

SCIENCE DEPARTMENT.

CHEMICAL PROBLEMS WITH SOLUTIONS,

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I.—PROBLEMS RELATING TO GASEOUS VOLUMES.

1. A certain quantity of hydrogen at normal temperature ($0^{\circ}\text{C}.$), and pressure (760 m.m.) measures 50 c.c. What will be its volume at a temperature of $15^{\circ}\text{C}.$, and pressure of 780 m.m.?

Solution.—The law according to which gases alter their volume with changes of temperature may be thus expressed: "A gas expands $\frac{1}{273}$ of its volume at $0^{\circ}\text{C}.$ for each increment of $1^{\circ}\text{C}.$ of heat." Boyle's law referring to alterations in the volumes of gases with changes of pressure upon them, is stated as follows: "The volume of a gas varies inversely as the pressure upon it." Now, if the gas measures 50 c.c. at $0^{\circ}\text{C}.$, at 15° it will measure $50 + \frac{1}{273}$ of 50; and if it measures 50 c.c. under a pressure of 760 m.m., then its volume under a pressure of 780 m.m. bears to 50 c.c. the ratio of 760 to 780. Uniting both these in one fraction we get as the expression of the required volume $\frac{50}{1} \times \frac{760}{780} \times \frac{273}{273}$. This fraction worked out gives as the required volume 51.39 c.c.

2. A certain quantity of hydrogen at a temperature of $15^{\circ}\text{C}.$ and a barometric pressure of 750 m.m. measures 50 c.c. What would be its volume at normal pressure and temperature?

Solution.—50 c.c. is equal to its zero-volume plus $\frac{1}{273}$ of that volume; and its volume at 760 m.m. pressure bears to 50 c.c. the ratio of 750 to 760. The fraction then becomes $\frac{50}{1} \times \frac{760}{750} \times \frac{273}{273}$, which, worked out, gives as the required volume 46.77 c.c.

3. A glass globe, having a capacity of 2 litres, is filled with oxygen under a pressure of 879 m.m. of mercury, and at a temperature of $20^{\circ}\text{C}.$ How much will escape when

the pressure is increased to 894 m.m. and the temperature to $25^{\circ}\text{C}.$?

Solution.—First reduce the volume to standard pressure and temperament, the expression for which will be $\frac{2}{1} \times \frac{879}{894} \times \frac{273}{273}$. Then find out what the volume would be at a temperature of $25^{\circ}\text{C}.$ and pressure of 894 m.m., thus, $\frac{2}{1} \times \frac{879}{894} \times \frac{273}{273} \times \frac{273}{273} \times \frac{894}{894}$. This fraction gives as a result 2. Therefore the volume at the increased temperature and pressure is just the same as at first, and so none would escape, the increase in volume from the rise of temperature being exactly counterbalanced by the diminution owing to increased pressure.

4. A gas measures 1 litre at $100^{\circ}\text{C}.$ and under a barometric pressure of 740 m.m. At what temperature will it measure 1.5 litres when the pressure rises to 760 m.m.?

Solution.—First find its volume at standard temperature and pressure,

$$\frac{1}{1} \times \frac{740}{760} \times \frac{273}{273} = .7479.$$

Now, as a litre contains 1,000 c.c., the volume at standard temperature and pressure will be 747.9 c.c. The difference between 1,500 c.c. (= 1.5 litres) and 747.9 c.c. = 752.1 c.c. = the amount of increase there must be. The pressure being 760 m.m. in both cases may be disregarded. Then the amount of increase is $\frac{752.1}{747.9}$ of the volume at $0^{\circ}\text{C}.$ A rise of 1° will increase it $\frac{1}{273}$; a rise of 273° will increase it 1; a rise of $273 \times \frac{752.1}{747.9}$ will increase it $\frac{752.1}{747.9}$.

$$\frac{273 \times 752.1}{747.9} = 274.5.$$

Therefore the required temp. is $274.5^{\circ}\text{C}.$

Will some reader send solution to the following question?—

5. The observed volume of a dried gas, measured in a tube over mercury, was 48 c.c.; the height of the mercury in the tube above that in the trough was 20 m.m.; the barometer stood at 754 m.m.; and the temperature of the room was $16^{\circ}\text{C}.$ Reduce the observed volume of the gas to standard pressure and temperature.