

XXI. *An Account of some Experiments on the Loss of Weight in Bodies on being melted or heated. In a Letter from George Fordyce, M.D. F.R.S. to Sir Joseph Banks, Bart. P.R.S.*

Read April 28, 1785.

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**A**LTHOUGH I have made many experiments on the subject of the loss of weight in bodies on being melted, or heated, I do not think it worth while to lay them all before the Society, as there has not appeared any circumstance of contradiction in them. I shall content myself with relating the following one, which appears to me conclusive in determining the loss of weight in ice when thawed into water, and subject to the least fallacy of any I have hitherto made, in shewing the loss of weight in ice on being heated.

The beam I made use of was so adjusted as that, with a weight between four and five ounces in each scale,  $\frac{1}{1000}$  part of a grain made a difference of one division on the index. It was placed in a room, the heat of which was 37 degrees of FAHRENHEIT's thermometer, between one and two in the afternoon, and left till the whole apparatus and the brass weights acquired the same temperature.

A glass globe, of three inches diameter nearly, with an indentation at the bottom, and a tube at the top, weighing about 451 grains, had about 1700 grains of *New-River* water poured into it, and was hermetically sealed, so that the

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whole,

whole, when perfectly clean, weighed  $2150\frac{1}{4}$  of a grain exactly; the heat being brought to 32 degrees, by placing it in a cooling mixture of salt and ice till it just began to freeze, and shaking the whole together.

After it was weighed it was again put into the freezing mixture, and let stand for about twenty minutes; it was then taken out of the mixture; part of the water was found to be frozen; and it was carefully wiped, first with a dry linen cloth, and afterwards with dry washed leather; and on putting it into the scale it was found to have gained about the  $\frac{1}{60}$  part of a grain. This was repeated five times: at each time more of the water was frozen, and more weight gained. In the mean time the heat of the room and apparatus had sunk to the freezing point.

When the whole was frozen, it was carefully wiped and weighed, and found to have gained  $\frac{3}{16}$  of a grain and four divisions of the index. Upon standing in the scale for about a minute, I found it began to lose weight, on which I immediately took it out, and placed it at a distance from the beam. I also immediately plunged a thermometer in the freezing mixture, and found the temperature 10 degrees; and on putting the ball of the thermometer in the hollow at the bottom of the glass vessel, it shewed 12 degrees. I left the whole for half an hour, and found the thermometer, applied to the hollow of the glass, at 32°. Every thing now being at the same temperature, I weighed the glass containing the ice, after wiping it carefully, and found it had lost  $\frac{1}{8}$  and five divisions; so that it weighed  $\frac{1}{6}$ , all but one division, more than when the water was fluid.

I now melted the ice, excepting a very small quantity, and left the glass vessel exposed to the air in the temperature of 32 degrees.

degrees for a quarter of an hour ; the little bit of ice continued nearly the same. I now weighed it, after carefully wiping the glass, and found it heavier than the water was at first one division of the beam. Lastly, I took out the weights, and found the beam exactly balanced as before the experiment.

The acquisition of weight found on water's being converted into ice, may arise from an increase of the attraction of gravitation of the matter of the water ; or from some substance imbibed through the glass, which is necessary to render the water solid.

Which of these positions is true may be determined, by forming a pendulum of water, and another of ice, of the same length, and in every other respect similar, and making them swing equal arcs. If they mark equal times, then certainly there is some matter added to the water. If the pendulum of ice is quicker in its vibrations, then the attraction of gravitation is increased. For there is no position more certain, than that a single particle of inanimate matter is perfectly incapable of putting itself in motion, or bringing itself to rest ; and therefore, that a certain force applied to any mass of matter, so as to give it a certain velocity, will give half the quantity of matter double the velocity, and twice the quantity, half the velocity ; and, generally, a velocity exactly in the inverse proportion to the quantity of matter. Now, if there be the same quantity of matter in water as there is in ice, and if the force of gravity in water be  $\frac{1}{28000}$  part less than in ice, and the pendulum of ice swing seconds, the pendulum of water will lose  $\frac{1}{28000}$  of a second in each vibration, or one second in 28000, which is almost three seconds a day, a quantity easily measured.

I shall just take notice of an opinion which has been adopted by some, that there is matter absolutely light, or which repels instead of attracting other matter. I confess this appears absurd to me; but the following experiment would prove or disprove it. Supposing, for instance, that heat was a body, and absolutely light, and that ice gained weight by losing heat; then a pendulum of ice would swing through the same arc in  $\frac{1}{1000}$  less time than a similar pendulum of water; for the same power would not only act upon a less quantity of matter, but a counter-acting force would also be taken away.

Till the experiment of the pendulum can be made, or some other equally certain be suggested and made, it would be wasting time to enter into conjecture about the cause of the gain of weight in the conversion of water into ice in a glass vessel hermetically sealed.

I shall only observe, that heat certainly diminishes the attractions of cohesion, chemistry, magnetism, and electricity; and if it should also turn out, that it diminishes the attraction of gravitation, I should not hesitate to consider heat as the quality of diminution of attraction, which would in that case account for all its effects.

We come, in the next place, to take notice of the second part of the experiment, *viz.* that the ice gained an eighth part of a grain on being cooled to 12 degrees of FAHRENHEIT'S thermometer. In this case, a variation may arise from the contraction of the glass vessel, and consequent increase of specific gravity in proportion to the air. But it is unnecessary to observe, that this would be so very small a quantity as not to be observable upon a beam adjusted only to the degree of sensibility with which this experiment was tried. In the second place, the air cooled by the ice above the scale becoming heavier than

the surrounding atmosphere, would press upon the scale downward with the whole force of the difference. If a little more than half a pint of air was cooled over the scale to the heat of the ice and glass containing it, that is, twenty degrees below the freezing point, the difference, according to General Roy's table, would have been the eighth part of a grain, which was the weight acquired; but the air within half an inch of the glass vessel being only one degree below the freezing point, I cannot conceive, that even an eighth part of a pint of air could be cooled over the scale to twenty degrees below the freezing point; nor that the whole difference of the weight of the air over the scale could ever amount to the 32d of a grain. I have, however, contrived an apparatus which is executing, in which this cause of fallacy will be totally removed. I shall, therefore, rest at present the state of this part of the subject; and leave it only proved, that water gains weight on being frozen.

I am, &c.

G. FORDYCE.

