to 0° using sulfur detectors ($B \sim 3$ Mev), plotted against the parameter T (effective nuclear temperature).[3,4]

Table I shows the result of applying these corrections to the (α, n) data of reference 1. Column 4 shows the value of T required
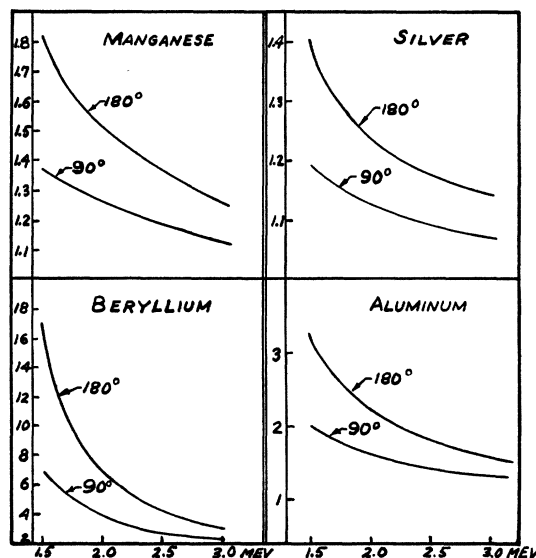

FIG. 1. Correction factors for detector activities at 90° and 180° with respect to 0° activity for (α, n) angular distributions. Abscissa is the effective nuclear temperature of the outgoing neutrons.