Paris, 1846. ⁹ Loc. cit., Section III, p. 290. ¹⁰ *Med. Chir. Trans.* ¹¹ Loc. cit., p. 30. ¹² *Anatomy for Artists.* ¹³ *Anatomy for Art Students*, by Professor Arthur Thomson, 2nd edition, 1899, pp. 37, 121. ¹⁴ *Topographische Anatomie*, Zweiter Band, 1895, p. 185. ¹⁵ *Curvature of the Spine*, 2nd edition, p. 41. ¹⁶ *Anatomie Artistique*, 1890. ¹⁷ Loc. cit., p. 171. ¹⁸ Loc. cit., Part VII, Book I, p. 339. ¹⁹ BRITISH MEDICAL JOURNAL, March 5th, 1892. ²⁰ BRITISH MEDICAL JOURNAL, March 5th, 1892.

THE RAPID ESTIMATION OF THE QUANTITY OF CHLOROFORM VAPOUR PRESENT IN MIXTURES OF CHLOROFORM VAPOUR AND AIR.

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A METHOD for the rapid estimation of CHCl_3 vapour in mixtures of CHCl_3 and air by means of the alteration of pressure produced by absorption of the CHCl_3 vapour by olive oil is described in the BRITISH MEDICAL JOURNAL of July 12th, 1902, and was demonstrated last July to the Physiological Society.¹

It was then stated that the method is applicable to mixtures of chloroform and air between 2 and 10 per 100, and the statement was confirmed by Professor Dunstan for amounts between 3 and 12 per 100.²

The original purpose of the present observations was to test the method for mixtures below 2 per 100. The actual determinations have been made in this laboratory by Dr. Victor Geets, of Brussels, who has, in prosecuting the inquiry, adopted a very simple method of control, which is in itself a very satisfactory laboratory method for the quantitative estimation of the percentage of chloroform vapour in a mixture of chloroform and air.

This method consists in the direct weighing on a chemical balance of a flask of known capacity (*circa* 500 c.cm.), (a) filled with air, (b) filled with the mixture of chloroform and air.

The adequacy of this datum as regards an estimation of percentage will be made clear by the following considerations: 500 c.cm. of a 1 to 10 per 100 mixture of chloroform and air implies 5 to 50 c.cm. of CHCl_3 vapour, weighing (on the assumption that 1 gram of liquid CHCl_3 = 200 c.cm. CHCl_3 vapour) 25 to 250 mg. *minus* the weight of the volume of air displaced by the CHCl_3 vapour.

The weight of a litre of CHCl_3 vapour at 0° C.

$$= \frac{12 + 1 + 106}{2} \times 0.0895 = 5.325 \text{ grams.}$$

Ditto, of a litre of air = 1.293 grams.

So that a litre of chloroform vapour is 4.032 grams heavier than a litre of air. Or each c.cm. of chloroform vapour replacing 1 c.cm. of air gives an increased weight of 4.032 mg.

Taking, then, 4 mg. as the additional weight due to the presence of each 1 c.cm. CHCl_3 in the mixture of air and chloroform (corrections for temperature and pressure not included), we have: In a 500 c.cm. flask each 1 per cent. (= 5 c.cm.) giving an increment of 0.020 gram.; and in a 250 c.cm. flask each 1 per cent. (= 2.5 c.cm.) giving an increment of 0.010 gram.

For practical purposes we can avoid calculation and estimate the percentage of CHCl_3 vapour by a direct reading of the difference of weight of a 250 c.cm. flask, (a) filled with air, (b) filled with the mixture of chloroform and air to be titrated. The excess of the latter, counted in centigrams, gives the percentage of the mixture:

Thus, an excess of 0.010 gram = 1.0 per 100

" " 0.050 " = 5.0 "

" " 0.027 " = 2.7 "

The weighing is easily made within the error of ± 1 mg., equivalent to an absolute error of $\pm \frac{1}{10}$ of 1 per cent., and to a relative error of ± 10 per cent. to ± 2 per cent. for absolute percentages between 1 and 5.

Both the manometric and the gravimetric methods are rapid and mutually control each other, giving estimates in reliable steps of at least 0.1 per cent. The manometric estimate is adapted to hospital use in the absence of a chemical balance; the gravimetric method is more rapid and more exact.

The chief practical advantages of a rapid method of estimating chloroform in air differ according as the chloroform question is viewed from the experimental or from the clinical standpoint. Experimentally it is important to possess a ready

means of frequently gauging the percentage of chloroform administered and exhaled. Clinically it is important to possess a ready means of familiarizing students with the smell of mixtures of known percentage. It is an easy matter for a laboratory expert to distinguish by smell whether there is more or less than 1 or 2 per 100 of chloroform vapour in a given atmosphere. Until it is possible to rapidly verify the percentage and to offer to inhalation by his students mixtures of known percentage, even the most experienced teacher of anaesthetics is not entitled to use clear arithmetical language, and to say that chloroform for the safe induction of anaesthesia in ordinary cases should be maintained between the limits of 1 and 2 per 100. But with a rapid method of estimation at hand, this all-important fact can be taught by smell, which after all is, and must remain, the most valuable indicator immediately at command of the practical anaesthetist.

The following table gives the comparative results of a preliminary series of parallel estimates by oil-absorption and by weighing:

Weight Readings and Calculations by Dr. Geets. Manometer Readings by Mr. Shapiro.

Percentage by Manometer.	Percentage by Weight.	Percentage by Manometer.	Percentage by Weight.
5.20	5.95	1.50	1.49
4.50	5.08	1.50	1.49
4.50	4.96	1.50	1.49
3.50	3.72	1.50	1.49
3.50	3.72	1.50	1.44
2.00	3.47	1.50	1.44
2.85	3.10	1.50	1.39
2.80	2.98	1.60	1.36
2.80	2.98	1.50	1.36
2.80	2.73	1.50	1.34
2.15	2.48	—	1.30
2.30	2.28	1.60	1.30
2.60	2.11	1.60	1.30
2.00	2.08	1.45	1.29
2.00	1.98	1.45	1.26
1.50	1.86	1.48	1.12
1.50	1.61	1.30	1.12
1.50	1.59	1.30	0.99
1.50	1.54	—	—

The individual discrepancies in the two series of this table are such as might be expected from experimental errors occurring in a first trial of two new methods by two independent observers. The error has been relatively more considerable at the lower percentages (below 2 per cent.) but is also considerable at the higher percentages. It is more probably attributable to imperfect graduation of the manometer than to incorrect weighing. To determine this point will, however, require further observations.

Corrections for temperature and pressure are of secondary importance in determinations of the present character. The temperature error for $+15^\circ$ is within $\frac{1}{2}\%$ of the nominal percentage, and can be practically eliminated by taking flasks = 260 c.cm capacity, that is, the usual 250 c.cm. flask + 10 c.cm. of its neck above the mark.

The usual corrections for T and H are, however, readily made, in accordance with the following formula, applicable to any flask capacity:

$$\log P = 1.8391 + \log m - \log v + \log T - \log H$$

P being the required percentage, m the observed increment of weight in mgs., v the flask capacity in c.cms., T the absolute temperature, H the barometric pressure, and 1.8391 a constant derived from the density of chloroform vapour at 0° (273° T) and 760 mm. Hg.

REFERENCES.

¹ *Proceedings*, 1902, p. 35. ² BRITISH MEDICAL JOURNAL, July 12th, 1902.

THE PHYSIOLOGICAL ACTION OF ETHYL BROMIDE AND OF SOMNOFORM.

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THE object of the experiments described below was the investigation of a new anaesthetic sold commercially under the name of "somnoform." This is a mixture containing ethyl chloride 65 per cent., methyl chloride 30 per cent., ethyl bromide 5 per cent. It has been largely used in France for producing anaesthesia for minor operations, and the