1 A metallic sphere of radius r_0 is placed at a distance R from a point charge. The sphere and the point charge attract each other with a force f:

A. $f(R) \propto \frac{r_0^3}{R^5}$.

B. $f(R) \propto \frac{r_0^2}{R^4}$.

C. $f(R) \propto \frac{1}{r_0^2} e^{-\frac{R}{r_0}}$.

D. $f(R) \propto \frac{1}{R^2} e^{-\frac{R}{r_0}}$.

2 Deep-sea divers use to breath a kind of artificial air in which Nitrogen is replaced by Helium. When they emerge from the sea, their voice is shifted to higher frequencies. This is so because:

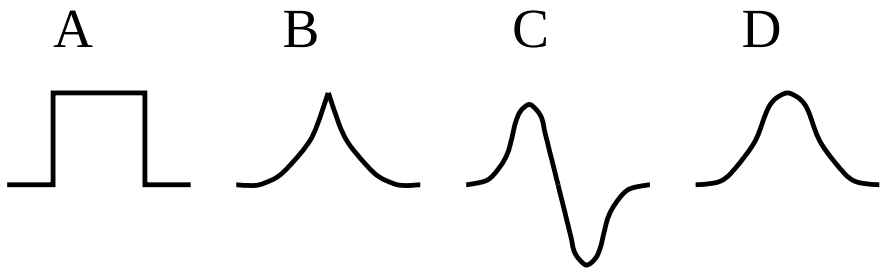
A. The ionization potential of He is much larger that that of N_2.

B. The mass of He is smaller than that of N_2.

C. Contrary to N_2 molecules, He atoms do not have internal vibrational degrees of freedom.

D. N_2 molecules have a non-vanishing quadrupole moment which enhances their mutual interaction.

3 Which of the following wavefunctions is a good candidate for the ground state of the unidimensional hamiltonian: $H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} - U_0 e^{-|x/a|}$?



4 A fluid in a container is subject to an adiabatic expansion. Which of the following statements is true?

A. The entropy increases.

B. The temperature increases.

C. The entropy remains constant.

D. The pressure increases.

5 Rising the temperature all materials eventualy melt. This is so because:

A. Temperature weakens the interaction between atoms because electrons are excited across their energy gap.

B. The entropy of the liquid is larger than that of the solid.

C. Solid and liquid are not qualitatively different states of matter and melting depends on details of the interaction.

D. The density of the liquid is lower than the one of the solid.

6 A coin has two perfectly equivalent faces : top and bottom. What is the probability to get the top of a coin after many unsuccessful trials ?

A. Is more likely to get the top.

B. 50%

C. Is more likely to obtain the bottom.

D. $1/N_{trial}$.

7 The resistivity of a normal metal does not go to zero as the temperature goes to zero. This is due to:

A. Zero-point quantum oscillations of the lattice which scatter the electrons

B. Presence of impurities

C. Scattering due to phonons

D. Both A and C.

8 Down to very low temperature, helium remains liquid due to zero-point motion and thus becomes superfluid, while molecular para-hydrogen, whose mass is about one half that of helium, solidifies and thus possesses no superfluid phase. This is because:

A. Para-hydrogen is not a boson
B. Free molecular rotation would require the quantum liquid phase to be too expanded
C. Quantum melting of the solid is impeded by macroscopic singlet spin coherence
D. Intermolecular forces are much stronger for para hydrogen.

9 You might have heard of many elementary excitations which occur in condensed matter systems present in nature: among them magnons, phonons, excitons, plasmons, rotons. Suppose that for a given material, you could change the mass of all nuclei from their actual value M_i to some other close-by value M_i^I, which of these excitations do you expect to shift strongly in energy?
A. all of them
B. magnons, excitons, plasmons
C. phonons, plasmons, rotons
D. phonons, rotons

10 A polished metal surface acts as a mirror because
A. photons cannot be absorbed and thus bounce back because of the electronic gap
B. photons cannot penetrate because there is no electronic gap, and thus bounce back
C. photons are totally adsorbed, and thus the virtual image remains
D. photons hybridize with electron-hole pairs of the metal, which are partly reflected and partly transmitted

11 Modern electronics is based on semiconductors, such as silicon. This is so because
A. the conductivity can be controlled by impurities and external fields
B. they are light, abundant, and nearly perfect materials
C. their conductivity is the right medium range, while metals conduct too much, and insulators not at all
D. the metal contacts necessary for transistor action are only feasible with semiconductors

12 Transparent insulating materials are characterized by the magnitude of their electronic energy gap. The material which in nature is likely to possess the largest gap is
A. solid iron at extremely high pressure
B. diamond
C. sodium chloride
D. liquid helium

13 The magnetic susceptibility of a free electron gas as the temperature $T \to 0$
A. diverges as $1/T$;
B. is finite and positive;
C. is finite and negative;
D. is zero.

14 The contribution to the specific heat of a phonon branch decays exponentially with temperature, hence it is
A. an acoustic branch;
B. an optical branch;
C. both of the above;
D. none of the above.

15 Two electrons interact through a central force. The lowest energy state has angular momentum $L = 0$ and
A. spin $S = 0$;
B. spin $S = 1/2$;
C. spin $S = 1$;
D. none of the above.

16 The zero-frequency long-wavelength dielectric constant of a metal is
A. slightly larger than one;

B. 0;
C. ∞;
D. slightly smaller than one;

17 The vanadium atom has 23 electrons in a configuration Argon + $3d^3 4s^2$. Therefore, according to the Hund's rules, it has the total spin S, the angular momentum L and total angular momentum J equal to
A. $S = 3/2$, $L = 5$, $J = 13/2$;
B. $S = 3/2$, $L = 3$, $J = 5/2$;
C. $S = 3/2$, $L = 5$, $J = 7/2$;
D. $S = 3/2$, $L = 3$, $J = 3/2$.

18 In the derivation of the canonic ensemble from the microcanonic one it is necessary that
A. the subsystem be macroscopic
B. the interparticle interactions be small
C. both A and B above
D. nor A nor B

19 Consider a particle on a one dimensional infinite lattice whose position at time t is $x(t)$. The particle performs a random walk with $Prob\{x(t+1) = x(t) + 1\} = p$ and $Prob\{x(t+1) = x(t) - 1\} = 1 - p$. The square fluctuation is $dx^2(t) = < x^2 > - < x >^2$:
A. dx^2 grows linearly with t for all p
B. dx^2 grows linearly with t only for p=1/2 and is proportional to t^2 otherwise
C. dx^2 is proportional to t^2 for all p
D. dx^2 is proportional to $\sqrt{t}$ for all p

20 Consider a finite volume divided into two equal parts one of which contains a gas in equilibrium and the other is empty. If, removing the wall separating the two parts, the temperature of the gas decreases, one can conclude that
A. the gas is monoatomic
B. the entropy of the gas has decreased
C. the potential energy of the gas has increased
D. the potential energy of the gas has decreased

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

26 All the aminoacids in proteins except glycine are chiral molecules
A. with configuration D
B. with configuration L
C. with both configurations L and D
D. with either L or D configuration depending on the protein

27 DNA, the polymer that contains the genetic code, is
A. a neutral and nonpolar molecule
B. a neutral and polar molecule
C. a negatively charged molecule
D. a positively charged molecule

28 ATP, the central carrier of chemical energy in the cell, is
A. an aminoacid
B. a monosaccharide
C. a component of the cell membrane
D. an enzyme cofactor

29 Can the three dimensional structure of globular proteins be determined at atomic resolution by using spectroscopic techniques?
A. Yes, using IR spectroscopy

B. Yes, using NMR spectroscopy
C. Yes, using EPR spectroscopy
D. No. It can be determined only using X-ray diffraction techniques