Indian Institute of Technology Rajasthan

Physics Test

Junior Technical Lab. Assistant (JTLA)

Total Marks: 100 **Date of Exam: 16-11-2012** **Time : One Hour**

Instructions:

(i) Q. No. 1 to 30 carries 3 marks each i.e. 30 x 3 = 90 marks
(ii) Q. No. 31 to 35 carries 2 marks each i.e. 5 x 2 = 10 marks
(iii) The answers should be circles in the question paper itself.
(iv) There is No negative marking.

---

1. A dielectric sphere of radius R has a radial polarization that varies with distance from the center of the sphere according to $\vec{P} = a\vec{r}$, where a is constant and ε is dielectric constant . The electrostatic potential at the center of the sphere is
   (a) $-aR^2/2\varepsilon$ (b) $-aR/2\varepsilon$ (c) $\varepsilon R^3/2a$ (d) $aR^2/2\varepsilon$
2. The kinectic energy (U) of three dimensional gas of N free electrons at 0 °K is
   (a) U = (3/5) (ε_f/N) (b) U= (5/3)(N/ ε_f) (c) U = (3/5) Nε_f (d) None
3. A system has energy levels given by 1, 2, 3 etc., units. The ground levels given has three states and the first excited level has two states. If the system of three microparticles and 4 units of energy ,the number of microstates can be according to Bose-Einstein distribution is
   (a) 6 (b) 12 (c) 18 (d) 27
4. Work done in an adiabatic expansion of perfect gas is given by
   (a) $\frac{P_2V_2 - P_1V_1}{1-\gamma}$ (b) $\frac{P_2V_2 + P_1V_1}{1-\gamma}$ (c) $\frac{P_1V_1 - P_2V_2}{1-\gamma}$ (d) $\frac{P_2V_2 - P_1V_1}{\gamma-1}$
   (where P_1 , P_2 & V_1 , V_2 are initial and final values of the pressure and volume and Υ= (C_P/C_v))

5. A carnot engine which works between source at 400°K and sink at 300°K, the entropy extracted from source is 10 cal/°K. The work done in Joules by the engine is (a) 4200 J (b) 400 J (c) 300 J (d) 1000 J
6. Which among the following sets of Maxwell relations is correct ? (U – internal energy , H- enthalpy, A- Helmholtz free enrgy, G-Gibbs free enrgy)

(a) $T=\left(\frac{\partial U}{\partial V}\right)_s$ and $P=\left(\frac{\partial U}{\partial S}\right)_V$ (b) $T=\left(\frac{\partial H}{\partial P}\right)_s$ and $T=\left(\frac{\partial H}{\partial S}\right)_P$

(c) $P=-\left(\frac{\partial G}{\partial V}\right)_T$ and $V=\left(\frac{\partial G}{\partial P}\right)_s$ (d) $P=-\left(\frac{\partial A}{\partial S}\right)_T$ and $S=-\left(\frac{\partial A}{\partial P}\right)_V$

7. The pressure , specific heat and entropy of photon gas has the following dependence on temperature

(a) T^4, T^3, T^4 (b) T^4, T^3, T^3 (c) T^4, T^4, T^4 (d) T^4, T, T^{-1}

8. The eigenvalues of the matrix are $\begin{pmatrix} -1 & 1 & 3 \\ 1 & 2 & 0 \\ 3 & 0 & 2 \end{pmatrix}$

(a) 4,2,-3 (b) 2,4, -4 (c) 2, 4,3 (d) 1,4,2

9. Let the wavefunction of the harmonic oscillator is given by

$$|\Psi\rangle=\frac{1}{\sqrt{14}}|\Psi_0\rangle+\frac{2}{\sqrt{14}}|\Psi_1\rangle+\frac{3}{\sqrt{14}}|\Psi_2\rangle$$

Where ψ_0 , ψ_1 and ψ_2 the eigenfunctions of the ground state , first excited state and second excited state respectively. The expectation value of the energy is

(a) $\frac{61}{28}\hbar\omega$ (b) $\frac{58}{28}\hbar\omega$ (c) $\frac{41}{28}\hbar\omega$ (d) $\frac{57}{28}\hbar\omega$

10. An intrinsic sample of Ge (bandgap E_g= 0.7 eV) is kept at room temperature (300 ^{O}K) having effective mass for $m_{effe}= m_e$ and $m_{effh} = m_h$, where m_e and m_h are rest mass of electron and holes respectively. The density of charge carrier is

(a) 1.6 x 10 ^{13} cm^{-3} (b) 1.6 x 10 ^{13} m^{-3} (c) 1.6 x 10 ^{11} cm^{-3} (d) 1.6 x 10 ^{18} cm^{-3}

(Hint : $n = p= 4.83 \times 10^{15} (m_{eff}/m_{rest})^{3/2} (T (^{O}K))^{3/2} \exp(-E_g/2k_BT)$ cm^{-3})

11. A linearly polarized light passes through a half-wave plate by 45 deg. with respect to optical axis. Which of the statement is correct.(a) The light is circularly polarized and rotated by 22.5 deg. (b) The light is linearly polarized and rotated further by 135 deg. (c) The light becomes unpolarized (d) The light is polarized and it is rotated by 90 deg. with respect to intial state of polarization

12. A oil drop of mass $m = 3.27 \times 10^{-10}$ gram remains stationary between two horizontal plates of separation $d = 2.0$ cm and potential difference $V = 2.00 \times 10^{4}$ *Volts*, the electric force balancing the gravitational force. What is the charge on the oil drop.

3.2 x 10 -9 C (b) 3.2 x 10 -19 C (c) 3.2 x 10 -18 C (d) 3.2 x 10 -11 C

13. The first few energy levels of certain diatomic (CO_2) molecule are separated uniformly. At a temperature of 300 K , the ratio of the number of molecules in the 4^{th} excited state to the number of molecules in 1^{st} excited are about 0.74. The energy levels are separated by an amount (a) 3.2 meV (b) 5 meV (c) 25 meV (d) 2.5 meV

14. If a voltmeter is connected to the ends of a p-n junction , it will read as

(a) Zero (b) More than junction voltage

(c) Junction voltage only (d) Less than junction voltage

15. The packing fraction of a body centered cubic lattice is

(a) 74% (b) 100 % (c) 68% (d) 52 %

16. Wind blowing towards east in horizontal plane in the northern hemisphere (a) Turns right to its direction due to coriolis force (b) Turns right due to centripetal force (c) turns left to its direction due to coriolis force (d) It is not affected.

17. Which of the following statement is correct (a) Enthalpy is expressed as U+PV and it is not a state function (b) Enthalpy is expressed as U+PV and it is a state function (c) Enthalpy is expressed as a (U+PV)/T and it is a state function (d) Enthalpy is expressed as U+PT and it is not a state function

18. Ɣ radiation is (a) Less ionizing and more penetrating (b) More ionizing and less penetrating (c) More ionizing and more penetrating (d) Less ionizing and less penetrating

19. Consider an electron in an infinite potential well of size 0.1 nm. The ground state energy of electron in electron volts (eV) is

(a) 40 eV (b) 3.73 eV (c) 36 eV (d) 37.6 eV

20.. An X-ray photon having energy 8.05 keV (Cu K_α X-ray) is scattered from the (110) plane of a polonium sample which has simple cubic (SC) structure. Adjacent diffraction peaks are observed at scattering angle 40.5^o and 76.8^o. The lattice constant and the order of the observed diffraction patterns at 40.5^o are

(a) 2.3728 ^{o}A , 2 (b) 3.36 ^{o}A , 2 (c) 3 nm , 3 (d) 3.36 ^{o}A , 3

21. Density, molecular weight and dielectric constant of silicon 2.33 grams/cm^3 ,28.855 grams and 11.9 respectively. The atomic polarizability (α) is

(a) 4.16×10^{-40} Fm^2 (b) 41.6×10^{-42} Fm^2 (c) 4.16×10^{-30} Fm^2

(d) 4.16×10^{40} Fm^2

(Hint : $P=N\alpha(E+(P/3\varepsilon_O))$)

22. A medium whose free electron density is given by 1×10^{18} cm^{-3} and its plasma frequency is given by ω_p. Mr. Green shines a laser of wavelength 532 nm and its frequency is ω_L ($>\omega_p$) . Which of the following statement is true.

(a) Completely reflected and refractive index of the medium is 1.46

(b) Partially transmitted , partially absorbed and refractive index of the medium is 0.54

(c) Partially reflected and refractive index of the medium is 1.434

(d) Completely transmitted and refractive index of the medium is 0.995

23. A convex lens of focal length 10 cm is placed 5 cm away from a concave lens of focal length 20 cm. A object is placed 15 cm away from the convex lens. The final image due to both the lenses formed at

(a) Real image and 100 cm from convex lens (b) Virtual image and – 100 cm from the concave lens (c) Virtual image and -100 cm from convex lens (d) Real and 100 cm from cancave lens

24. A small body excutes a circular motion of radius 10 cm in frictionless horizontal plane P. Its speed at an instant is 10 cm/sec. It reaches opposite point in 1 sec. The centripetal acceleration at this point is

(a) 27.88 cm/sec^2 (b) 278.8 cm/sec^2 (c) 27 cm/sec^2 (d) 2.7888 cm/sec^2

25. The expression (∂ω/∂k) for a wave equation stands for
(a) Group velocity (b) Wave velocity (c) dispersive power (d) None of these

26. The Lagrangian for a simple pendulum is given by $L=\frac{1}{2}ml^2\dot{\theta}^2-mgl(1-\cos\theta)$.
The Hamilton's equations are given by

(a) $\dot{p}_\theta=-mgl\sin\theta;\quad \dot{\theta}=\frac{p_\theta}{ml^2}$ (b) $\dot{p}_\theta=-m\ddot{\theta};\quad \dot{\theta}=\frac{p_\theta}{m}$

(c) $\dot{p}_\theta=mgl\sin\theta;\quad \dot{\theta}=\frac{p_\theta}{ml^2}$ (d) $\dot{p}_\theta=-\left(\frac{g}{l}\right)\theta;\quad \dot{\theta}=\frac{p_\theta}{ml}$

27. The quarks up(u), down (d) and strange (s) are having charges of 2e/3 , -1e/3, -1e/3 respectively. The bound state of proton and neutron are
(a)(uss),(uud) (b) (uud),(udd) (c) (uus), (uud) (d) (uud),(uss)

28. An ideal gas consists of N monoatomic molecules whose partition function and internal energy are

(a) $Z=\frac{1}{h^{3N}N!}V^N(2\pi mkT)^{\frac{3N}{2}};\quad \frac{3NkT}{2}$

(b) $Z=\frac{1}{h^{3N}(3N)!}V^{3N}(2\pi mkT)^{\frac{3N}{2}};\quad \frac{3NkT}{2}$

(c) $Z=\frac{1}{h^{N}N!}V^{N}(2\pi mkT)^{\frac{N}{2}};\quad \frac{3kT}{2}$

(d) $Z=\frac{1}{h^{3N}N!}V^{N}(2\pi mkT)^{\frac{3N}{2}};\quad 3NkT$

29. A cw laser beam of cross-section 1mm by 1mm and has intensity of 10^4 W/meter^2.The wave length of the beam is 632.8 nm. The number of photons emitted by the laser per second are
(a) 3.2x 10^{16} (b) 3.2x 10^{15} (c) 3.2x 10^{14} (d) 10 x 10^{12}

30. For a one-dimensional free electron gas, the electronic density n and the Fermi energy (E_F) are related by

(a) $n=\frac{\pi\hbar E_F}{2m}^2$ (b) $n=\frac{\pi\hbar E_F}{2m}$ (c) $n=\frac{\sqrt{2mE_F}}{\pi\hbar}$ (d) $n=\frac{\pi\hbar}{2mE_F}$

31. Divergence of $\mathbf{r} = i\,x + j\,y + k\,z$

(a) 0 (b) 1 (c) 3 (d) non of these

32. The lowest value taken by the function $3x^4 + 4x^3 - 12x^2 + 6$ is

(a) -26 (b) 6 (c) 1 (d) 0

33. Which of the following functions of x could be represented by a Fourier series over the range $-\infty < x < \infty$?

(a) tanh−1(x) (b) tan x

(c) | sin x |−1/2 (d) cos -1 (sin 2x)

34. The area of ellipse $x^2/a^2 + y^2/b^2 = 1$ is

(a) ab (b) πab

(c) π2ab (d) 1

35. The Eigenvalues of the Hermitian martrix are

(a) Real (b) Complex (c) Purely imaginary (d) Zero