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PHYSICS

PRACTICAL EXPERIMENTS

3th. Feb. '64. TO VERIFY CHARLES' LAW ; TO CALCULATE COEFF. EXPANSION OF AIR.

APPARATUS: Apparatus shown in diagram with concentrated sulphuric acid in the tube with an enclosed space of air above it; mercury thermometer (c. 0°–100°c.); stand; bunsen; stirrer

METHOD: The level of the sulphuric acid in the apparatus is adjusted to the top of the scale so that room is left for the air in the apparatus to expand. Mercury may be used in this experiment byt it is most important that the air should be dried before-hand. Due to its affinity for water, the concentrated acid acts automatically to dry the air.

Now heat the apparatus, stirring vigourously, and fixing the thermometer so that the bulb is touching the enclosed space of air in the vessel. Slow heating is better, for it achieves a more evenly distributed heat throughout the apparatus.

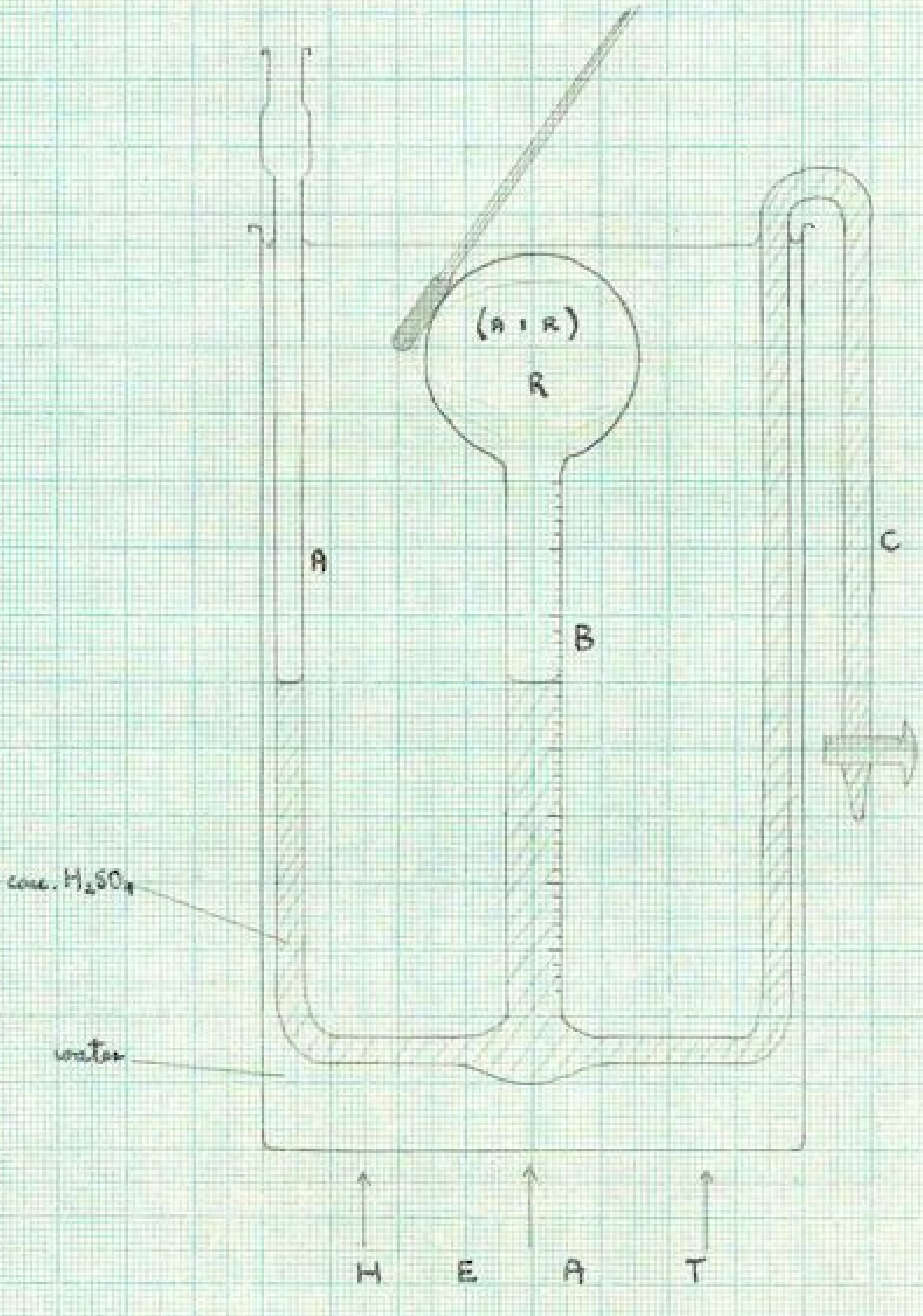
Now record the volume of air in the apparatus about every 3 or 4°c. Continue reading values for V and T until a satisfactory number of readings has been reached.

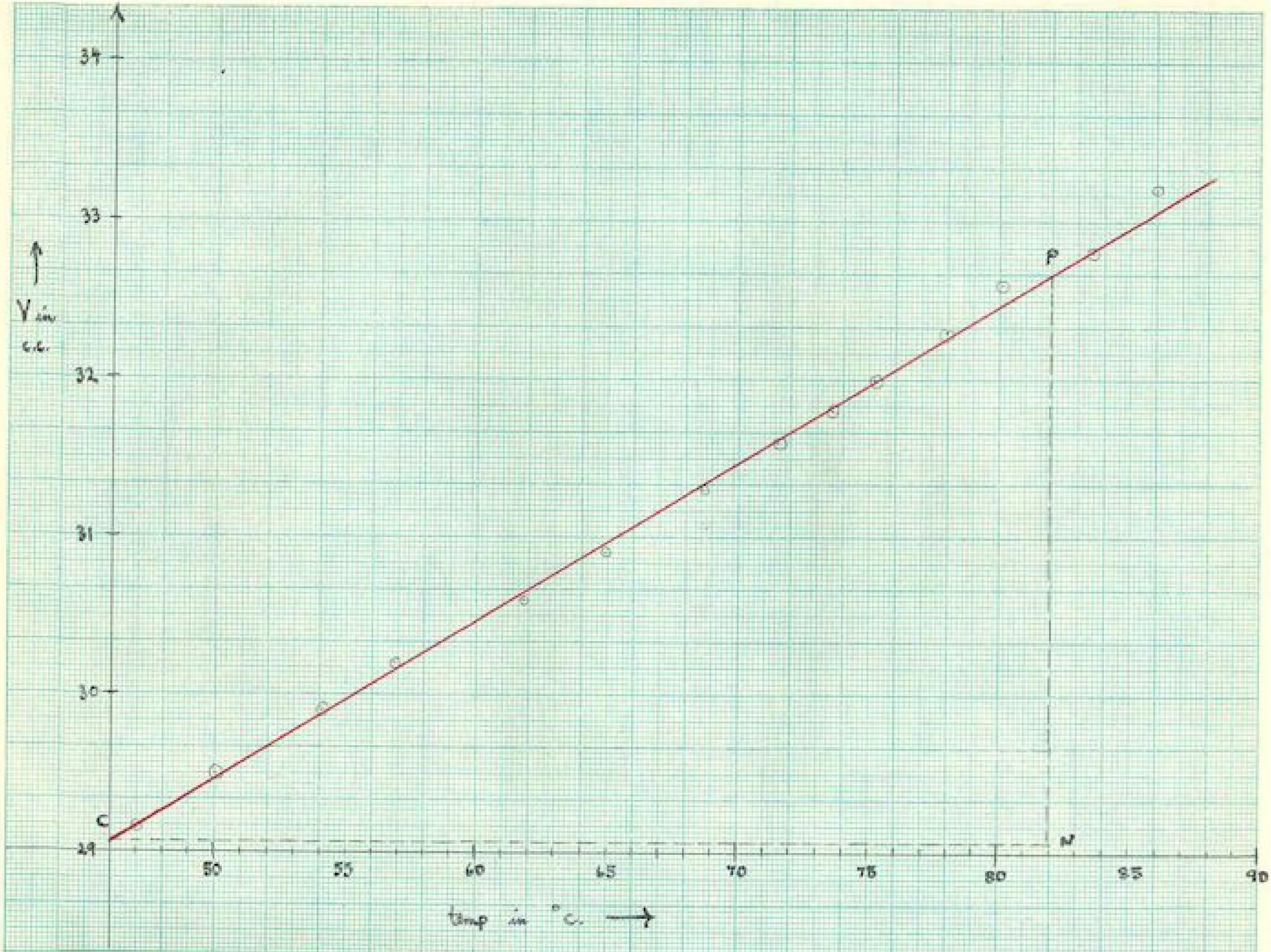
If desired, the temperatures and volumes can be noted as the temperature now falls, although this is a slow method. If this is done, the average of the two results is taken.

If a wider range of results is desired, ice is packed around the air tube and then lower temperatures can be noted.

Charles's Law only applies at constant Pressure, so before each reading the ~~mercury~~ sulphuric acid levels in A and B are at the same level, by running out the acid through the tap in tube C. This brings the pressure in R to atmospheric pressure.

Verification of Charles's Law





Y in c.c.
34
33
32
31
30
29
C
P
N
50
55
60
65
70
75
80
85
90
temp in °C.

RESULTS:

Volume in c.c.	Temp. in °c.	Volume in c.c	Temp. in °c.
29·15 c.c.	47·0 °c.	31·6 c.c.	71·5 °c.
29·5	50·0	31·8	73·6
29·9	54·1	32·0	75·2
30·2	56·9	32·3	78·0
30·6	61·8	32·6	80·1
30·9	64·9	32·8	83·6 ~~83·35~~
31·3	68·7	33·2	86·0

If therefore values of V as ordinates are plotted against values of T as abscissae, and a straight line results, this verifies Charles's Law:-
i.e. at Constant Pressure, Volume $\propto$ Temperature.

To find the Coefficient of Expansion of Air at Constant Pressure, Select a pt. P on the line and let C be the point where the line cuts the axis of volume. Let O be true origin of co-ordinates.

The Coefficient, α, is defined as the fractional increase of the volume at 0°c. per °c. rise in temp.

$\therefore$ If V is the volume at θ°c., and V_0 the volume at 0°c.

$$\therefore \alpha = \frac{V - V_0}{V_0 . \theta} = \frac{3.6}{17.\ 29\frac{1}{5}} = 0.003643 = \frac{1}{274.57}$$

$\therefore$ Coefficient of expansion of air $= \frac{1}{274.6}$ per °c.

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<u>$= 0.003643$ per °c.</u>

7th. May. '64

THE SURFACE TENSION OF A SOAP-FILM.

APPARATUS: Pieces of bent copper wire, as in diagram (a); Soap solution; Beaker; wooden stand; thin cotton thread; callipers.

METHOD: Construct the apparatus shown in (a) with the cotton and two bent pieces of copper wire. Dip the apparatus in soap solution so that a film ACDF is formed. Suspend this carefully and burst the two other soap films ABC and DEF. Wipe the outer edge of the cotton thread with blotting paper and adjust the frame so that the film is symmetrical.

Now, with callipers measure the smallest diameter of the film, GH; let this be 2b. Similarly measure AC (2a cms.) and CD (2h cms.). The bottom half DEF is now removed and weighed, while it is still wet; let this be m_1 gms.

For greater accuracy, the experiment is repeated with larger weights, in the form of copper wire, suspended from DEF. Let the total of these further weights be m_2, m_3 gms. etc.

RESULTS:

	2a	2b	2h	a	b	h	(a+b)	(a−b)	h^2	m gms
①	2·75	2·2	4·45	1·375	1·1	2·225	2·475	0·275	4·95	0·97
②	2·75	2·5	4·50	1·375	1·25	2·25	2·625	0·125	5·063	1·71
③	2·75	2·65	4·55	1·375	1·325	2·275	2·700	0·05	5·175	4·34

① $T = \dfrac{9{\cdot}7 \times 98{\cdot}1}{2\left(2{\cdot}475 + \dfrac{4{\cdot}95}{0{\cdot}275}\right)} = 23{\cdot}25$ dynes/cm.

② $T = \dfrac{17{\cdot}1 \times 98{\cdot}1}{2\left(2{\cdot}625 + \dfrac{5{\cdot}063}{0{\cdot}125}\right)} = 19{\cdot}45$ dynes/cms.

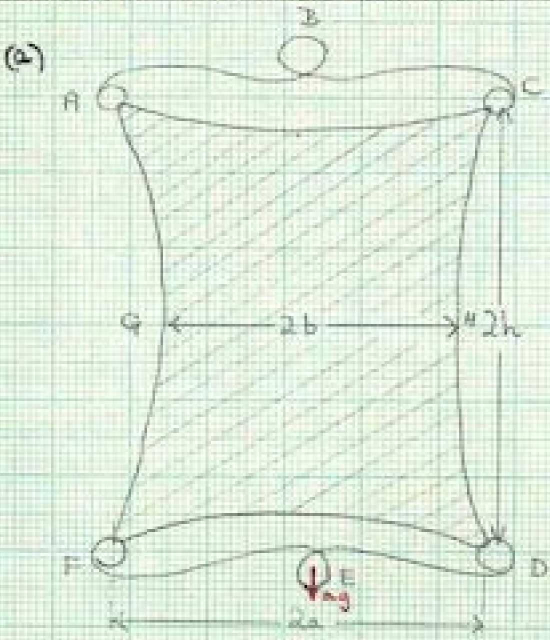
③ $T = \dfrac{43{\cdot}4 \times 98{\cdot}1}{2\left(2{\cdot}7 + \dfrac{5{\cdot}175}{0{\cdot}05}\right)} = 20{\cdot}05$ dynes/cm.

} 20·917 dynes/cm.

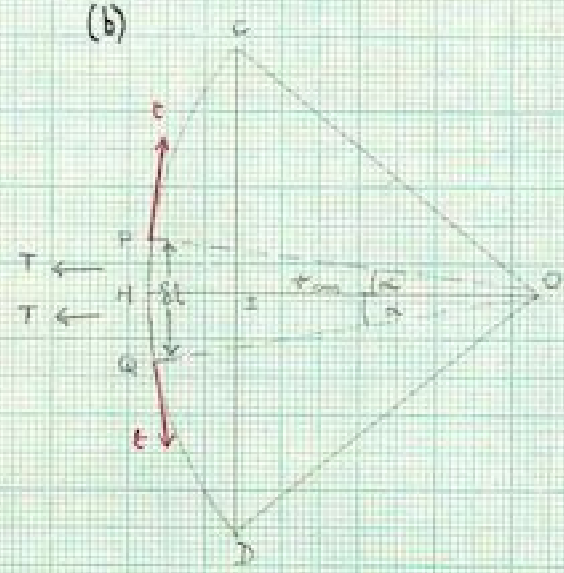
∴ Surface Tension of Soap Film at 17°C = 20·9 dynes/cm.

SURFACE TENSION OF SOAP-FILM

(a)



(b)



THEORY: Let the vertical sides of the thread be pulled into arcs of radius of curvature r cms. Let the tension in the thread be t dynes and the Surface Tension of the Soap Film T.

Thus, Resolving horizontally for PQ : $2T.\delta l = 2t.\sin\alpha$

But as α is small, $2T\,\delta l = 2t\,\frac{\delta l}{2r}$ $\quad\therefore\ t = 2Tr$ ...... (1)

Now, considering equilibrium of film at GH:

Forces producing rupture = mg downwards

Forces preventing rupture = $2t + (2T\times 2b)$ upwards

$\therefore\ mg = 2t + 4T.b$ ..... (2)

From (1) and (2) $\quad 2Tr = \frac{1}{2}(mg - 4Tb) \quad \therefore\ mg = 4T(b+r)$

$\therefore\ T = \dfrac{mg}{4(r+b)}$ .... (3)

Now by Pure Geometry $\quad CI.ID = I.H\,(2r - HI)$

i.e. $\quad h^2 = (a-b)(2r - \overline{a-b})$

$\therefore\ 2r = \dfrac{h^2}{(a-b)} + (a-b) \quad \therefore\ r = \dfrac{h^2 + (a-b)^2}{2(a-b)}$ .... (4)

From (3) and (4) $\quad T = \dfrac{mg}{4\left(\frac{h^2+(a^2-b^2)^2}{2(a-b)} + b\right)} = \dfrac{mg}{2\left(\frac{h^2}{a-b} + (a-b) + 2b\right)}$

$\therefore$ <u>Surface Tension of Soap Film</u> $= \dfrac{mg}{2\left(\frac{h^2}{a-b} + (a+b)\right)}$ dynes/cm.