

way with those found experimentally. Since the value of  $C^1$  for any other strength of acid may be found by graphical interpolation, the equation may be used to calculate the time necessary for complete conversion under a fairly wide variety of conditions.

It must be added that in practice the matter has sometimes appeared to be rather less simple than the theory would indicate. Some writers have seen a complicating factor in the supposed destructive effect upon creatinine of acids at high temperatures; yet Janney and Blatherwick [1915] found creatinine to be totally unaffected by boiling for fourteen hours with sulphuric acid of about 11 *N* concentration. Whatever the reason, it is not always easy to reconcile the conclusions of different observers who have attempted to settle empirically the conditions suitable for a quantitative conversion. It would serve no purpose to quote these conclusions in detail; but some of the more consistent among them may be combined in the statement that moderate quantities of creatine can be transformed into creatinine by treatment with normal HCl for fifteen days at 26° C. or for twenty-four hours at 60 to 65° [Hahn and Barkan, 1920, 1, 2], or, alternatively, by treatment with  $N/2$  HCl for three hours at 91° [Folin, 1906] or for fifteen minutes at 117° [F. G. Benedict and Myron, 1907].

### Salts and Derivatives of Creatine.

*Creatine Nitrate*,  $C_4H_9O_2N_3$ ,  $HNO_3$ .—Dessaignes [1854] obtained this salt by passing a rapid current of nitrous vapours into an excess of solid creatine suspended in water; the creatine promptly dissolved, and the solution presently deposited a mass of glittering little crystals. On recrystallisation these took the form of thick short prisms. The nitrate could be obtained also by evaporating, at 30° or *in vacuo*, a mixture of creatine with one equivalent of nitric acid.

*Creatine Sulphate* and *Hydrochloride*,  $(C_4H_9O_2N_3)_2 \cdot H_2SO_4$  and  $C_4H_9O_2N_3 \cdot HCl$ , are prepared by direct combination of creatine with the equivalent amount of acid, and subsequent evaporation at a low temperature. These salts resemble the nitrate in crystalline form, but are more soluble [Dessaignes, 1854].

*Creatine Phosphomolybdate* has been described by Kerner [1869]. It forms long rhombic prisms having the form of arragonite, readily soluble in water, and obtained by adding phosphomolybdic acid to a concentrated solution of creatine.

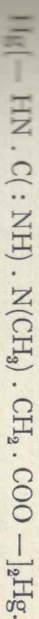
*Creatine Cadmium Chloride*,  $C_4H_9O_2N_3 \cdot CdCl_2 \cdot 2H_2O$ .—A neutral solution of cadmium chloride is warmed to 50°, and saturated with

finely powdered creatine. After twenty-four hours the solution is filtered from any unchanged creatine that may have separated, and is allowed to evaporate slowly over sulphuric acid. The cadmium chloride is deposited gradually in beautiful crystals, which often attain a considerable size. The crystals are obtained by exposure to air at ordinary temperatures, but less than two molecules of water of crystallisation. They are very soluble in water, in which they undergo hydrolytic dissociation; a concentrated solution therefore deposits upon cooling only [Neubauer, 1866, 2].

*Creatine Zinc Chloride*,  $C_4H_9O_2N_3 \cdot ZnCl_2$ .—This compound is prepared like the corresponding cadmium derivative. Its crystals are obtained by evaporation, and contain no water of crystallisation. In other respects these substances behave alike [Neubauer, 1863; 1866, 2].

*Creatine Copper Chloride* and *Creatine Mercuric Nitrate*.—These compounds are said to resemble the two foregoing ones, but have not been further described [Neubauer].

*Creatine Mercury Compound*,  $C_4H_9O_2N_3 \cdot Hg$ .—This is obtained by treating an ice-cold solution of creatine with a slight excess of potassium hydroxide and adding an ice-cold solution of mercuric chloride. A yellow oxide of mercury no longer disappears rapidly upon treatment with water, and then at 80 to 90° has the empirical composition  $C_4H_9O_2N_3 \cdot Hg$  and then at 80 to 90° has the empirical composition  $C_4H_9O_2N_3 \cdot Hg$ . It is very soluble in dilute hydrochloric, less so in acetic acid. [Folin] who describes it, assigns to it a constitution which is represented by the formula,



*Phenylcreatine*,  $C_8H_9O_4N_3$ , probably  $CH_3 \cdot CO \cdot NH \cdot CO \cdot NH_2$ .  $CH_3 \cdot CO \cdot CO \cdot NH_2$  is a neutral substance melting at 140°. It is prepared by treating creatine at water-bath temperature with an excess of acetic anhydride, evaporating to a syrup, and then the latter to stand till crystallisation takes place. The crystals are obtained by drying on porous porcelain and recrystallising from alcohol [Fleckenmeyer, 1895].

*Phthalylcreatine*,  $C_6H_4[CO \cdot NH \cdot CNH \cdot N(CH_2) \cdot CH_2 \cdot CO]_2$ .  $C_6H_4[CO \cdot NH_2]_2$  is obtained in 35 per cent. yield by melting together 10 grams of phthalic anhydride with 2.6 grams of creatine or creatinine, heating the mixture for 10 hours at 140°, extracting the cooled residue with ether, and recrystallising the residue thrice from absolute alcohol. It forms hair-like colourless crystals, melting