SISSA ISAS
SCUOLA INTERNAZIONALE SUPERIORE DI STUDI AVANZATI - INTERNATIONAL SCHOOL FOR ADVANCED STUDIES
I-34014 Trieste ITALY - Via Beirut 4 - Tel. [+]39-40-37871 - Telex:460269 SISSA I - Fax: [+]39-40-3787528

Spring 2002 – Entrance Examination: Condensed Matter
Multiple choice quizzes

---

1. The resistivity of a solid is generally a function of temperature. Which of the following statements is correct:

   (a) Resistivity increases with temperature in both insulators and metals

   (b) Resistivity increases with temperature in insulators, and decreases in metals

   (c) Resistivity decreases with temperature in insulators, and increases in metals

   (d) Resistivity increases in metals, but is infinite in insulators.

2. The external appearance of a material is related with the nature of its energy spectrum. Thus metals are reflecting and shining because they have a lot of low-energy electronic excitations, and insulators are transparent because they have none. What is the appearance of a semiconductor like silicon, and why?

   (a) it is reflecting and shining, because it has a small gap

   (b) it is transparent, because it has a large gap

   (c) it is reflecting and shining, only when heavily doped

   (d) it is transparent because it has a gap, even if small

3. Sodium and chlorine form a ionic salt NaCl because:

   (a) The energy obtained ionizing Cl is higher than the energy required to ionize Na. In addition, further electrostatic energy is gained in the solid.

   (b) Energy is required to form both Na^+ and Cl^-, but the electrostatic energy gained in the solid compensates the energy cost of ions formation.

   (c) The energy obtained ionizing Na is lower than the energy required to ionize Cl, but the electrostatic energy gained in the solid compensates the energy cost of Cl^- formation.

   (d) The energy obtained ionizing Cl is lower than the energy required to ionize Na, but the electrostatic energy gained in the solid compensates the energy cost of Na^+ formation.

4. The quantum numbers of a multielectron atom can be labeled with the spectroscopic symbol ${}^{2S+1}L_J$, where S is the total spin angular momentum, L is the total orbital angular momentum and J is the total angular momentum. Only one of the following combinations exists, which one?

(a) ${}^1S_1$

(b) ${}^2P_{1/2}$

(c) ${}^{3/2}P_{1/2}$

(d) ${}^3F_1$

5. Above the Curie temperature a ferromagnetic metal (Fe, Co, Ni) behaves as:

   (a) A diamagnetic material. Magnetic dipoles are completely disappeared and the magnetic susceptibility is small and negative.

   (b) A paramagnetic material. Magnetic dipoles are still present but they are no more ordered in domains. The magnetic susceptibility is small, positive and temperature dependent.

   (c) A paramagnetic metal. Only the Pauli paramagnetism is present. The magnetic susceptibility is small, positive and temperature independent.

   (d) None of the above.

6. Consider a gas of hydrogen atoms at very low density. According to the principles of statistical mechanics the probability of finding an atom in the ground state is given by $P_{1s} = e^{-E_{1s}/k_BT}/Z(T)$ where $Z(T)$ is the partition function. However, $\sum_{n=1}^{\infty} n^2 e^{-E_{1s}/(k_BTn^2)}$ is clearly infinite at any non-zero temperature T. Accordingly $P_{1s} = 0$. How do you explain this apparent paradox ?

   (a) The above sum enters the classical partition function and is invalid for quantum systems.

   (b) There is no paradox. The probability of finding an hydrogen atom in the ground state is indeed negligeable.

   (c) Inclusion of the continuum states in the partition function fixes the problem.

   (d) The effectively finite volume per atom provides a natural cut-off to the sum over the excited states.