

International School for Advanced Studies
1999 Entrance Examination: Condensed Matter
Multiple choice quizzes

1. A perfect insulating solid is set in vibration at a single phonon frequency ω_0 and then let evolve. It is observed that the amplitude of the macroscopic vibration slowly decays in time. If transmission to the supporting medium is negligible, what is this decay generally due to?
 - a) radiation losses in the surrounding vacuum
 - b) anharmonicity of interatomic forces
 - c) progressive expansion of the solid
 - d) false, a perfect solid will vibrate forever

2. Helium is an element that never solidifies, and remains liquid down to zero temperature due to zero-point motion connected with its very small mass. Molecular hydrogen which is even lighter does not do that. Why?
 - a) intermolecular interactions are much stronger in hydrogen
 - b) hydrogen does not remain molecular, but forms a covalent crystal
 - c) the superfluid liquid ground state is forbidden by nuclear spins
 - d) statistics is different, hydrogen is not a boson

3. Magnetism is the rule for 3d transition metals, but disappears in the 4d and the 5d metals. Why?
 - a) it is replaced by superconductivity
 - b) the 4d and 5d elements are not metals
 - c) the spin magnetic moment is canceled by an orbital moment
 - d) Hund's rule intra-atomic coupling is weaker

4. Light reflection (at say normal incidence) from a surface is maximum when the medium is:
 - a) totally absorbing or metallic
 - b) totally transparent
 - c) semimetallic, or narrow-gapped
 - d) high refractive index insulating

5. Every atom has well-defined ionization energy I and electron affinity A , measuring respectively the energy necessary to remove an electron, and the energy gained by adding one. Which one among the following statements is true:
- a) I and A are minimum in the halogens
 - b) I and A are minimum in the alkalis
 - c) I is minimum and A is maximum in the halogens
 - d) I is minimum and A is maximum in the alkalis
6. The the magnetic susceptibility of a metal is made up of a (Pauli) spin contribution and a (Landau) orbital one. Which one among the following statements is true:
- a) both Pauli and Landau are diamagnetic
 - b) both Pauli and Landau are paramagnetic
 - c) Pauli is paramagnetic and Landau is diamagnetic
 - d) Landau is paramagnetic and Pauli is diamagnetic
7. Long-range order is hampered by fluctuations in low-dimensional systems. Which one among the following statements is true:
- a) 2D long-range order is impossible at finite T for both discrete and continuous symmetry breaking.
 - b) 2D long-range order is impossible at finite T for discrete but not for continuous symmetry breaking.
 - c) 2D long-range order is possible at finite T for both discrete and continuous symmetry breaking.
 - d) 2D long-range order is impossible at finite T for continuous but not for discrete symmetry breaking.
8. When a solid melts:
- a) there is usually (but not always) an increase of entropy, always an increase of volume, usually (but not always) an increase of internal energy.
 - b) there is usually (but not always) an increase of internal energy, usually (but not always) an increase of volume, always an increase of entropy.
 - c) there is always an increase of volume, always an increase of internal energy, always an increase of entropy.
 - d) there is usually (but not always) an increase of volume, always an increase of internal energy, always an increase of entropy

9. Suppose you could exert a gigantic uniform pressure, of in principle unlimited magnitude, on every existing object, each made of the most disparate material. At such extremely high pressure and at zero temperature, and assuming that nuclei are classical, what among these statements is true?
- a) all materials collapse
 - b) all materials become metallic
 - c) all materials become insulating
 - d) some materials become molecular, some become magnetic.
10. Near absolute zero temperature, the specific heat of a superconductor behaves as:
- 1) $\approx |T - T_c|^{-\gamma}$, where γ is an appropriate critical exponent.
 - 2) $\approx T$
 - 3) $\approx T^3$
 - 4) $\approx \exp\left(\frac{-\Delta}{k_B T}\right)$, where Δ is the Cooper gap.
11. Landau's mean field theory of critical phenomena holds
- a) above the upper critical dimension
 - b) below the lower critical dimension
 - c) in between the upper and the lower critical dimensions
 - d) both above the upper and below the lower critical dimensions
12. Bose–Einstein condensation of very dilute rubidium vapors confined in a magnetic trap have been observed at microkelvin temperatures, as metastable states which last long enough (of the order of seconds) to carry out experiments. Which is the reason of such long lifetimes?
- a) It is a system of non–interacting particles.
 - b) The three–body collisions are rare events in dilute and cold gas.
 - c) The system is confined.
 - d) A systems of Rubidium atoms does not solidify at low pressure.

The following questions should be answered only by candidates interested in a bio-simulation curriculum

13. Two phenylalanine rings in a protein form a π complex. Their interaction is
- a) Mostly hydrophobic

- b) Mostly electrostatic
 - c) Both electrostatic and H-bonding
 - d) H-bonding
14. Why does toluene form a more stable complex with Ag^+ than benzene does?
- a) Because toluene is more electron-poor than benzene
 - b) Because toluene is more electron-rich than benzene
 - c) Because only toluene can form an H-bond with Ag^+
 - d) Because toluene is a stronger acid than benzene
15. The lowest pK_a of the Gly-Asp dipeptide is 2.81. Which group is responsible for this pK_a ?
- a) Gly side-chain
 - b) Gly backbone
 - c) Asp side-chain
 - d) Asp backbone