I. EXAMINERS REPORT ON PAPER B2: (CONDENSED MATTER PHYSICS AND PHONONICS)

The overall performance on this paper was good, with an unscaled mean for the paper of 59.9, s.d. 14.3. There was an even distribution of difficulty between questions which suggests that it was a fair test for all the material in the syllabus. It was marked with the requirement to produce excellence in order to achieve top marks and the highest score achieved was 85%. A general failing with many candidates was the reluctance to draw diagrams to illustrate their answers. The inclusion of diagrams aids both the discussion of the subject in question and the presentation of the material, often enabling answers to be much more succinct and well thought out.

Q1 Av. (s.d.)	Q2 Av. (s.d.)	Q3 Av. (s.d.)	Q4 Av. (s.d.)	Q5 Av. (s.d.)	Q6 Av. (s.d.)	Q7 Av. (s.d.)	Q8 Av. (s.d.)	Total Av. (s.d.)
12.3 (3.9)	10.7 (3.5)	13.4(3.4)	12.0(3.9)	12.4 (3.3)	12.1 (3.9)	11.6 (2.9)	11.4 (3.5)	59.9 (14.3)

II. INDIVIDUAL QUESTIONS

A. Q1: 118 attempts, mean 12.3, s.d. 3.9

This was a quite standard question which required a simple analysis of X-ray scattering from an fcc structure, followed by the use of the lattice constant to deduce the Fermi energy. It was generally well done, with the overwhelming majority of candidates able to quote the selection rules for fcc and calculate the required values. The majority, but not all candidates, could deduce the carrier density from the lattice constant and fcc structure, but many did not state the assumptions in their calculation such as the gold being monovalent and the mass of the electron being equal to the free electron value. The heat capacity was estimated well, however the attempts at the experimental section were very poor. A significant number of candidates described measurements of thermal or electrical conductivity instead and very few could give any real experimental method.

B. Q2: 84 attempts, mean 10.7, s.d. 3.5

A question on phonon dispersion which was generally well answered, but where candidates often lost marks due to some poorly labelled and specified diagrams. The first section on sound velocity caused several candidates problems as they attempted to take derivatives of the dispersion relation before simplifying the sin term, which made the derivation more involved. A common error was to show the dispersion relation for light as having the same or even lower velocity than the phonons. The most difficult part of the question was to deduce something about the density of phonon states, although there were some good answers to this.

C. Q3: 110 attempts, mean 13.4, s.d. 3.5

This was a standard, if slightly long, piece of derivation for the expressions for the density of carriers as a function of temperature. The expressions for the temperature dependence of the chemical potential for an **intrinsic** material were simple to derive and well done. The question on the dependence of the chemical potential on temperature and doping was much less well done. The majority of candidates made the erroneous assumption that the expression which they had just derived for intrinsic materials was still correct for doped semiconductors, rather than using the earlier expression quoted in the question.

D. Q4: 100 attempts, mean 12.0, s.d. 3.9

A question on collective magnetism in which the majority of candidates gave a good summary of the exchange interaction and how this leads to ferromagnetism. The descriptions of the molecular field approximation were well done but were often too simple, with many candidates ignoring the need to link the molecular field to the exchange interaction as quoted in the question, thus losing several marks. The description of domain formation and hysteresis was generally good.

E. Q5: 89 attempts, mean 12.4, s.d. 3.3

This was a difficult essay question which was often very well answered. Candidates often lost marks by simply not answering all of the questions. The qualitative description of superconductivity was generally good. The description of methods of measuring the band gaps was hindered by two factors, in particular the reluctance of candidates to draw diagrams which could make their descriptions much clearer, and secondly the wording of the question, which several candidates interpreted incorrectly as meaning that the two methods for measuring the band gap should be the same in both cases. This is possible (absorption at the band gap/activation across the band gap/or tunnelling (less well known for semiconductors)) but clearly restricted the choice of technique for those who interpreted the wording this way.

F. Q6: 94 attempts, mean 12.0, s.d. 3.9

A very standard p-n junction question. The explanation of depletion layer and the origin of the I-V curve was frequently very poor, mainly because many candidates attempted to do this without drawing any diagrams at all and therefore found it difficult to distinguish the different processes which take place. The derivation requires several steps and assumptions and on more than one occasion candidates made simple errors early on which propagated through their working but then miraculously produced the final answer, thus making it very difficult to give any marks for partial answers. Very few candidates appreciated that the diode can be used as a voltage controlled capacitance.

G. Q7: 5 attempts, mean 11.6, s.d. 2.9

This was a quite straightforward quantum well question. There were very few answers, probably because the equivalent question last year was too difficult, but those doing this question often did well and better than on other questions in the paper. The calculation of the number of confined states is simply an infinite quantum well approximation and the density of states needs to be constant for each level as it is a two dimensional sheet. Very few candidates remembered that the quantum well needed to be included into a forward biassed p-n junction in order to produce a laser.

H. Q8: 82 attempts, mean 11.4, s.d. 3.5

This was a question on aspects of the operation of a Nd:YAG laser. Almost all candidates who attempted this question were able to derive conditions on the pump rates and level lifetimes in order that a steady-state population inversion may be achieved, but only around half were able to find the necessary condition on the Einstein A-coefficient for this to be so. Most candidates provided reasonable sketches of the relevant energy levels of the Nd:YAG laser, and could identify those properties of these levels which assist the formation of a population inversion. The calculation of the threshold pump power for laser oscillation caused many candidates difficulties: several candidates tried to calculate the output power of the Nd:YAG laser, and a surprising number took the diameter of the pumped volume to be equal to that of the Nd:YAG disk rather than that of the (smaller) pump beam. Only approximately half the candidates calculated the longitudinal mode spacing of the cavity correctly, and only a few of these used this information to determine whether or not lasing on more than one longitudinal mode was likely.