equilenin type (III) and reduction to the œstrone type (one aromatic ring) is envisaged.

These experiments are being extended in several directions, and will be described in detail elsewhere.

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[1] Cohen, *J. Chem. Soc.*, 429; 1935.
[2] Doisy *et al.*, *J. Biol. Chem.*, **101**, 753; 1933.
[3] Fieser and Herschberg, *J. Amer. Chem. Soc.*, **57**, 1508, 1853; 1935.
[4] Robinson and Walker, *J. Chem. Soc.*, 1530; 1935.

Excitation of Nuclei by Neutrons

THOUGH many investigations have been made both of fast neutrons and those of thermal energy, much less is known about neutrons of medium velocity. The experiments described below have been devised to investigate such neutrons.

Wertenstein found that artificial radioactivity induced in various substances by neutrons is influenced by layers of gold or lead interposed between the neutron source and the test-piece. The activity was increased if the test-piece consisted of silver or iodine whereas it was decreased if silicon or aluminium were used. It is now known that silicon and aluminium can be activated by fast neutrons only, whereas silver and iodine are more sensitive to slow neutrons. This agrees with Wertenstein's interpretation of the increased activity as being due to a slowing down by the absorber of the fast neutrons from the source. The energy lost by the neutrons is taken up by gold or lead nuclei in the form of excitation energy, and is presumably re-emitted as gamma radiation.

Now neither gold nor lead is strongly activated by neutrons. We thought it interesting to extend Wertenstein's measurements[1] to silver since this is a substance which can be strongly activated. For this purpose we prepared a silver cylinder with walls 15 mm. thick and measured the activation produced in different test-pieces by a Rn–Be source with and without the silver cylinder surrounding the source. Table 1 shows the observed change in the activation as a fraction of that obtained without the silver cylinder.

Test-piece	Increase of activation
Silicon	-23 ± 4 per cent
Aluminium	-19 ± 3 ,,
Silver	$+40 \pm 5$,,
Iodine	$+19 \pm 1{\cdot}7$,,
Rhodium	$0 \pm 2{\cdot}5$,,

From these results, the following conclusions can be drawn:

(1) The effect observed by Wertenstein is not restricted to the substances investigated by him.

(2) The decrease of activation of aluminium and silicon gives directly the cross section for the total absorption of fast neutrons by slowing down and possibly by capture. This cross section comes to 3×10^{-24} cm.^{2}.

(3) Collisions of neutrons with silver nuclei can lead either to an excitation of the nucleus without capture of the neutron, or to capture resulting in the formation of a radioactive element. This conclusion depends on the fact that both the existing isotopes of silver can be activated by capture and so no isotope is left that possibly could only be excited, but not activated.

(4) The activity induced in silver and rhodium is very differently affected by the absorber although these substances show almost the same increase when the neutrons are slowed down by paraffin. This proves that the neutrons slowed down by silver have different energies from those slowed down by paraffin. It further shows that the variation of the activation cross section with neutron energy is markedly different for different elements, at least in the energy range of the neutrons slowed down by silver.

Additional measurements gave the result that the increase of the activation of a silver test-piece is approximately proportional to the thickness of the retarding silver layer between 1 mm. and 15 mm. This result confirms Wertenstein's view that the slowing down of a fast neutron is effected by a single collision. It also shows that no appreciable part of the activity induced by neutrons in a thin silver test-piece is due to neutrons slowed down in the test-piece itself.

We have also studied the influence of a 3 mm. cadmium absorber interposed between the source and the test-piece. No decrease in activity was produced by the cadmium either with or without the silver cylinder surrounding the source. Provided cadmium does not retard neutrons to an extent comparable with silver, it follows from the margin of error in these measurements, that for the neutrons responsible for the activation by a bare source the cross section for absorption in cadmium is smaller than 10^{-23} sq. cm. In the case of the neutrons slowed down by silver the experimental error is larger; the lower limit for the cross section comes therefore to about 2×10^{-23} cm.^{2}.

According to Bethe's[2] theory of the variation of capture cross section with velocity, these limits indicate that the energies of both types of neutrons are of the order of 1,000 volts or higher.

To check directly the assumption that the neutrons are really slowed down by the silver we made the following experiments: A silver test-piece was placed at such a distance from the source that no measurable activity was produced. Then it was backed by a paraffin block in such a way that there was no paraffin between the source and the test-piece. With this arrangement the measured activity was enhanced by 25 per cent when the source was covered with the silver cylinder. Thus the elimination of primary neutrons in the silver block is more than compensated by the increased efficiency of those slowed down in the silver. This is to be expected as slower neutrons reach thermal velocity more quickly in paraffin since they need fewer collisions. As, on the other hand, slow neutrons are absorbed by paraffin, one should expect the effect to decrease if paraffin was interposed between the retarding cylinder and the test-piece. This was verified: When, in addition to the paraffin block behind the source, a block of paraffin 11 cm. thick was put in front of the test-piece the increase produced by the silver cylinder was only ten per cent.

Our thanks are due to Mr. Alton, of the Radium Institute, for supplying the radium emanation and for filling the sources.

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Nov. 10.

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