PHYS-E0421 Solid State Physics (5cr), Spring 2019
2nd midterm exam, 27 May 2019

Even quite short answers to the questions are sufficient in most cases (preferably with supporting schematic figures and equations) as long as you focus on the main points. The points after questions hint how long answers are expected.

1. Long wave length optical phonons in ionic solids. Why cannot they be described as those in metals or covalent solids? How can they be described? What are the main features in their dispersion relations? Can you explain the origin of these features?
   (4 p)
2. Figure 1 shows the reflectivity for InAs which is a III-V semiconductor. Explain the different features seen!
   (2 p)
3. Figure 2 shows the reflectivities of three different n-doped InSb samples. Interpret the results! What can you say about the carrier concentrations of the different samples?
   (2p)
4. Table I shows exciton binding energies in different materials. How can these results be interpreted in terms of simple models?
   (4p)
5. Figure 3 shows the magnetization of isolated Gd^{3+}, Fe^{3+}, and Cr^{3+} ions in insulators as a function of the applied magnetic field and temperature. Eplain the overall behaviour of the data qualitatively! The low temperature data for Cr^{3+} can be explained quantitatively by the crystal field quenching model. On the basis of the figure, what are the quantum numbers [J,L,S] used for Cr^{3+} in this model? Explain how did you find your answer? How many 3d electrons the Cr^{3+} ion could have on the basis of the determined [J,L,S] set?
   (4 p)
6. Figure 4 shows the heat capacity per unit volume of a system of paramagnetic ions in a constant magnetic field as a function of temperature. Explain the reasons for the low and high temperature behaviours!
   (2 p)
7. Stoner criterium for ferromagnetism. In what kind of materials it predicts ferromagnetism? Why? How it can be used to predict the temperature dependence of magnetization?
   (4 p)
8. Domain structure of a ferromagnet. Why does it exist? What determines the thickness of the Bloch walls between the domains. How does the domain structure affect the magnetization curve (M vs. H) of a ferromagnet?
   (3 p)

Fig. 1.

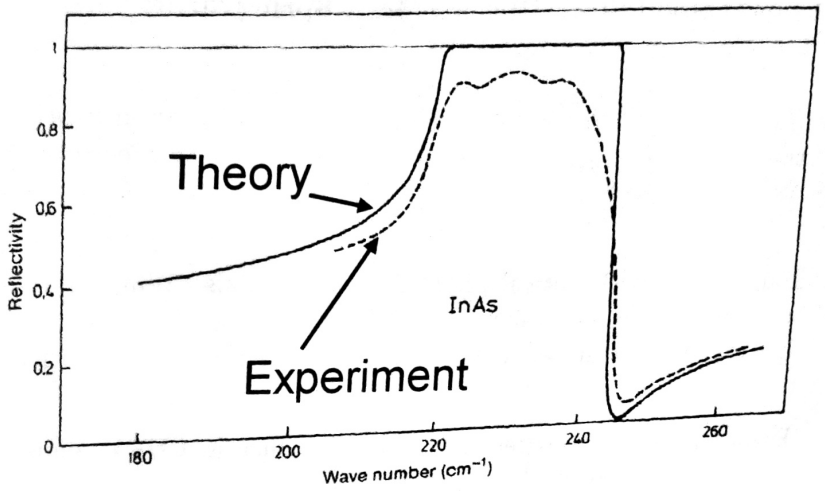

Fig. 2. Reflectivity of different n-doped InSb samples

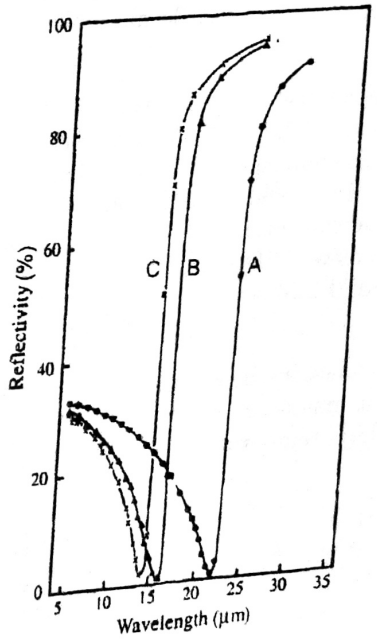

Table I

Material	Binding energy (meV)	Material	Binding energy (meV)
GaP	3.5	BaO	56
Ge	4.2	KCl	400
Si	14.7	KI	480
CdS	29		

Fig. 3.

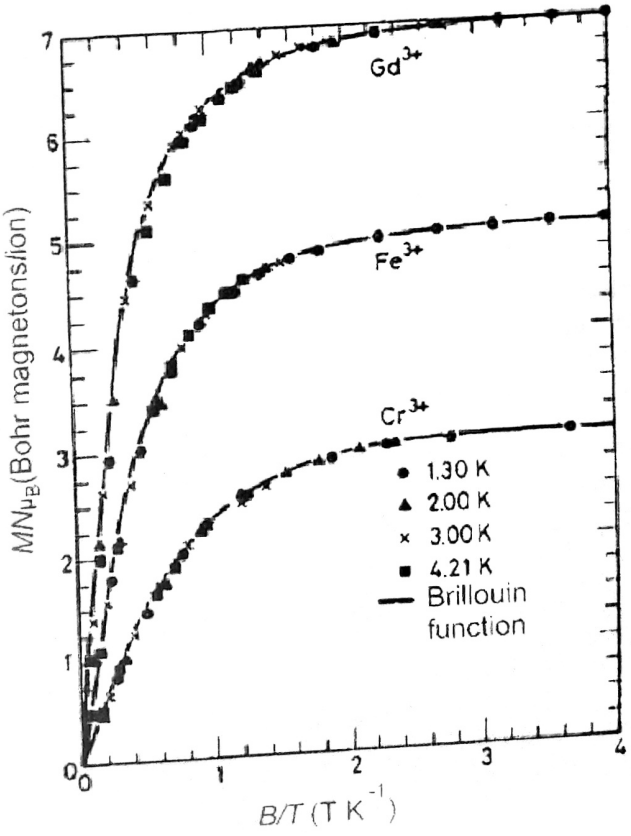

FIG 4