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Studies in surface physics

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The content of this thesis is grouped into four separate contributions to the field of surface physics.

a) Critical point nucleation theory. A theory of nucleation of metastable liquids or gases near the critical point is presented. The Cahn-Hilliard theory of inhomogeneous systems is combined with Widom's theory of the free energy of uniform fluids in the two phase region near the critical point, to find the free energy W of formation of a critical nucleus in this region. By introducing an experimental criterion on W for the condensation of a metastable gas, we are able to calculate the metastability limit as a function of temperature, and to compare it with the experimental results of Dahl and Moldover, and a theory of Eggington.

b) Physical theory of surface tension. We apply the Lifshitz' theory of van der Waals forces to the inhomogeneity created by the diffuse region in a fluid interface. This enables us to discuss the reason for the stability of the diffuse interface, and to calculate surface tensions and interface widths to within the correct order of magnitude, as a function of temperature near the critical point. As with other continuum theories of the diffuse interface, our theory will not reduce to the low temperature "sharp interface" limit. However it has a much sounder physical basis, and avoids the mean field approximation which is usually the starting point for alternative theories.

c) Interaction theory of fibrous bed filtration. A fundamental theory of the coalescence of emulsion droplets in fibrous bed filters is presented by considering the interaction of droplets with fibres and with other free and attached droplets. It is possible to explain why some

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filters work and others do not, and to present some predictions which can be tested by experiment. The experiments of Sareen, which are the only known experiments on filters with controlled and known electrolyte concentrations, in general support our theory.

d) Interaction of adsorbed molecules. We apply Lifshitz' theory of van der Waals forces to the problem of the interaction of two dipoles and a plane. This is used as a model for the interaction of molecules in a two dimensional gas adsorbed on the surface of a solid substrate. It is shown that the critical temperature of this gas is different from that normally calculated by applying dimensional considerations to the known three dimensional gas critical temperature.