

ature a gas expands  $\frac{1}{273}$  of the volume it occupies at  $0^\circ$ . That is if a gas at  $0^\circ$  C occupies 273 volume, at  $1^\circ$ , it occupies  $273 + \frac{1}{273}$  of 273 or 274 volumes, at  $2^\circ$  it occupies  $273 + \frac{2}{273}$  of 273 or 275 volumes, etc.

But Magnus and Regnault shewed that Hydrogen expands less than air, and Carbonic Dioxide more.

For pressure—Boyle's or Marriot's law, viz: that the volume occupied by a gas is inversely proportional to the pressure to which it is subjected.

For instance, a gas which occupies 1 volume at any pressure becomes  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $\frac{1}{4}$ , &c. volume when subjected to pressure twice, thrice, four times, &c. as great, and twice, thrice, &c. the volume at a pressure of  $\frac{1}{2}$ ,  $\frac{1}{3}$ , &c. as great.

II.—According to Boyle's law—1 volume air at a pressure of 740 min. becomes  $\frac{740}{750}$  at a pressure of 750 min., and 100 volumes air at a pressure of 740 min. become  $\frac{740}{750} \times 100$  or  $\frac{296}{3}$  or 98 $\frac{2}{3}$  volumes.

III.—According to Lussac's law—1 CC. at  $0^\circ$  C becomes  $\frac{273+18.5}{273}$  CC. at  $18.5^\circ$  C. and

100 CC. at  $0^\circ$  C becomes  $\frac{273+18.5}{273} \times 100$  CC.  
at  $18.5$  and  $\frac{273+18.5}{273} \times 100 = 106 \frac{212}{273}$  CC.

#### IV.

I.—How is Carbonic acid prepared?

II.—Give and explain the equations representing the reaction.

III.—Describe fully what takes place when a stream of Carbonic acid is led into lime water to saturation, also what occurs when the liquid so produced is boiled.

IV.—How would you prove that Carbonic acid really consists of Carbon and Oxygen in the proportion stated in the formula?

I.—Most common method is to pour Muriatic acid upon some Carbonate, for instance, marble, chalk or limestone.

II.—The following equation represents

reaction of  $\text{CaCO}_3$ :  $\text{CaCO}_3 + 2\text{HCl} = \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ . The H changes places with the Ca, and  $\text{H}_2\text{CO}_3$  is formed, but it is very unstable and immediately splits up into  $\text{H}_2\text{O}$  and  $\text{CO}_2$ .

You may use any strong acid and any metallic Carbonate.

II.—Lime water is  $\text{Ca(OH)}_2$  dissolved in  $\text{H}_2\text{O}$ . When  $\text{CO}_2$  is first led into this lime water, the insoluble Calcic Carbonate,  $\text{CaCO}_3$  is formed and precipitated. When an excess is led into the soluble Calcic Carbonate,  $\text{CaH}_2(\text{CO}_3)_2$  is formed and dissolved. On boiling the liquid, the soluble Carbonate splits up into the insoluble Carbonate, which is thrown down. Water and Carbonic Dioxide, the  $\text{CO}_2$ , escapes as a gas.

IV.—Burn charcoal in a known volume of O in excess. On cooling the gas, no alteration in volume occurs, hence  $\text{CO}_2$  contains its own volume of O, and therefore a molecule contains two atoms O. The composition by weight can be shown by burning a known quantity of pure Carbon (Diamond or Graphite) in a current of O gas, and weighing the  $\text{CO}_2$  produced.

#### V.

I.—What are the principal ores of Tin Iron, Lead, Copper and Zinc?

II.—Describe the process of smelting any one of them.

I.—Of Tin the only important one is tin-stone  $\text{SnO}_2$ .

Of Iron, the black Oxide  $\text{Fe}_3\text{O}_4$ , the red Oxide or Hematite  $\text{Fe}_2\text{O}_3$ , Ferrous Carbonate or clay ironstone  $\text{FeCO}_3$ , and iron pyrites  $\text{FeS}_2$  are the most important.

Of Lead, the only important one is the Sulphide or Galena  $\text{PbS}$ .

Of Copper, copper pyrites  $\text{Cu}_2\text{S} + \text{Fe}_2\text{S}_3$  and the Carbonate or Malachite  $\text{CuCO}_3$  are the principal ones, but it is found native in quartz rock.

Of Zinc, the carbonate called Calamine  $\text{ZnCO}_3$ , and the Sulphide or Blende  $\text{ZnS}$ .

II.—For description of smelting