

three observations  $> 1$  included in (1), (2) and (3) of A is

$${}_n C_3, \frac{n(n-1)(n-2)}{1!2!} \text{ and } \frac{n(n-1)(n-2)}{2!}$$

respectively. Adding them with the proper signs it will be seen that  ${}_n C_3$  samples with three observations in each  $> 1$  are to be subtracted from (E) and the final distribution of  $x$  for the interval  $\frac{3}{n}$  to  $\frac{4}{n}$  becomes

$$I_n^n \left[ x^{n-1} \left\{ {}_n C_1 \left( x - \frac{1}{n} \right)^{n-1} + {}_n C_2 \left( x - \frac{2}{n} \right)^{n-1} + {}_n C_3 \left( x - \frac{3}{n} \right)^{n-1} \right\} \right] dx \quad (F)$$

As in the previous cases (F) can be shown to be equal to

$${}_n C_3 \cdot (4) - {}_n C_2 \cdot n \cdot (3) + {}_n C_1 \cdot n \cdot {}_n C_2 \cdot (2) - {}_n C_0 \cdot n \cdot {}_n C_3 \cdot (1),$$

where (4), (3), (2) and (1) refer to (B).

The above argument can be extended to the case of  $x$  lying in the interval  $\frac{p}{n}$  and  $\frac{p+1}{n}$ ,  $p$  being  $> n$ . The number of combinations having  $p$  observations  $> 1$  to be subtracted from the distribution for the interval  $\frac{p-1}{n}$  and  $\frac{p}{n}$  is

$${}_n C_p - {}_n C_1 \cdot n \cdot {}_n C_{p-1} + {}_n C_2 \cdot n \cdot n \cdot {}_n C_{p-2} - \dots + (-1)^{p-1} {}_n C_{p-1} \cdot n \cdot (n-p).$$

This is equal to  $(-1)^p$  or  $-{}_n C_p$  according as  $p$  is odd or even. Hence the distribution for the interval  $\frac{p}{n}$  and  $\frac{p+1}{n}$  is obtained by subtracting  $(-1)^{p-1} {}_n C_p$  times the distribution of  $x$  modes having  $p$  observations  $> 1$  from the distribution for the preceding interval.

In general the distribution of  $x$  for the interval  $\frac{p}{n}$  to  $\frac{p+1}{n}$  is also given by

$${}_n C_p \cdot (p+1) - {}_n C_{p-1} \cdot n \cdot {}_n C_1 \cdot (p) + {}_n C_{p-2} \cdot n \cdot n \cdot {}_n C_2 \cdot (p-1) - \dots + (-1)^{p-1} {}_n C_{p-1} \cdot n \cdot {}_n C_p \cdot (1),$$

where  $(p+1)$ ,  $(p)$ ,  $\dots$ ,  $(1)$  refer to the integrals given in (B).

The above method of approach will lead to the distribution of the means of Type II and I curves which will be useful in getting the distribution of the mean of  $Y = \left( 1 + \frac{T^2}{N-1} \right)$ , where  $T^2$  refers to Hotelling's<sup>2</sup>  $T^2$ . As the actual expressions for the distribution of  $y$  are complicated they will be dealt with in another communication.

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Imperial Agricultural  
Research Institute,  
New Delhi, July 12, 1944.

1. Irwin, J. O., *Biometrika*, 1927, **19**, 223. 2. Hotelling, H., *Annals of Math. Stat.*, 1931, **2**, 360.

### NEW BANDS OF THE Hg Br MOLECULE

In the course of a reinvestigation of the band systems of the HgBr molecule, in order to bring them into conformity with those of HgCl, the authors have obtained a new band system in the region  $\lambda 2470$ - $\lambda 2430$ , consisting of diffuse and headless bands. About thirty

bands could be measured and assigned to the three sequences (0,1), (0,0) and (1,0). The intensity distribution gives a narrow Condon Parabola. The following vibrational constants have been determined:

$$r_e = 40720 \quad w_e' = 166.0 \quad w_e'' = 183.0 \\ x_e' w_e' = 1.1 \quad x_e'' w_e'' = 2.0$$

The final state of this system appears to be the same as the final state of the class I system of the HgBr bands, studied previously by Wieland<sup>1</sup> and by Sastry.<sup>2</sup> Full details will be published shortly.

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Andhra University,

Guntur,

November 20, 1944.

1. Wieland *Helv. Acta. Phys.*, 1929, **2**, 46 and 77.  
2. Sastry, *Nat. Inst. Sci. Int. Proc.*, 1941, **7**, 353.

### MAGNETISM OF GERMANIUM

From several points of view, germanium is an interesting element. It crystallizes in the diamond structure. But in electrical properties, it behaves like a semiconductor. Unlike diamond, germanium is soft and has a metallic lustre. One would expect these properties to be reflected in the magnetic behaviour of germanium.

This element has been studied by Owen (1912) who obtained  $\chi = 0.12^p$  as its specific susceptibility. A redetermination of the susceptibility seemed desirable since a sample of Hilger's spectroscopic brand was available. Curie's method was adopted, using water as the standard. The element showed a trace of ferromagnetic impurity, for which due correction was made. The average specific susceptibility obtained with two pieces was found to be  $\chi = 0.147$ . This gives for the atomic susceptibility the value  $\chi = 10.7$ .

Diamond, silicon, germanium and grey tin belong to the same class of elements from the point of view of crystal chemistry. It is obvious, however, that germanium stands unique on account of some of its properties being absent in the other cases.

A calculation of the atomic susceptibility of germanium on the basis of Slater's method, as modified by Angus (1932) gives  $\chi = 40.9$ . On the same basis, the ionic susceptibility of  $Ge^{+4}$  (which is in  $^1S_0$  state) works to  $\chi = 16.8$  while the experimental value for the metal is  $\chi = 10.7$ . These results suggest that the metal contains  $Ge^{+4}$  ions, with the two  $4p$  electrons showing evidence of both valence characteristics and metallic bond. That the valence characteristics are predominant and the metallic bond subdued are apparent from the following facts.

Owen (1912) found that when the element is melted, there is a large rise in the diamagnetic susceptibility. In the case of covalent or hemipolar combination, the increase of diamagnetism is accompanied by a link depression. On melting, this depression should partly vanish and the valence electrons would evince a larger diamagnetism.

I am indebted to Dr. K. Rangadhama Rao for the specimen of germanium.  
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Bangalore.  
January 10, 1945.

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\* All susceptibility values are given in  $10^{-6}$  unit.  
(*Ann. der Phys.*, 1912, 37, 657. *Angus, Proc. Roy. Soc.* 1932, 136, 569.)

#### A NEW METHOD OF DESIGNING PACKED COLUMNS

PACKED columns have been designed using almost exclusively overall transfer coefficients and overall H.T.U.s rather than individual film coefficients and individual H.T.U.s. Since the overall transfer coefficients and overall H.T.U.s are defined (for distillation) as follows:—

$$\frac{1}{K_G a} = \frac{1}{k_G a} + \frac{m}{k_L a}$$

$$\frac{1}{K_L a} = \frac{1}{k_L a} + \frac{1}{m k_G a}$$

$$H.T.U_{OG} = H.T.U_G + H.T.U_L \frac{mG}{L}$$

$$H.T.U_{OL} = H.T.U_L + H.T.U_G \frac{L}{mG}$$

where  $G$  = the rate of flow of the vapours in  
 $\frac{\text{lb. moles}}{\text{hr.} \times \text{sq. ft.}}$

$L$  = the rate of flow of the overflow in  
 $\frac{\text{lb. moles}}{\text{hr.} \times \text{sq. ft.}}$

$m$  = the slope of the equilibrium curve. their use for design purposes can only be justified when they are constant. For example this happens to be so (1) when the resistance of one of the films predominates over that of the other, so that the resistance of the second can be neglected, (2) when the value of " $m$ " remains constant. When both the films are controlling, and the vapour-liquid equilibrium curve is not a straight line, then  $K_G a$ ,  $K_L a$ ,  $H.T.U_{OG}$  &  $H.T.U_{OL}$  are functions of the slope  $m$ ; and since  $m$  is a variable they cannot be used for design purposes. They are, nevertheless, used (incorrectly) as no alternative method of approach has been presented to the Chemical Engineer.

If the reasonable assumption be made that the slope of the equilibrium curve is constant over small distances:—

$$m = \frac{dy_i}{dx_i} = \frac{dy^*}{dx^*} = \frac{dy}{dx}$$

where  $y_i$  and  $x_i$  are the interfacial compositions in any differential section of a packed column.

$y^*$  is the composition of the vapour in equilibrium with liquid of composition  $x$  present in the differential section.

$x^*$  is the composition of the liquid in equilibrium with vapour of composition  $y$  present in the same section

then equations can be derived by means of which the height of any packed column can be computed:—

$$h = \frac{G}{k_G a} \int_{y_F}^{y_D} \frac{dy}{(y^* - y)} + \frac{L}{k_L a} \int_{y_F^*}^{y_D^*} \frac{dy^*}{(y^* - y)} \quad (1)$$

$\leftarrow N_{G_1} \rightarrow$                        $\leftarrow N_{G_2} \rightarrow$

$$h = \frac{G}{k_G a} \int_{x_F}^{x_D} \frac{dx}{(x - x^*)} + \frac{L}{k_L a} \int_{x_F^*}^{x_D^*} \frac{dx^*}{(x - x^*)} \quad (2)$$

$\leftarrow N_{L_1} \rightarrow$                        $\leftarrow N_{L_2} \rightarrow$

The integrals  $N_{G_1}$ ,  $N_{G_2}$ ,  $N_{L_1}$  &  $N_{L_2}$  can be evaluated graphically. However, if both  $k_G a$  &  $k_L a$  are unknown, the height can be expressed either in terms of  $k_G a$  or  $k_L a$ . This is done by solving the above as simultaneous equations.

$$h = \frac{G}{k_G a} \left[ \frac{N_{G_1} N_{L_1} - N_{G_2} N_{L_2}}{N_{L_1} - N_{G_2}} \right]$$

$$= \frac{L}{k_L a} \left[ \frac{N_{G_1} N_{L_1} - N_{G_2} N_{L_2}}{N_{G_1} - N_{L_2}} \right] \quad (3)$$

Full details of the derivation and applications of the above equations will be published elsewhere.

My thanks are due to Dr. M. A. Govinda Rau, at present Reader in the Alagappa Chettiar College of Technology, University of Madras, for the help that he has given me in this investigation.

Chemical Engineering Section,  
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November 29, 1944.

J. SIMON.

#### A NEW ANTI-SNAKE-VENOM SERUM

THE anti-snake-venom serum in use in India at present is effective only against the venoms of cobra and Russell's viper. Lamb (1903, 1904, 1905) when he prepared this bivalent serum showed that it did not neutralise the venoms of any snakes other than the two (cobra and Russell's viper) against which it was prepared. The only improvement introduced in recent years has been the concentration of the anti-snake-venom serum (Maitra *et al.*, 1933, and Greval, 1934). Thus we have lacked a remedy against the bite of krait and the saw-scaled viper—two snakes as common as cobra and Russell's viper.

We have been working on the preparation of a polyvalent anti-snake-venom serum which would be effective against the poison of all the four common poisonous snakes of India—cobra, Russell's viper, common krait, and saw-scaled viper. In this we have succeeded and have taken up its manufacture at the Haffkine Institute.

We have also worked out a method for assaying our polyvalent anti-snake-venom serum on the lines of Ipsen's method (1938) sponsored by the League of Nations Permanent Commission on Biological Standardisation. We have assayed four batches of our polyvalent serum and find that 1 ml. of our serum neutralises not less than the following quantities of dried venoms, when the serum along with the venom is injected intravenously into white mice: cobra 0.6 mg.; common krait 0.45 mg.; Russell's viper 0.6 mg.; and saw-scaled viper 0.45 mg.

We are arranging to issue our polyvalent serum in lyophilised form, i.e., preserved by drying from the frozen state. In this form the serum does not require to be stored in a refrigerator. It may be stored in any cool dark place and may even be carried in a haversack