4. How would you begin to teach (*a*) Dictation, (*b*) Composition, (*c*) History?
5. Discuss Object Lessons?
6. Show how "copying" tends to produce general demoralization in a school. What means would you adopt to prevent copying?
7. Compare the respective merits of written questions and answers, and of oral questioning and answering.
8. In teaching spelling would you rely on one, or more, of the senses? Give your reason for doing so.

Additional questions for 2nd and 1st class candidates:

FOR SECOND CLASS.

9. What do you understand by a "good education"?

FOR FIRST CLASS.

10. Give some of the qualities of good reading. What peculiarities of pronunciation may be observed among pupils?
11. Who was Frœbel? What special advantage did he seek to gain by his system?

Practical Department.

LESSONS IN CHEMISTRY.

(Continued from last month.)

The chemical combination and the volume of the (so-called) permanent gases, or perfect gases, like air, oxygen, hydrogen, nitrogen, carbonic oxide, and nitrous oxide are found to be regulated by simple laws. In the case of easily condensable gases like carbonic acid, hydrochloric acid, and ammonia, however, these laws do not hold with rigid precision when the gas approaches the condensing point, that is just before it becomes a liquid.

I. Boyle and Mariotte's Law.

The volume of a gas under constant temperature varies inversely as the pressure upon it, that is the volume becomes $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c. of the initial volume as the pressure is increased to 2, 3, 4, 5, &c. times the original pressure: also the volume becomes 2, 3, 4, 5, &c. times the initial volume when the pressure on the gas is reduced to $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c. of the original pressure. This law is fully discussed in Hydrostatics, to which the student should now refer for problems. He should also at this stage master the chapter in Hydrostatics on thermometers and thermometric scales, and become familiar with the metric system of weights and measures which is now generally adopted in scientific works.

No limit has been found to this law, the gas expands or contracts very nearly uniformly. If the volume is kept constant while the pressure increases or diminishes, then the density of the gas varies as the pressure, that is 2, 3, 4, 5, &c. times the original weight of gas, or $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$ times that weight are contained in the same space according as the pressure has been increased or diminished 2, 3, 4, 5, &c. times.

See Hydrostatics—specific gravity, air-pump, barometer, and problems. The standard pressure to which we reduce gases for comparison is a pressure equal to the weight of 760 millimetres (mm.) or about thirty inches of mercury. This pressure is observed by means of the barometer.

Examples. 100 cubic inches of nitrogen collected when the barometer stands at 28 inches will contract to $\frac{28}{31}$ of 100 cubic inches when the barometer rises to 31 inches supposing the temperature to remain uniform.

Again, 100 litres of oxygen measured when the barometer stands at 760 mm. will expand to $\frac{760}{758}$ of 100 litres when the barometer falls to 758 mm., if the temperature remains unchanged. Also, gas at 762 mm., mercurial pressure, will expand to $\frac{762}{760}$ of its original volume when the pressure falls to 760 mm.; or gas at 760 mm. will contract to $\frac{760}{762}$ of its initial volume when the pressure rises to 762 mm.

II. The Law of Charles and Gay Lussac.

The volume of a gas varies directly as its absolute temperature, which is found by adding 273° to the temperature by the centigrade scale, or 459° to the temperature expressed on the Fahrenheit scale.

It has been discovered that the following statement is very nearly correct for all permanent gases:

273 volumes at 0° C. become
274 " 1° C.
275 " 2° C., and so on without limit, increasing one volume for every rise of 1° C. in the temperature.

Also 273 volumes at 0° C. become
272 " $-$1° C.
271 " $-$2° C.
270 " $-$3° C. and so on contracting one volume for every decrease of 1° C. in the temperature. If the law holds good beyond the temperatures we can actually reach by experiment, the volume of a gas must evidently cease to contract at — 273° C. This temperature is therefore called the *absolute zero* and corresponds to — 459° F. Hence on the *absolute scale of temperature*, 0° C. is 273°, and if the absolute scale is taken from Fah., 0° Fah. is 459° on the absolute, and the rule given above is manifest.

Examples. 100 litres of gas collected at 15° C. what will be the volume at 20° C, the barometer remaining unchanged? The absolute temperatures are 15 + 273, and 20 + 273, *i.e.*, 288° and 293°, and by the law of Charles the volume varies directly as the absolute temperature, hence 288 volumes will expand into 293 volumes, or 1 volume to $\frac{293}{288}$ and 100 volumes to $\frac{293}{288}$ of 100 volumes = 101·8 litres.

Again, 30 cubic inches of oxygen measured at 50° F., what is the volume when the temperature falls to 32° F.? The absolute temperatures are 509° and 491°.

Hence by the law 509 volumes will contract to 491
1 volume " " $\frac{491}{509}$
30 cubic inches " " $\frac{491}{509}$ of 30 cubic inches.

If, as is usual, corrections for both pressure and temperature are required we may easily combine the two results in one operation. Thus, 15 litres of hydrogen are collected under a pressure of 680 mm. and at 25° C. What volume will the gas occupy at 0° C. and 760 mm.? The pressure increases from 680 to 760, hence the volume decreases from 760 to 680, *i.e.*, 15 litres become $\frac{680}{760}$ of 15 litres.

The absolute temperatures are 298° and 273°, hence 298 volumes contract to 273, or 1 to $\frac{273}{298}$ liters.

The standard temperature is the melting point of ice that is 0° C.

Hence the ($\frac{680}{760}\times 15$) litres will become $\frac{273}{298}(\frac{680}{760}\times 15)=12·293$ or 32° F. Thus the *standard conditions* used for comparing gases are 0° C. and 760 mm. pressure, or in English measures 32° F. and 30 inches barometric pressure.

III The Law of Avogadro and Ampere.

The weights of equal volumes of all perfect gases under like conditions of pressure and temperature are precisely identical with their atomic weights. Thus:

44·4 cubic in. of hydrogen weigh 1 grain under standard conditions.
44·4 " " oxygen " 16 " " "
44·4 " " nitrogen " 14 " " "
44·4 " " chlorine " 35·5 " " "
and so on for all substances that can be reduced to the gaseous form. Similarly in French measures.