G-98

ENTRANCE EXAMINATION, FEBRUARY 2014
QUESTION PAPER
Ph.D. (ACRHEM)

Marks: 75
Time: 2.00 Hrs. Hall Ticket No.

Please confirm that
(a) This booklet has all 11 pages (including 2 blank pages) printed clearly and numbered
(b) You are given a clean and clear OMR answer sheet.

Read **carefully all** the instructions given below & on the OMR sheet.

1. Please enter your Hall Ticket Number on Page 1 **(this sheet)** of this booklet **without fail.**
2. Please enter your Hall ticket number on the **OMR answer sheet without fail.**
3. All answers are to be marked on the OMR answer sheet following the instructions provided on the OMR answer sheet.
4. **No additional sheets will be provided.** Rough work is to be done in the booklet itself / space provided in the booklet on pages 10 & 11.
5. **Handover** the OMR answer sheet at the end of the examination.
6. Question paper has two parts: **Part-A** and **Part– B.**
7. **Part-A** consists of 25 objective type questions of one mark each. **There is negative marking of 0.33 marks for every wrong answer.** The marks obtained by the candidate in this part will be used for resolving tie cases.
8. **Part-B** consists of 25 questions. Each correct answer carries two marks. There is no negative marking in this section.
9. Non programmable calculators are permitted.
10. All the symbols used in text have their usual meanings.

PART A

1. Bragg's angle for first and second order reflections by a crystal are respectively θ_1 and θ_2. Then $\sin\theta_1/\sin\theta_2$ is
   A. 1 B. 2 C. ½ D. ¼

2. Which of the following bonds are directional
   A. Van der Waals B. Metallic C. Ionic D. Covalent

3. In NaCl, the Na ions are positively charged Chloride ions are negatively charged. In spite of coulomb attraction between them, the two ions do not collapse
   A. Because of the presence of free electrons
   B. Because of the low melting point
   C. Because of its high specific heat
   D. Because of short range repulsive force

4. The occupation number at room temperature of an electron start lying 0.1 eV above the Fermi level is
   A. 0.500 B. 0.018 C. 0.400 D. 1.000

5. The effective mass of an electron
   A. depends on its effective charge only
   B. can never be negative
   C. can never be infinity
   D. can be positive, negative as well as infinity

6. A phonon is the quantum of
   A. Electromagnetic wave
   B. Elastic wave
   C. Polarization wave
   D. Magnetization wave

7. Which of the following had the hydrogen bonding?
   A. C B. CH_4 C. HF D. NaCl

8. A light beam of intensity I= 3000W/m^2 falling on a perfectly reflecting mirror. The radiation pressure would be
   A. 10^6 N/m^2 B. 10^{-6} N/m^2 C. 10^{-5} N/m^2 D. 10^5 N/m^2

9. The vibrational frequency of CO which has stiff bond of 18.7×10^{15} dyne /cm and reduced mass of the order of 11.4×10^{-24} gms.
   A. 6.45x10 ^{13}/sec
   B. 6.54 x10 ^{13}/sec
   C. 6.45x10 ^{14}/sec
   D. 6.54x10 ^{14}/sec

10. A semiconductor that is electrically neutral has
    A. Equal numbers of positive and negative charges
    B. No majority charge carriers
    C. No minority charge carriers
    D. No free charge carriers

11. In a semiconductor if N(E) is the density of state then the Fermi level is proportional to
    A. N
    B. N^2
    C. $N^{2/3}$
    D. $N^{3/2}$

12. The Jones matrices for a quarter wave plate with fast axis vertical and horizontal respectively are
    A. $\begin{bmatrix}1 & 0\\0 & 0\end{bmatrix}$ and $\begin{bmatrix}0 & 0\\0 & 1\end{bmatrix}$
    B. $e^{\frac{i\pi}{4}}\begin{bmatrix}1 & 0\\0 & -i\end{bmatrix}$ and $e^{\frac{i\pi}{4}}\begin{bmatrix}1 & 0\\0 & -i\end{bmatrix}$
    C. $\frac{1}{2}\begin{bmatrix}1 & i\\-i & 1\end{bmatrix}$ and $\frac{1}{2}\begin{bmatrix}1 & -i\\i & 1\end{bmatrix}$
    D. $\frac{1}{2}\begin{bmatrix}i & 0\\0 & i\end{bmatrix}$ and $\frac{1}{2}\begin{bmatrix}0 & i\\i & 0\end{bmatrix}$

13. For an excitation source of 4358 A^0, the Raman spectrum of benzene shows Raman lines 608 and 846 cm^{-1}. At what wavelength would these stokes Raman lines appear if benzene is irradiated with monochromatic light of 5461 A^0?
    A. 17704 A^0, 17466 A^0
    B. 17466 A^0, 17704 A^0
    C. 1178A^0, 1599 A^0
    D. 1599 cm^{-1}, 1178 cm^{-1}

14. The probability that an energy level is occupied by an electron if the state is at a values of KT above the Fermi level is
    A. 0.269
    B. 0.500
    C. 1.000
    D. 0.125

15. The control terminal (pin 5) of a 555 timer IC is normally connected to ground through a capacitor C= 0.01μF to
    A. Protect the IC from high voltages
    B. Prevent false triggering of the timer
    C. convert the trigger input to a sharp pulse
    D. Suppress any negative triggering pulse

16. Two sources of intensities I and 4I are used in an interference experiment. Find intensities at point where waves from two sources superimpose with a phase difference of (i) $\pi/2$ and (ii) π.

A. 5I, I
B. I, 5I
C. 3I, 5I
D.5I,3I

17. Calculate the thickness of a QWP made of quartz, Given n_0= 1.5442, ne= 1.5533, λ= 800 nm.
A. 3.3 μm
B. 1.1 μm
C. 2.2 μm
D. 4.4 μm

18. The half life of a radioactive element is 2 days. After how many days will 1/32 of element will be left behind?
A. 16 days
B. 12 days
C. 10 days
D. 8 days

19. In a reversible expansion of a gas
A. The change in the internal energy is zero if the gas is ideal
B. The heat absorbed by the system is balanced by the work performed
C. The maximum amount of work is done by the system
D. None of the above

20. In the adiabatic expansion of a gas, the temperature drops because

A. The intermolecular forces are minimized.
B. The work done on the surroundings is obtained at the expenses of the internal energy
C. The heat produced from the work escapes to the surroundings
D. The increasing disorder is balanced by a decrease in the enthalpy

21. What is the density (in units of m^{-3}) of an ideal gas in a vacuum of 10^{-3} torr at room temperature (20^0C).

A. 2.66×10^{19} m^{-3} B. 6.66×10^{19} m^{-3} C. 9.13×10^{19} m^{-3} D. 3.30×10^{19} m^{-3}

22. The Laplace transform of the periodic half sine wave with maximum amplitude E and period T is

A. $\frac{\left(\frac{2\pi}{T}\right)E}{s^2+\left(\frac{2\pi}{T}\right)^2}\left[\frac{1+e^{-sT/2}}{1-e^{-sT}}\right]$

B. $\frac{\left(\frac{2\pi}{T}\right)E}{s^2+\left(\frac{2\pi}{T}\right)^2}\left[\frac{1-e^{-sT/2}}{1+e^{-sT}}\right]$

C. $\frac{\left(\frac{2\pi}{T}\right)E}{s^2+\left(\frac{2\pi}{T}\right)^2}\left[\frac{1+e^{-sT}}{1-e^{-sT/2}}\right]$

D. $\frac{\left(\frac{2\pi}{T}\right)E}{s^2+\left(\frac{2\pi}{T}\right)^2}\left[\frac{1-e^{-sT}}{1+e^{-sT/2}}\right]$

23. The mean free path $\lambda_{e\text{-}i}$ for electron –ion collision is proportional to

A. $T_e^{-3/2}$ B. $T_e^{1/2}$ C. T_e D. T_e^2

24. The phase velocity of motion of ripples on water is $v_p = \left(\frac{2\pi s}{\rho\lambda}\right)^{1/2}$ where the surface tension and ρ the density of the water is. The group velocity of the disturbance made up of wavelengths close to a given λ is

A. $\frac{2v_p}{3}$ B. $\frac{4v_p}{3}$ C. $\frac{3v_p}{2}$ D. $\frac{5v_p}{2}$

25. For electronically excited molecular systems the following statement is true

A. Temperature has no effect on intrinsic transitions probabilities of fluorescence or phosphorescence
B. Emission characteristics are not affected by radiative process
C. Temperature decreases the intrinsic transitions probabilities of fluorescence or phosphorescence
D. Emission characteristics are not affected by nonradiative competitive process.

PART B

26. A sample of BCC iron was placed in an x-ray diffractometer using incoming x-rays with a wavelength λ=0.1541 nm. Diffraction from the {1 1 0} planes was obtained at $2\theta=44.70^0$. Then the value of lattice constant is

A. 0.286 nm B. 0.1 nm C. 1 nm D. 2.86 nm

27. The miller indices of a plane that makes intercepts of $2A^0$, $3A^0$, $4A^0$ on the coordinate of an orthorhombic crystal with a:b:c=4:3:2 is

A. (4 2 1) B. (6 4 3) C. (2 3 4) D. (1 2 4)

28. The valence band of a simple cubic metal has the form $E=Ak^2+B$, where $A=10^{-38}$ Jm^2. The value of m*/m is

A. 0.6 B. 0.8 C. 1.0 D. 0.2

29 Sm^{+3} has five electron in the f-shell (l=3). What are the values of L, S and J

A. $5, \frac{5}{2}, \frac{5}{2}$

B. $3, \frac{5}{2}, \frac{5}{2}$

C. $5, \frac{5}{2}, \frac{3}{2}$

D. $5, \frac{3}{2}, \frac{5}{2}$

30. Germanium having a forbidden gap of 0.72 eV is irradiated with monochromatic radiation. The wavelength required that would be sufficient to create an electron hole pair will be

A. 17000 A^0

B. 17,250 A^0

C. 17,500 A^0

D. None of these

31. The exciting line in an experiment is $5460A^0$ and the raman stokes line is at 5520 A^0. The wavelength of the anti-stokes line is

A. 18514 cm^{-1}

B. 18515 cm^{-1}

C. 5519 cm^{-1}

D. 5520 cm^{-1}

32. If the fundamental band of $H\ ^1Cl\ ^{35}$ lies at 3.56 μm, the wavelength of the corresponding band of H^2Cl^{37} is ?

A. 2.47 μm B. 2.74 μm C. 4.38 μm D. 4.83 μm

33. A conducting wire along the z axis carries a current I. The resulting magnetic vector potential is given by

$$\bar{A} = \hat{z}\,\frac{\mu I}{2\pi}\,ln\left(\frac{1}{\rho}\right)$$

What is the magnetic induction $\bar{B}$?

A. 0 B. $\hat{\varphi}\,\frac{2\mu I}{\pi\rho}$ C. $\hat{\varphi}\,\frac{\mu I}{2\pi\rho}$ D. $\hat{\varphi}\,\frac{3\mu I}{2\pi\rho}$

34. With the quantum mechanical angular momentum operator defined as $\bar{L} = -i(\bar{r} \times \bar{\nabla})$, $L_x + iL_y$ is

A. $e^{i\varphi}\left(\frac{\partial}{\partial\theta} + icot\theta\frac{\partial}{\partial\varphi}\right)$
B. $-e^{-i\varphi}\left(\frac{\partial}{\partial\theta} - icot\theta\frac{\partial}{\partial\varphi}\right)$
C. $e^{-i\varphi}\left(\frac{\partial}{\partial\theta} - icot\theta\frac{\partial}{\partial\varphi}\right)$
D. $-e^{i\varphi}\left(\frac{\partial}{\partial\theta} - icot\theta\frac{\partial}{\partial\varphi}\right)$

35. The three functions sinx e^{-x} and e^{x} are linearly independent. The wronskian w is
A. w= 0
B. w= 4sinx
w=0 for x=±nπ, n=0,1,2....
C. (n+1) π
D. (2n+3) π

36. White light falls normally on a transmission grating that contains 1000 lines /cm. At what angle will light of wavelength λ=650 nm emerge in the first order spectrum?
A. 0^0 B. 45.15^0 C. 86.24^0 D. 3.73^0

37. The hole to electron mobility ratio in a heavily doped n type semiconductor is 0.4, if The dopant concentration is 4.2×10^{18} atoms/m^3 and intrinsic concentration is 1.5×10^{14} atoms /m^3 then the ratio of the conductivity of the n-type semiconductor to that of the intrinsic semiconductor is (assume semiconductor is of same material and temperature is constant).

A. 2×10^4 B. 5×10^{-4} C. 2×10^{-4} D. 5×10^3

38. In an experiment to characterize a JFET at a voltage (V_{GS}) = 0V for a drain source voltage (V_{DS}) = 5 V the drain current (I_D) = 5mA. Keeping V_{GS} constant, when V_{DS} = 10V, I_D= 5.25 mA. In the third experiment when V_{DS}= 10V at V_{GS}= -0.25 V the I_D = 4mA. The amplification of JFET is

A. 100 B. 20 C. 50 D. 55.5

39. At what temperature the rates of spontaneous and stimulated emissions are equal? Assume λ= 500 nm.
    A. 41562 ^{0}K
    B. 31462 ^{0}K
    C. 44562 ^{0}K
    D. 41462 ^{0}K

40. NA of an optical fiber is 0.5 and core R.I. is 1.54. Find RI of cladding
    A. 1.496
    B. 1.456
    C. 1.436
    D. 1.416

41. Find the degree of degeneracy for energy level $17K^2/2mL^2$ for a particle in a cubic box.
    (A) Two fold
    (B) Four fold
    (C) One fold
    (D) Three fold

42. A rod is moving with 0.6c velocity in the laboratory. An observer in lab measures the length to be 1m. The actual length of rod is
    A. 1.0 m
    B. 1.25m
    C. 1.6m
    D. 0.6 m

43. The tire of a bicycle is filled with air to a gauge pressure of 550 kPa at 20 ^{0}C . What is the gauge pressure in the tire after a ride on a hot day when the tire air temperature is 40 ^{0}C ? (Assume constant volume and a constant atmospheric pressure of 101 kPa.
    A. 490 kPa B. 594.4 kPa C. 692.3 kPa D. 292.2 kPa

44. At sufficient high temperature, the van der waals equation of state has the form P=RT/($\bar{V} - b$) this implies that:
    A. Intermolecular attraction is most important at these temperatures.
    B. The gas behaves like an ideal gas at these temperatures.
    C. Intermolecular repulsion is the dominant interaction at these temperature .
    D. The pressure is then independent of the type of gas.

45. A cylindrically symmetric plasma column in a uniform B field has $n(r) = n_0 e^{-\frac{r^2}{r_0^2}}$ and $n_i = n_e = n_0 e^{\frac{e\varphi}{kT}}$, evaluate the diamaganetic current density of radius j_D in A/m^2 for B=0.4T, $n_0 = 10^{16}$ m^{-3}, $kT_e = kT_i$= 0.25 eV, $r = r_0$ = 1.0 cm .

    A. 0.125 B. 0.471 C. 0.147 D. 0.251

46. $\int_0^{2\pi} \frac{cos^2\theta}{26-10cos2\theta} d\theta =$

A. $\frac{\pi}{20}$ B. $\frac{\pi^2}{20}$ C. $\frac{\pi^2}{16}$ D. $\frac{\pi}{16}$

47. The complex potential $F(z) = z + \frac{1}{z}$ representing fluid flow around a long cylinder of unit radius. The velocity and stagnation points of the flow are

A. $1 - \frac{1}{\bar{z}^2}, z = \mp 1$

B. $1 - \frac{1}{\bar{z}^2}, z = 0,1$

C. $\left(1 - \frac{1}{\bar{z}^2}\right)^2, z = \mp 1$

D. $\left(1 - \frac{1}{\bar{z}}\right)^2, z = 0,1$

48. Three equal masses are connected by springs so that they move along a circle with one end of the spring fixed. The eigen frequencies of the system and the Langrangian in normal co-ordinates are respectively

A. $(2-\sqrt{2})\frac{k}{m}, (2+\sqrt{2})\frac{k}{m}, 2\frac{k}{m}, \frac{1}{2}m(\dot{Q}_1^2 - \omega_1^2 Q_1^2 + \dot{Q}_2^2 - \omega_2^2 Q_2^2 + \dot{Q}_3^2 - \omega_2^2 Q_3^2)$

B. $(\sqrt{2}-2)\frac{k}{m}, (\sqrt{2}+2)\frac{k}{m}, \sqrt{2}\frac{k}{m}, \frac{1}{2}m(\dot{Q}_1^2 + \dot{Q}_2^2 + \dot{Q}_3^2)$

C. $(\sqrt{2}-2)\frac{k}{m}, (\sqrt{2}+2)\frac{k}{m}, \sqrt{2}\frac{k}{m}, \frac{1}{2}m(\omega_1^2\dot{Q}_1^2 + \omega_2^2\dot{Q}_2^2 + \omega_3^2\dot{Q}_3^2)$

D. $(2-\sqrt{2})\frac{k}{m}, (2+\sqrt{2})\frac{k}{m}, 2\frac{k}{m}, \frac{1}{2}m(\omega_1^2\dot{Q}_1^2 + \omega_2^2\dot{Q}_2^2 + \omega_3^2\dot{Q}_3^2)$

49. The electron and proton of a Hydrogen atom interact through the gravitational interaction. Following perturbation theory, what is the relative energy shift $\Delta E/E_{is}$, where ΔE is the energy change due to gravitational force and E_{is} is the ground state energy of Hydrogen

A. 8.8×10^{-40} B. 6.65×10^{-37} C. 8.8×10^{-37} D. 6.65×10^{-40}

50. What is the Deby length (λ_D) and number of particles N_D in a Debye sphere for the earth's ionosphere with n= 10^{12} m^{-3}, kT_e= 0.1eV.

A. 10^{-4} m, 4.8×10^{10} m^{-3}
B. 6.6×10^{-7} m, 1.2×10^{11} m^{-3}
C. 10^{-1} m, 6.9×10^{18} m^{-3}
D. 2.3×10^{-3} m, 5.4×10^{10} m^{-3}