

iron and nickel, and the reduction of the observations has now been completed, with the result that the Curie law, with certain limitations, is found to apply to the ferromagnetic state, and the relation $k.T = a$ constant is approximately satisfied, but the constant now is of a very different magnitude from the former one. There is, however, this simple and important relation between the constants in the two states—their ratio is the kinetic energy per unit of temperature per gram of two degrees of freedom, and is thus immediately connected with the gas constant R. This result is of importance because it shows that the change from the ferromagnetic to the paramagnetic state is quantitatively explicable as due to the acquisition of the kinetic energy per unit temperature required for the two degrees of rotational freedom which are effective in controlling magnetic susceptibility.

Thus there is proof from magnetic data alone, independently of thermal data, that the change at the critical temperature from ferro- to paramagnetism is due to the gain of energy associated with two degrees of freedom.

This acquisition of energy-content makes itself evident in the increase of specific heat which ferromagnetics show at and above the critical temperature, and is quantitatively in agreement with the magnetic result.

It is no longer necessary now to assume, as has been done, that an immense intrinsic magnetic field is the cause of ferromagnetism, although it may be convenient to introduce a fictitious magnetic field such that it will give rise to energy effects equivalent to the energy of two degrees of freedom.

The results which have been discussed above are also a confirmation of the simple view advanced by Ewing in his earlier papers on the molecular theory of magnetism, in which he suggests that the loss of ferromagnetic qualities may be caused by the oscillations of the molecular magnets which become wider and wider up to the critical temperature, at which point they pass from vibration to rotation.

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May 30.

Molecular Anisotropy in Liquids.

A VERY remarkable feature shown by many liquids in experiments on the molecular scattering of light is that the scattered beam in a direction transverse to the primary rays shows a large admixture of unpolarised light, the proportion of this to polarised light in the scattered beam being several times greater than in the case of the same substance in the condition of vapour at atmospheric pressure. This fact seemed at first very puzzling; an explanation is, however, now forthcoming. A theory of the phenomenon has been worked out by the writer which not only explains the facts in a simple and quantitative manner, but has also pointed out the way to further fruitful research. It may be briefly indicated as follows:

The polarised and unpolarised parts of molecularly scattered light may be conceived as arising in two distinct ways; the former is a mass-effect arising from the thermal fluctuations of density in the fluid, and its magnitude is given by the Einstein-Smoluchowski formula

$$\frac{\pi^2}{18} \cdot \frac{RT\beta}{N\lambda^4} \cdot (\mu^2 - 1)^2 (\mu^2 + 2)^2,$$

and as we pass from the condition of vapour to that of liquid in which the molecules are more closely

packed together, it increases much less than in proportion to the increased density. The unpolarised part of the scattered light is, on the other hand, a molecular effect, and its magnitude increases simply in proportion to the number of molecules per unit volume. The ratio of unpolarised to polarised part of the scattered light should therefore be considerably enhanced. This is exactly what is observed. If I_1 and $2I_2$ are respectively the polarised and unpolarised parts of the transversely scattered light, the ratio $I_2/(I_1 + I_2)$ may be determined experimentally by analysis with the aid of a double-image prism and a nicol. The Table below shows in the second column the value of this ratio as determined by Lord Rayleigh for certain substances in the state of vapour, in the third column the value of the ratio for the liquid state at ordinary temperature as calculated from the writer's theory, and in the fourth column the value as determined by Mr. K. Seshagiri Rao in the present writer's laboratory. The agreement is significant.

RATIO OF COMPONENTS OF POLARISATION

Substance.	Observed, Vapour.	Calculated, Liquid.	Observed, Liquid.
	Per cent.	Per cent.	Per cent.
Ethyl Ether . . .	1.7	10.9	8.2
Benzene . . .	6.0	39.8	39.8
Chloroform . . .	3.0	18.2	15.5

We may also view the matter in another way. When a substance is in the state of vapour under small pressures, both the positions and orientations of its molecules are absolutely at random, and assuming the molecules to be anisotropic, the degree of imperfection of polarisation of the light scattered by it may easily be calculated, as has been done by the late Lord Rayleigh. On the other hand, in the liquid state, the packing of the molecules is so close that their ordering in space is no longer at random; but we may still, at least in the case of ordinary liquids, consider the orientations to be arbitrary without serious error. If we take this into account in determining the resultant effect of the waves scattered by the individual molecules, we should be led to the same result as has been indicated above.

The theory put forward has other notable successes to its credit. The Einstein-Smoluchowski formula indicates that though the density of a liquid diminishes with rise of temperature, its scattering power should increase and become very large as the critical temperature is approached. Similarly, as the temperature is increased, the scattering power of the saturated vapour should increase much more rapidly than in proportion to its density. Accordingly, in both cases, we should expect the polarisation of the scattered light to improve steadily with rise of temperature and become practically complete as the critical temperature of the liquid is approached. Experiments with benzene liquid and vapour made by Mr. K. R. Ramanathan have quantitatively confirmed this prediction. A similar improvement in polarisation has also been observed by Mr. V. S. Tamma in experiments on the scattering of light in binary liquid mixtures as the critical temperature for separation into two phases is approached.

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