* Thermal Properties of Solids *

1. The amount of thermal energy required to raise the temp of 1kg of substance by 1K or 1°C is termed as
   (a) Heat capacity ✓(b) specific heat capacity (c) Latent Heat
   (d) specific latent heat
2. The SI unit of for the specific heat capacity is
   ✓(a) $J\ kg^{-1}\ {}^{\circ}C^{-1}$ (b) $J\ kg^{-1}$ (c) $J\ K^{-1}$ (d) $J\ {}^{\circ}F^{-1}$
3. Heat absorbed or relased by the same state of matter is represented by ✓(a) $Q = mc\Delta\theta$ (b) $Q = mc/\Delta\theta$ (c) $Q = m/c\Delta\theta$ (d) $Q = \Delta\theta/mc$
4. The formula for calculating the heat capacity
   (a) $c = C/\Delta\theta$ (b) $H = \Delta\theta/Q$ (c) $Q = C/\Delta\theta$ ✓(d) $C = H/\Delta\theta$
5. Cp is always greater than
   ✓(a) Cv (b) 1 (c) 0 (d) $\Delta\theta$
6. At constant volume dv=0 According Thermodynamic first law then the specific heat at constant volume is Cv =
   (a) $\left(\frac{dQ}{dT}\right)_v$ (b) $\left(\frac{\partial E}{\partial T}\right)_v$ (c) $\left(\frac{\partial P}{\partial T}\right)_v$ ✓(d) a & b
7. The contribution of specific heat of solids
   (a) $C_{latt.} + C_{vib.}$ (b) $C_{elec.} + C_{latt.} + C_{vib}$ ✓(c) $C_{latt.} + C_{elec}$ (d) All
8. At room temp., heat capacity of solids is nearly 3Nk =
   (a) 4R ✓(b) 3R (c) 5R (d) 2R
9. The K.E. of average thermal energy of single one dimensional harmonic oscillator is
   (a) $\frac{p^2}{4m}$ (b) $\frac{p^2}{m}$ ✓(c) $\frac{p^2}{2m}$ (d) $\frac{2m}{p^2}$
10. The P.E. of average thermal energy of single one dimensional of harmonic oscillator, V(x) is P.E. at displacement x from mean position.
    ✓(a) $\frac{1}{2} m\omega_0^2 x^2$ (b) $m\omega_0^2 x^2$ (c) $\frac{1}{2} m\omega_0 x^2$ (d) $m\omega_0 x^2$
11. According to classical theory of applying maxwell-Boltzmann distribution law, average energy of each harmonic oscillator is
    (a) $\bar{E} = \frac{1}{2} KT$ ✓(b) $\bar{E} = KT$ (c) $\bar{E} = \frac{3}{2} KT$ (d) $\bar{E} = 2KT$
12. Total vibrational energy of crystal containing N identical atoms is
    (a) NKT (b) 2NKT ✓(c) 3NKT (d) $\frac{1}{2}$NKT
13. Total vibrational energy of crystal depends on temp. at constant volume specific heat

(a) 3NK (b) 3NKT (c) 3KT (d) None

(14) According to classical theory, the molar specific heat OR molar heat capacity of all solids is constant & is independent of temp. & frequency this is called

(a) Drude-Lorentz law (b) Widemann-Franz Relⁿ (c) Dulong & petit's law
(d) Maxwell-Boltzmann law

(15) The quantum-mechanical harmonic oscillator modes determines the energy levels of a particular mode

(a) $E_n = \frac{1}{2}\hbar\omega$ (b) $E_n = (n+\frac{1}{2})\hbar\omega$ (c) $E_n = n\hbar\omega$ (d) None

(16) $E_n = \frac{1}{2}\hbar\omega$ term represents the i.e. $n=0$

(a) zero point energy (b) Fermi energy (c) Thermal energy (d) all

(17) According to planck's quantum theory the discreate energy values of an oscillator with frequency ν are given

(a) $E_n = n\hbar\omega_0$ (b) $E_n = \hbar\omega_0$ (c) $E_n = \frac{1}{2}\hbar\omega_0$ (d) None

(18) According to average energy of Einstein heat capacity is dependent of temp.

(a) $\bar{E} = \left[\hbar\omega_0 + \frac{\hbar\omega_0}{e^{\left(\frac{\hbar\omega_0}{K_BT}\right)}-1}\right]$ (b) $\bar{E} = \left[\frac{\hbar\omega_0}{2} + \frac{\hbar\omega_0}{e^{\left(\frac{\hbar\omega_0}{K_BT}\right)}-1}\right]$

(c) $\bar{E} = \left[\hbar\omega_0 + \frac{1}{e^{\left(\frac{\hbar\omega_0}{K_BT}\right)}-1}\right]$ (d) $\bar{E} = \frac{\hbar\omega_0}{2}$

(19) According to Einstein quantum harmonic oscillator average energy ~~time~~ temp. independent zero point energy

(a) $\bar{E} = \left[\frac{\hbar\omega_0}{2} + \frac{\hbar\omega_0}{e^{\frac{\hbar\omega_0}{K_BT}}-1}\right]$ (b) $\bar{E} = \frac{\hbar\omega_0}{2}$

(c) $\bar{E} = \left[\frac{\hbar\omega_0}{e^{\left(\frac{\hbar\omega_0}{K_BT}\right)}-1}\right]$ (d) None

(20) $\theta_E = \frac{\hbar\omega_0}{k_B}$ where θ_E is the characteristics of temp is known as

(a) Laplace temp. (b) Lorentz temp. (c) Einstein temp. (d) classical Temp.

(21) According Einstein theory of lattice heat capacity, the average energy of spectic heat of Einstein theory at constant volume.

(a) $C_V = 3Nk_B \left(\frac{\theta_E}{T}\right)^2 \frac{e^{\theta_E/T}}{(e^{\theta_E/T}-1)^2}$ (b) $C_V = 3Nk_B\left(\frac{\theta_E}{T}\right)^2$

(c) $C_V = Nk_B\left(\frac{\theta_E}{T}\right)^2 \frac{e^{\theta_E/T}}{(e^{\theta_E/T}-1)^2}$ (d) None

(22) at high temp. $k_BT >> \hbar\omega_0$ or $T >> \theta_E$ the average energy is

(a) $\bar{E} = k_BT$ (b) $\bar{E} = \frac{3}{2}k_BT$ (c) $\bar{E} = \frac{1}{2}k_BT$ (d) All of these

(23) at high temp. $k_BT >> \hbar\omega_0$ or $T >> \theta_E$ the specific heat capacity at constant volume is

(a) $C_V = 3N$ (b) $C_V = 3Nk_B$ OR $C_V = 3R$ (c) $C_V = Nk_B$ (d) $C_V = 2Nk_B$

(24) at low. temp. $k_BT << \hbar\omega_0$ or $T << \theta_E$ the specific heat capacity at constant volume is

(a) $C_V = 3Nk_B\left(\frac{\theta_E}{T}\right)^2 e^{-\left(\frac{\theta_E}{T}\right)}$ (b) $C_V = \left(\frac{\theta_E}{T}\right)^2 e^{-\theta_E/T}$

(c) $C_V = 3Nk_B \frac{\theta_E}{T} e^{-\theta_E/T}$ (d) $C_V = Nk_B\left(\frac{\theta_E}{T}\right)^2 e^{-\theta_E/T}$

(25) Let x be the positions of line element & $u(x,t)$ its displacement from the mean position at any time t. therefore amount of strain e

(a) $e = \frac{dx}{du}$ (b) $e = \frac{dy}{dx}$ (c) $e = \frac{dy}{dt}$ (d) $e = du.dx$

(26) one dimensional wave eq^n is

(a) $\frac{\partial^2 y}{\partial x^2} = \frac{1}{V_S^2}\frac{\partial^2 y}{\partial t^2}$ (b) $\frac{\partial^2 y}{\partial t^2} = \frac{1}{V_S^2}\frac{\partial^2 y}{\partial x^2}$ (c) $\frac{\partial^2 y}{\partial t^2} = \frac{1}{V_S}\frac{\partial^2 y}{\partial x^2}$ (d) None

Note

$V_s = \sqrt{\frac{Y}{\rho}}$ represents the velocity of propogation of the wave, stri

(27) the frequency of string can have discreate values only an integral multiple of

(a) $\frac{V_s}{L}$ ✓(b) $\frac{V_s}{2L}$ (c) $\frac{V_s}{4L}$ (d) $\frac{2L}{V_s}$

* Free electron theory of metals * MCQ's

① For impure metals, electrical conductivity is inversly proportional to

ⓐ $\sigma \propto \frac{1}{T}$ ⓑ $\sigma \propto \frac{1}{\sqrt{T}}$ ⓒ $\sigma \propto \frac{1}{T^2}$ ⓓ $\sigma \propto \frac{1}{P}$

② For pure metals, electrical conductivity σ is

ⓐ $\sigma \propto \frac{1}{T}$ ⓑ $\sigma \propto \frac{1}{\sqrt{T}}$ ⓒ $\sigma \propto \frac{1}{T^2}$ ⓓ $\sigma \propto \frac{1}{P}$

③ For most metal resistivity is inversely proportional to

ⓐ $\rho \propto \frac{1}{T}$ ⓑ $\rho \propto \frac{1}{\sqrt{T}}$ ⓒ $\rho \propto \frac{1}{P}$ ⓓ $\rho \propto \frac{1}{\sqrt{P}}$

④ Above Debye Temp. the ratio of thermal & electrical conductivity is proportional to

ⓐ $\frac{K}{\sigma} \propto T$ ⓑ $\frac{K}{\sigma} \propto \sqrt{T}$ ⓒ $\frac{K}{\sigma} \propto P$ ⓓ $\frac{K}{\sigma} \propto T^2$

⑤ It is the ratio of thermal conductivity K & electrical conductivity σ is called

ⓐ Dulong petites Relⁿ ⓑ Wiedmann Franz Relⁿ
ⓒ Drude & Lorentz Relⁿ ⓓ Fermi Relⁿ

⑥ If free time taken b/w two successive collisions is τ & velocity along one direction be u then

ⓐ $\tau = \frac{u}{\lambda}$ ⓑ $\tau = \lambda/u$ ⓒ $\tau = \lambda u$ ⓓ None

⑦ Electrical conductivity σ =

ⓐ $\frac{ne\lambda u}{6KT}$ ⓑ $\frac{ne^2\lambda u}{6KT}$ ⓒ $\frac{ne\lambda u}{3KT}$ ⓓ $\frac{ne^2\lambda u}{3KT}$

⑧ Thermal conductivity K =

ⓐ $\lambda n^2 u k_B$ ⓑ $\frac{\lambda n^2 u k_B}{2}$ ⓒ $\frac{\lambda n u k_B}{2}$ ⓓ $\frac{\lambda n^2 u k_B}{3}$

⑨ In Widemann-Franz Relⁿ $K/\sigma \propto T$ where $3\left(\frac{k_B}{e}\right)^2$ is constant is called

ⓐ Lorentz number ⓑ magnetic number ⓒ Principal Quant No.
ⓓ None

⑩ In Sommerfeld's model, E_n =

ⓐ $\frac{n^2h^2}{4mL^2}$ ⓑ $\frac{n^2h^2}{6mL^2}$ ⓒ $\frac{n^2h^2}{8mL^2}$ ⓓ $\frac{n^2h^2}{2mL^2}$

(11) In same case, $E_n \propto$

Note (a) n (b) n^2 (c) $n^{1/2}$ (d) $n^{1/3}$

Note: E_n exist only for integral values of n & n is called quantum no.

(12) Wave function of electron occupying n^{th} state According to Sommerfeld's model

(a) $\psi_n(x) = \sqrt{2/L} \cdot \cos \frac{n\pi x}{L}$ (b) $\psi_n(x) = \sin \frac{n\pi x}{L}$

(c) $\psi_n(x) = \sqrt{2/L} \cdot \sin \frac{n\pi x}{L}$ (d) $\psi_n(x) = \sqrt{L/2} \sin \frac{n\pi x}{L}$

Where :- $\sqrt{2/L}$ is Normalized cond.

(13) The momentum of free electron is related to a wave vector by

(a) $p = \hbar k$ (b) $p = hk$ (c) $p = \hbar/k$ (d) $p = h/k$

(14) According to classical theory of free electron all the valence electron in metal can absorb

(a) Heat energy (b) thermal energy (c) solar energy (d) None

(15) An electronic contribution to the specific heat of metal of

(a) $\frac{3}{2}R$ per kilogram at. weight (b) $\frac{5}{2}R$ / kilogram at. weight

(c) $\frac{9}{2}R$ per kilogram at. weight (d) $3R$ per kilogram at. weight

(16) According to the total specific heat of metal can be expressed as, C_V

(a) $\frac{3}{2}R$ (b) $\frac{5}{2}R$ (c) $\frac{9}{2}R$ (d) $3R$

Note :- $3R \rightarrow$ atomic
$\frac{3}{2}R \rightarrow$ electronic

(17) According to Dulong & Petit law observed that the specific heat above the characteristics temp. is the same for all solids is equal to (a) $5R$ (b) $\frac{3}{2}R$ (c) $9R$ (d) $3R$

(18) A non-zero temp. the probability of filling Fermi energy level of a metal with electron is

(a) $1/3$ (b) $2/3$ (c) $1/2$ (d) 0

(19) The average distance travelled by a free electron between two successive collisions with lattice ions of metallic crystal is called as

(a) mean free path (b) free path (c) drift velocity (d) mean collision time.

(20) The time between two successive collisions of a free electron with lattice ions a metallic crystal is called

(a) mean collisons time (b) collision time (c) mean free path (d) free path

(21) At absolute zero of temp. the highest filled energy level of a metal is called

(a) Fermi energy level (b) de Broglie energy level (c) maxwell energy level (d) None.

(22) The fermi-surface need not always be

(a) spherical (b) cubic (c) parallelopiped (d) None

(23) Drude & Lorentz based their calculation on M-B statistics & the expression obtained for electrical conductivity was

(a) $\sigma = \frac{ne^2\tau}{m}$ (b) $\sigma = \frac{ne\tau}{m}$ (c) $\sigma = \frac{e^2\tau}{m}$ (d) $\sigma = \frac{me^2\tau}{n}$

(24) Drude & Lorentz based their calculation on M-B statistics & the expression obtained for electrical conductivity was

(a) $\sigma = \frac{me^2 l}{nv}$ (b) $\sigma = \frac{e^2\tau}{m}$ (c) $\sigma = \frac{ne^2}{m}$ (d) $\sigma = \frac{ne^2 l}{mv}$

(25) The Relationship between current density j & Electric field E is

(a) $j = \sigma E$ (b) $j = \sigma / E$ (c) $j = \sigma 2E$ (d) $j = E$

[Ohm's law]

(26) The probability of electron occuption at any temp above 0K in a a fermi dirac fun^n given as

(a) $P(E) = \frac{1}{1+\left[\frac{E-E_F}{KT}\right]}$ (b) $P(E) = \frac{1}{1-e^{\left[\frac{E-E_T}{KT}\right]}}$

(c) $P(E) = \frac{1}{1+e^{\left[\frac{E-E_F}{KT}\right]}}$ (d) $1+e^{\left[\frac{E-E_T}{KT}\right]}$

(27) At sufficiently high temp. an appreciable no. of electrons will have the K.E. energy required to escape through the surface. is called

(a) Thermionic emission (b) Photoelectric emission (c) a & b (d) None

(28) The Gross work function of metal is

(a) $W_c = \int_0^{\infty} f_r . dr$ (b) $W_c = \int_0^{\infty} F_r^2 . dr$ (c) $W_c = \int_{-\infty}^{\infty} f_r . dr$ (d) $W_c = \int_{-\infty}^{\infty} f_r^2 \, dr$

(29) Which of the following is correct free electros theory

(a) A-gas of free electrons is responsible for the properties of metal. (b) Semiconductors can be explained properly

(c) Insulators can be explained properly

(d) None

(30) According to free electron theory

(a) valence electrons are tightly bound with the atom

(b) valence electrons are weakly bound with the atom

(c) There is no free electron

(d) None.

(31) Electrons in Fermi level will follow

(a) Bose-Einstein energy distribution (b) Fermi-Dirac energy

(c) M-B energy (d) All