Chapter 1

Introduction

In the last few decades, with advances in experimental, theoretical and computational techniques, nanoscience has become a rapidly expanding field of interdisciplinary research [1–7]. However, the first seed of nanoscience was planted long ago. In 1857, Michael Faraday introduced 'gold colloid' samples to the Royal Society. He added phosphorous to a solution of gold chloride and after a short while noted that the blue color of the solution changed to a ruby red dispersion. The resulting suspension of nanosized gold particles in solution appeared totally transparent at some frequencies, but for others could look colored (ruby, green, violet or blue). Since then, many experiments and theoretical studies have been carried out to explain the unique properties of similar systems which, in todays terminology are called *low dimensional.* From the late 1980s, we find a remarkable growth of activity on these materials, and today, the science of such systems has become an interesting area of research because of novelties related to fundamental issues and widespread technological applications.

In general, low dimensional systems are categorized as follows: (a) two dimensional (2D) systems, in which the electrons are confined in a plane (*eg.* layered structures, quantum wells and superlattices); (b) one dimensional (1D) systems, in which electrons are free to move only in one dimension (*eg.* linear chain like structure, semiconductor quantum wires), and (c) zero dimensional (0D) systems,

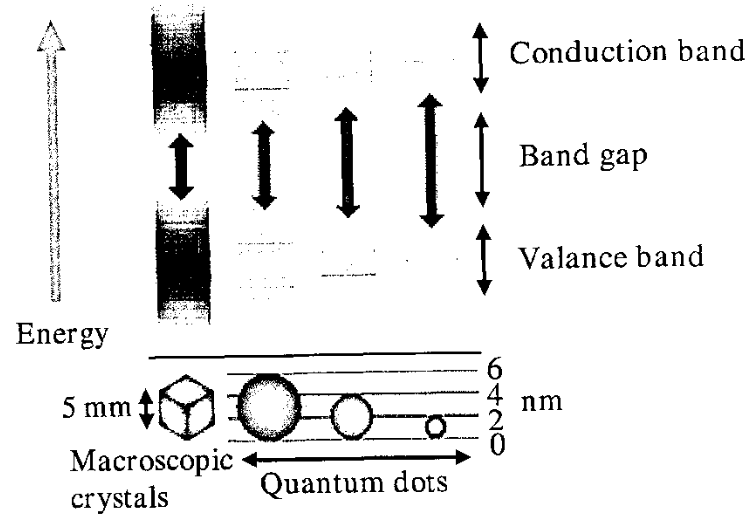

Figure 1.1: Quantum paintbox!! from Ref. [8].

where electrons are confined in all three dimensions (*eg.* quantum dots, clusters and nano-sized colloidal particles). The dimension of these materials in the direction of confinement is in the nanometer scale, hence the name nanomaterials. In this length scale, classical physics fails to explain the behavior of these materials. Rather, one needs quantum mechanical concepts. Interestingly, because of quantum effects, the physical properties of nanomaterials change drastically from their corresponding bulk behavior. Modern technology exploits this fact and uses these materials in diverse applications. For example, the confinement of electrons within the semiconductor low dimensional systems increases their electronic band gap, which can be explained by a simple 'particle in a box' model. By varying the size of the nanocrystals, one can tune their band gap and hence their color [see Fig. 1.1].

The aim of the work presented in this thesis is to study optical and vibrational properties of different low dimensional systems. In Section 1.1 of this Chapter, we shall briefly discuss the theoretical concepts (especially the ones we have used) in explaining the electronic properties of these systems. Vibrational properties in nano-