Condensed Matter Physics

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Part B - Advanced

Quick Note: Condensed Matter Physics is not included in the Core Part A syllabus.

1. Lead is superconducting below 7 K and has a critical magnetic field 800×10^{-4} tesla close to 0 K. At 2 K the critical current that flows through a long lead wire of radius 5 mm is closest to
(February 15, 2022)

A. 1760 A

B. 1670 A

C. 1950 A

D. 1840 A

2. A lattice is defined by the unit vectors $\vec{a_1} = a\hat{i}$, $\vec{a_2} = -\frac{a}{2}\hat{i} + \frac{a\sqrt{3}}{2}\hat{j}$, and $\hat{a_3} = a\hat{k}$, where $a > 0$ is a constant. The spacing between the (100) planes of the lattice is
(November 19, 2020)

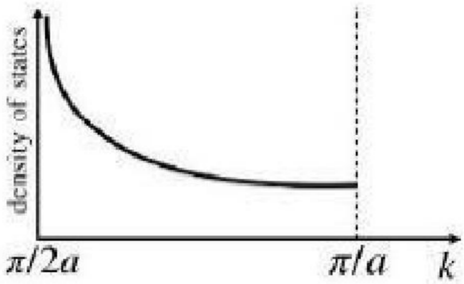
A. $\sqrt{3}a/2$

B. $a/2$

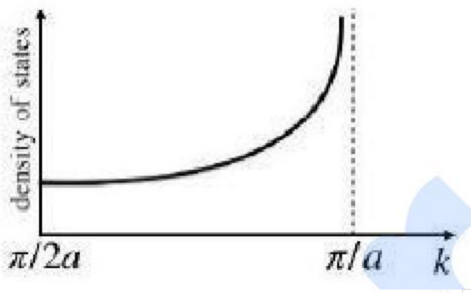
C. a

D. $\sqrt{2}a$

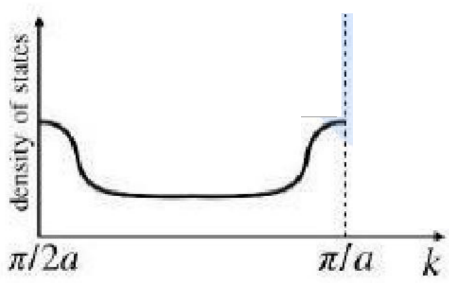
3. A tight binding model of electrons in one dimension has the dispersion relation $\varepsilon(k) = -2t(1 - \cos ka)$, where $t > 0$, a is the lattice constant and $\frac{-\pi}{a} < k < \frac{\pi}{a}$. Which of the following figures best represents the density of states over the range $\frac{\pi}{2a} \leq k < \frac{\pi}{a}$? (November 19, 2020)



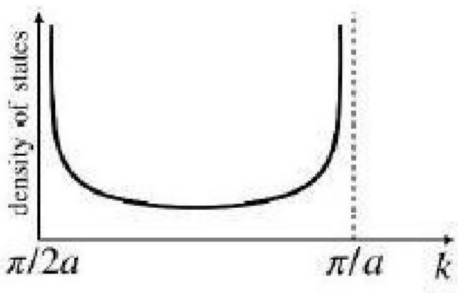
A.



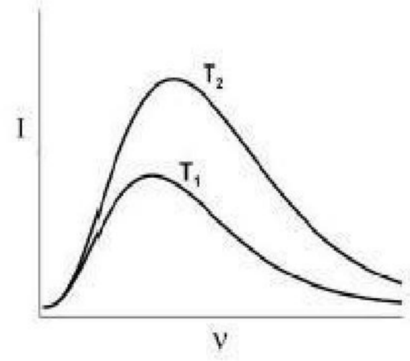
B.



C.



D.



4. The energy density I of a black body radiation at temperature T is given the Planck's distribution function

$$I(\nu, T) = \frac{8\pi\nu^2}{c^3} \frac{h\nu}{(e^{\frac{h\nu}{k_B T}} - 1)}$$

where ν is the frequency. The frequency $I(\nu, T)$ for two different temperatures T_1 and T_2 are shown above: If the two curves coincide when $I(\nu, T)\nu^a$ is plotted against ν^b/T, then the values of a and b are, respectively,
(November 19, 2020)

A. 2 and 1

B. -2 and 2

C. 3 and -1

D. -3 and 1

5. For an ideal gas consisting of N distinguishable particles in a volume V, the probability of finding exactly 2 particles in a volume $\delta V << V$, in the limit $N,\ V \to \infty$, is
(November 19, 2020)

A. $2N\delta V/V$

B. $(N\delta V/V)^2$

C. $\frac{(N\delta V)^2}{2V^2} e^{-N\delta V/V}$

D. $\left(\frac{\delta V}{V}\right)^2 e^{-N\delta V/V}$