

54. The acceptor density in a sample of Ge of energy gap 0.67 eV is  $0.9 \times 10^{21} \text{ m}^{-3}$ . The Fermi level in the sample at 300 K is
- (A) 0.45 eV
  - (B) 4.5 eV
  - (C) 0.045 eV
  - (D) 9 eV

55. If the atoms vibrating in a lattice at finite temperature are considered to be a collection of  $N$  identical harmonic oscillators (Einstein Model) the heat capacity at constant volume for such a solid is given by

- (A)  $C_V = Nk_B x \frac{e^x}{e^x - 1}$
- (B)  $C_V = Nk_B x^2 \frac{e^x}{e^x - 1}$
- (C)  $C_V = Nk_B x^2 \frac{e^x}{(e^x - 1)^2}$
- (D)  $C_V = Nk_B x \frac{e^x}{(e^x - 1)^2}$

where  $x = \hbar\omega/k_B T$ .

56. The eigenstates  $\psi$  of the Hamiltonian  $\mathcal{H} = -\frac{\hbar^2}{2m}\nabla^2 + U(\mathbf{r})$ , which describes the interaction of an electron with wave vector  $\mathbf{k}$  with the lattice through the potential  $U(\mathbf{r} + \mathbf{R}) = U(\mathbf{r})$  for all Bravais lattice vectors  $\mathbf{R}$ , are given by

- (A)  $\psi_{nk}(\mathbf{r}) = e^{i\mathbf{k}\cdot\mathbf{r}}$
- (B)  $\psi_{nk}(\mathbf{r}) = e^{i\mathbf{k}\cdot\mathbf{r}} u_{nk}(\mathbf{r})$
- (C)  $\psi_{nk}(\mathbf{r}) = A e^{i\mathbf{k}\cdot\mathbf{r}}$
- (D)  $\psi_{nk}(\mathbf{r}) = A \sin(\mathbf{k}\cdot\mathbf{r}) + B \cos(\mathbf{k}\cdot\mathbf{r})$

57. If the dispersion relation for a monatomic chain of identical atoms, each of mass  $M$ , with interatomic spacing  $a$ , is  $\omega = (2\alpha/M)^{1/2}(1 - \cos Ka)$  where  $\alpha$  is the force constant between nearest-neighbour atoms, the acoustic phonon mode has a frequency at the first Brillouin zone boundary given by

- (A)  $(\alpha/M)^{1/2}$
- (B)  $(2\alpha/M)^{1/2}$
- (C)  $(\alpha/2M)^{1/2}$
- (D)  $(4\alpha/M)^{1/2}$