

this respect. The essence of the argument may be said to be that any attempt at an unambiguous space-time co-ordination in quantum phenomena implies a renunciation of the strict application of the conservation laws, due to the essentially uncontrollable exchange of energy and momentum between the object under investigation and the rigid bodies and clocks which define the space-time frame; conversely, any well-defined application of the conservation laws in quantum phenomena implies an essential renunciation as regards space-time co-ordination⁴.

As the fundamental relations between the wave and particle aspects of light and matter can be expressed in full conformity with the relativity principle, the still unsolved difficulties of quantum electrodynamics, emphasised by Dirac in connexion with this discussion, can scarcely be attributed to any incompatibility between the foundations of quantum theory and relativity theory. The root of these difficulties may rather be looked for in the atomistic nature of electricity, which is as foreign to classical physical theories as the quantum of action itself. The rational incorporation of these different aspects of atomic problems in a comprehensive theory will probably claim entirely new points of view, taking the essentially atomistic structure of all measuring agencies into consideration; but at the moment there would seem to be no reason to expect that this would involve any real departure from the conservation laws of energy and momentum.

Finally, it may be remarked that the grounds for serious doubts⁵ as regards the strict validity of the conservation laws in the problem of the emission of β -rays from atomic nuclei are now largely removed by the suggestive agreement between the rapidly increasing experimental evidence regarding β -ray phenomena and the consequences of the neutrino hypothesis of Pauli so remarkably developed in Fermi's theory.

N. BOHR.

Institute of Theoretical Physics,
Copenhagen.
June 6.

¹ P. Dirac, *NATURE*, 137, 298 (1936). E. J. Williams, *NATURE*, 137, 614 (1936). R. Peierls, *NATURE*, 137, 904 (1936).

² N. Bohr, H. A. Kramers and J. C. Slater, *Phil. Mag.*, 47, 785 (1924).

³ N. Bohr and L. Rosenfeld, *Kgl. Danske Vidensk. Selsk. math.-fys. Medd.*, 12, 8.

⁴ N. Bohr, *Phys. Rev.*, 48, 696 (1935).

⁵ N. Bohr, Faraday Lecture, *J. Chem. Soc.*, 349 (1932).

[SO₃]_x

MESSRS. Gerding, Nijveld and Muller¹ infer from the Raman spectrum of sulphur trioxide that it is a mixture of polymorphs. It is interesting to have such information, but to chemists who have known the compound this has always been a necessary assumption.

I remember Frankland introducing me to sulphuric anhydride early in 1867, at the Royal Institution, where we were doing gas analysis with the Frankland and Ward apparatus. He distilled it out of Nordhausen acid, using a bulb blown on the spot from an odd bit of tube, heating the small still on a warm tile of a Hofmann combustion furnace. To-day I can see him doing this: it was the way he had of showing one how to use one's fingers. Somehow I fell in love with the silken beauty of the oxide. As a German student, it was my first research *Schatz*: I cultivated its more acquaintance by the kilo, to

the surprise of my fellow students and even of Kolbe.

I am carried back to 1868, when I tested its action on a large number of chlorides. Typical is the effect it has on carbon tetrachloride, forming carbonyl chloride and pyrosulphuryl chloride, S₂O₅Cl₂, it would seem directly, as SO₂Cl₂ and SO₃ do not combine. On the other hand, the anhydride combines readily with HCl and EtCl forming simple chlorides—compounds which behave, however, as though they were the trioxide: they are not active apparently through their chlorine, as indeed is the case with acid chlorides generally. Pyrosulphonyl chloride is both a sulphonating and a chlorinating agent; sulphonyl chloride chlorinates.

The peculiarities of the 'trioxide' are not sufficiently recognized. It has high residual affinity. It is the perfect sulphonating agent, used alone but preferably diluted with sand. SO₃HCl is a convenient form in which to administer it—not nearly so powerful; the anhydride may even be used in solution in SO₂HCl with effect. I always feel proud of having introduced this chloride into use; it has played a big part in the manufacture of saccharin.

No text-book does justice to the protean character of the sulphuric acids: their properties have been Ostwaldized into oblivion. $\frac{1}{2}$ H₂SO₄ is not the equivalent of the acid: it is 90 per cent a monosulphonic acid—the lactic acid of the sulphur series—not dihydric sulphate. The well-defined stable acid of the series is anhydrosulphuric acid—*oxodisulphonic acid*. The first product of the interaction of vitrollic acid and, say, salt or sodium nitrate is not the acid sulphate of the text-books but H₃Na(SO₄)₂—a fact which makes the use of nitre in nitrations uneconomic. When chemists some day recover the full use of symbols and pay attention to facts, these and not a few other matters will receive the attention too long denied to them. Sulphonation is the most important of all the processes in the dyestuff industry—and we owe it to Faraday.

HENRY E. ARMSTRONG.

55 Granville Park,
Lewisham, S.E.13.

¹ *NATURE*, 137, 1033 (June 20, 1936).

Kinetics of Gas Reactions: an Attempt to Connect Thermal Decomposition and Oxidation Processes

THE thermal decomposition of formaldehyde¹ and of acetaldehyde² can be represented by $x-t$ graphs which indicate a period of rapid decomposition, followed by one of slow decomposition. The experimental results of Spence³ for the rates of oxidation of formaldehyde appear to be represented by similar graphs, indicating a similarity in the processes. Seddon and I have pointed out⁴ that, in the case of acetaldehyde, the total rate of thermal decomposition appeared to be independent of all conditions except temperature and initial concentration, the nature of the final products, whether methane and carbon monoxide on one hand, or propylene, carbon dioxide and water on the other, being materially dependent on certain other conditions.

Now in the case of the oxidation of formaldehyde, it appears that the final stage in the process follows two alternative courses, which may be represented by,

