(*a*). Water is hard because the Lime or Magnesia salts, which are held in solution in the water, unite with one of the constituents of soap to form an insoluble chemical compound which grates on the hands; hence (*b*) the test for hard water is that when soap is used in it, the soap does not form a lather, but curdles.

(*c*). $CaSO_4$ when dissolved in water is detected by means of Baric Chloride, which throws down a white precipitate.

III. (*a*). "Give proofs that the atmosphere is not a chemical compound. (*b*). State the ordinary impurities in air. (*c*). What objection to calling CO_2 an impurity?"

(*a*). 1. If O and N be brought together in certain proportions, no heat is evolved, hence the mixture cannot be a chemical compound, although it has all the properties of pure atmospheric air.

2. Air is soluble in water, as is also its components, O and N. But it is found that the air expelled by boiling, from water in which it has been dissolved, contains more than 20.8 per cent. of O. This is because O is more soluble than N, and the two gases dissolve in water in proportion to their individual solubility, hence the two components of air act as if they were in a free state, therefore we conclude that air is merely a mixture of O and N, and not a compound.

3. Potassic Pyrogallate absorbs free O. If air be confined in a tube over Mercury, and Potassic Pyrogallate be admitted, the Mercury will rise in the tube, as O is absorbed, to about one-fifth the space originally occupied by the air. This absorption of the O alone proves that it is not a chemical compound with N, because if any other gas in which O is a chemical constituent is treated in the same way, no action whatever takes place.

4. The gas Nitric Oxide which is colorless, has the power of uniting with free O to form Nitrogen Trioxide Acid, which is of a reddish brown color. Nitric Oxide does not take O from substances which have it chemically combined, but when it mixes with air it invariably becomes red, proving that the O with which it unites is in a free state.

(*b*). The ordinary impurities of air are *Carbonic Acid* (CO_2), *Aqueous Vapor* and *Ammonia*.

(*c*). Objection might be made to calling CO_2 an impurity because it is necessary to the existence of plants, whose Chlorophyll in sunlight has the power of absorbing C from CO_2 and setting free O into the atmosphere.

IV. (*a*). "State the impurities of coal gas, and (*b*) how they are separated. (*c*). Why is C_2H_4 the more luminous, and CH_4 the more heating?"

(*a*). The impurities of coal gas are *Ammonia*, *Carbonic Acid* and *Hydric Sulphide*.

(*b*). The Ammonia may be completely separated by means of sawdust soaked in Hydric Sulphate; and forms the chief source of Sal Ammoniac.

The separation of Carbonic Acid is effected by absorbing it with lime.

Hydric Sulphide is disposed of by absorbing it with Ferric Hydrate; the sulphur of the former uniting with the iron of the latter to form Ferric Sulphide, while the remaining Hydrogen and Oxygen unite to form water.

(*c*). C_2H_4 contains a greater proportion of C than CH_4, and as the brilliancy of the flame is due to fine particles of incandescent Carbon, the flame of burning C_2H_4 will be more luminous than that of CH_4; but, on the other hand, since CH_4 contains relatively more H than C_2H_4, and that the intensity of heat is chiefly due to the presence of burning H, the flame of burning CH_4 will be hotter than that of C_2H_4.

V. "The Acids HCl, HNO_3 and H_2SO_4 are poured into a tube. State the order in which they will arrange themselves, and explain."

If we take a litre of water and a litre H_2SO_4 it will be found that the H_2SO_4 is 1.842 times heavier than the water. In the same way HNO_3 is known to be 1.517, and