TEST SERIES CSIR-NET/JRF DEC. 2018

BOOKLET SERIES D

Paper Code 05

Test Type: TEST SERIES

[SOLID STATE AND ATOMIC & MOLECULAR PHYSICS]

PHYSICAL SCIENCES

Duration: 01:30 Hours

Date: 30-11-2018

Maximum Marks: 80

Read the following instructions carefully:

* Single Paper Test is divided into **TWO** Parts.

Part - A: This part shall carry **10** questions. Each question shall be of **2 marks.**

Part - B: This part shall contain **30** questions. Each question shall be of **2 marks**.

* Darken the appropriate bubbles with HB pencil/Ball Pen to write your answer.

* There will be negative marking @25% for each wrong answer.

* The candidates shall be allowed to carry the Question Paper Booklet after completion of the exam.

* For rough work, blank sheet is attached at the end of test booklet.

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PART-A : GENERAL APTITUDE

1. What should be the unit digit ?
$(24562)^{1249} - (5677)^{834}$
(a) 4 (b) 7 (c) 3 (d) 9

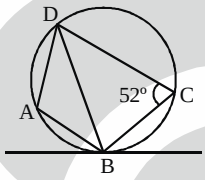
2. X and Y runs a race of 4.5 km in a circular course of 400 m. The speed of X and Y are in the ratio 5 : 4. The number of times X passes Y during the race is
(a) 4 (b) 3 (c) 2 (d) 5

3. P, Q, R can walk at the speed of 3 km, 4 km and 5 km per hour respectively. They start to walk from Delhi at 12 pm, 1 pm and 2 pm respectively, when Q catches P, then Q sends P back with a book to deliver to R. At what time will R get the book ?
(a) 4 : 30 pm (b) 4 : 15 pm (c) 5 pm (d) 4 pm

4. Iron is 20 times heavier than tin and lead is 9 times heavier than tin. In what ratio iron and lead is to be mixed to get a alloy 14 times heavier than tin ?
(a) 7 : 2 (b) 5 : 6 (c) 3 : 4 (d) 4 : 3

5. What is the actual profit percentage if a shopkeeper sells rice at 20 % profit on cost price and uses a weight which is 25 % less than the standard weight ?
(a) 40 % (b) 50 % (c) 75 % (d) 60 %

6. In the given figure, what is the value of $\angle BAD$?



(a) 128° (b) 52° (c) 38° (d) 90°

7. Ravi starts walking facing north and walks 5 km, then he turns to his right and walks for 10 km, next he again turns to his right and walks for 10 km. Now, he turns to his left and walk for 2 km and stops there. What is the distance between his starting point and the final point ?
(a) 7 km (b) 13 km (c) 9 km (d) 10 km

8. Six friends P, Q, R, S, T, U are sitting in a row facing the East. R is between P and T. Q is just to the right of T, but to the left of S. U is not at the right end. Who is at the extreme right end ?
(a) P (b) R (c) Q (d) S

9. Pointing to a lady in a photograph, Simran said, "Her son's father is the Son-in-law of my mother". How is Simran related to the lady in the photograph ?
(a) Aunt (b) Sister (c) Daughter (d) Mother

10. Find out what should come in place of question mark (?) ?
3, 7,23, ? 479
(a) 63 (b) 95 (c) 120 (d) 98

PART-B : SOLID STATE AND ATOMIC & MOLECULAR PHYSICS

11. In a simple cubic of lattice constant 0.2 nm, the number of atoms per mm^2 along with 110 plane is
(a) 1.32×10^{13} (b) 2.14×10^{13} (c) 1.77×10^{13} (d) 4.32×10^{13}

12. A metal piece of dimension 2mm×2mm×2mm contains 4×10^{16} electrons. The magnitude of the fermi wave vector of the system, in the free electron approximation is
(a) 5.28×10^{8} m^{-1} (b) 6.04×10^{6} m^{-1} (c) 3.84×10^{7} m^{-1} (d) 4.32×10^{5} m^{-1}

13. Magnon (energy quanta of spin wave) follows $\omega^2 = \omega_0^2\left(1-\cos^2 ka\right)$ dispersion relation in some solids. The specific heat of magnon at low temperature varies as
(a) T^3 (b) $T^{3/2}$ (c) T (d) T^3

14. The frequency of AC current flows across Josephson junction for 1 mV applied DC bias is
(a) 4483 MHz (b) 483 GHz (c) 483 THz (d) 483 KHz

15. Graphite has a layered crystal structure in which the coupling between carbon atoms in different layers is much weaker than the atoms in the same layer. The total specific heat at low temperature (where T is the temperature)
(a) $AT + BT^3$ (b) $AT + BT^2$ (c) $A + BT$ (d) $A + BT^3$

16. An electron of mass m moves in a square lattice of lattice spacing a. If there are two electrons per atom, then which of the following is correct?
(a) Valence band is completely filled (b) Valence band is half filled
(c) Valence band is 1/3rd filled (d) none of these

17. Assume that the energy of the two particles in the field of each other is given by $U(r) = -\frac{\alpha}{r} + \frac{\beta}{r^8}$ where α and β are cosntants and r is the distance between the centres of particles. In stable configuration, the ratio of energy of attraction to the energy of repulsion will be
(a) 1 (b) 4 (c) 6 (d) 8

18. For a diatomic linear chain, the phonon dispersion relation $\omega(k)$ has two branches corresponding to + and – sign respectively

$$\omega(k) = f\left(\frac{1}{M_1}+\frac{1}{M_2}\right) \pm f\left[\left(\frac{1}{M_1}+\frac{1}{M_2}\right)^2 - \frac{4}{M_1M_2}\sin^2\frac{qa}{2}\right]^{1/2}$$

There are two atoms in the unit cell with masses M_1 and M_2 and the force constant of nearest neighbour interaction is F and the effective mass $\mu = \frac{M_1M_2}{M_1+M_2}$ is kept constant. The velocity of sound will be

(a) $\frac{a}{2}\sqrt{\frac{f}{M_1+M_2}}$ (b) $\frac{a}{2}\sqrt{\frac{f}{2(M_1+M_2)}}$ (c) $a\sqrt{\frac{f}{M_1+M_2}}$ (d) $\frac{a}{4}\sqrt{\frac{f}{M_1}}$

19. Sodium transforms from bcc to hcp at about T = 23K. Assumig that the density remains fixed and $\frac{c}{a}$ ratio is ideal. The hcp lattice spacing, a [given that the cubic lattice spacing $a' = 4.23\text{Å}$ in the cubic phase] is
(a) 3.77 Å (b) 2.70 Å (c) 3.88 Å (d) 4.77 Å

20. The effective mass tensor (M_{ij}) for electrons in a simple cubic tight binding band at the centre (k = (0, 0, 0) of the brillion zone will be

(a) $\frac{\hbar^2}{E_1a^2}\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$ (b) $\frac{\hbar^2}{E_1a^2}\begin{pmatrix}1&0&0\\0&1&0\\1&0&0\end{pmatrix}$ (c) $\frac{\hbar^2}{E_1a^2}\begin{pmatrix}1&0&0\\0&-1&0\\0&0&-1\end{pmatrix}$ (d) $\frac{\hbar^2}{E_1a^2}$

Where, $E(k) = -E_1\left(\cos k_x a + \cos k_y a + \cos k_z a\right)$

21. The critical temperature (T_C) of Hg is about 4K. The superconducting band gap accounted for BCS theory is about
(a) 1.217 meV (b) 2.314 meV (c) 5.217 meV (d) 7.271 meV

22. A monoatomic monovalent metal has an fcc structure of lattice constant *a*. The metal consists of N primitive unit cell (N is very large). Take the conduction electron in the metal as free independent electron. Then the ratio of the volume of Fermi sphere to the volume of the first Brillion zone is

(a) 2 (b) $\frac{1}{2}$ (c) $\frac{1}{3}$ (d) 3

23. From the phonon dispersion Relation, $\omega(k) = \sqrt{\frac{4c}{M}} \sin\frac{ka}{2}$
in a monoatomic linear lattice of N with extending 0 to L atoms with nearest neighbour interaction, then the density of the vibrational states, if ω_m is the maximum frequency (where *a* is the lattice constant, *c* is the force constant)

(a) $\frac{2N}{a}\frac{1}{\sqrt{\omega_m^2-\omega^2}}$ (b) $\frac{N}{a}\frac{1}{\sqrt{\omega_m^2-\omega^2}}$ (c) $\frac{N}{2a}\frac{1}{\sqrt{\omega_m^2-\omega^2}}$ (d) $\frac{2N}{a}\frac{1}{\sqrt{\omega_m^2+\omega^2}}$

24. A long thin super conducting wire of lead having radius of 1mm at 4.2K. The critical temperature for lead is 7 K and critical magnetic field is 1×10^5 A/m then the critical current density
(a) 0.71×10^6 A/m^2 (b) 3.84×10^7 A/m^2 (c) 1.71×10^8 A/m^2 (d) 12.8×10^9 A/m^2

25. A hypothetical semiconductor has a conduction band that can be described by $E_c(k) = E_1 - E_2\cos ka$ and a valence band that can be described by $E_v(k) = E_3 - E_4\sin^2 ka$ where $E_i > 0$ $(i = 1,2,3,4)$ and $-\frac{\pi}{a} \le k \le \frac{\pi}{a}$ than the band width of the conduction band anad band gap between them

(a) $E_2, E_3 + E_1 + E_2$ (b) $2E_2, E_1 - E_2 - E_3$ (c) $2E_2, E_1 - E_2$ (d) $E_3, E_2 - E_3$

26. The interaction Hamiltonian in spin-orbit coupling is given by the $\hat{H} = \alpha\vec{L}\cdot\vec{S}$ where $\vec{L}$ is the orbital angular momentum and $\vec{S}$ is the spin angular momentum of the electron. Then, the difference in the energy level of $^2D_{5/2}$ and $^2D_{3/2}$ is $(\hbar = 1)$

(a) $\frac{5}{2}\alpha$ (b) $\frac{3}{2}\alpha$ (c) $\frac{1}{2}\alpha$ (d) α

27. The numbers of levels into which $^2D_{3/2}$ splits when a very strong magnetic field (greater to break the spin-orbit coupling) is applied is
(a) 12 (b) 10 (c) 7 (d) 4

28. The vibrational Raman spectrum of a molecule is recorded. The Raman shift for the fundamental line from the Rayleigh line is measured to be 178 cm^{-1}. The equilibrium frequency of the oscillation is 2100 cm^{-1}. The anharmonicity constant of the oscillator is
(a) 0.03 (b) 0.02 (c) 0.05 (d) 0.1

29. At a temperature of 5000K, the most intense transition in a rotational speectra occurs at a *J* level which is equal to (B = 10 cm^{-1})
(a) 2 (b) 3 (c) 4 (d) 5

30. For a transition $^2D_{3/2}\left(m_j=\frac{3}{2}\right)\rightarrow {}^2P_{1/2}\left(m_j=\frac{1}{2}\right)$ in presence of a magnetic field *B*, the energy of the photon emitted (in units of μ_B B) is (μ_B is the Bohr magneton)

(a) $\frac{17}{15}$ (b) 1 (c) $\frac{11}{15}$ (d) $\frac{13}{15}$

31. For the Zeeman spectrum of the transition $^2D_{5/2}\rightarrow {}^2P_{3/2}$, how many distinct spectral lines are observed?

(a) 3 (b) 6 (c) 9 (d) 12

32. The minimum wavelength of X-rays emitted from an X-ray tube operating at a voltage of 10^4 volts is roughtly equal to

(a) 2.5Å (b) 2.0Å (c) 1.5Å (d) 1.2Å

33. The number of spectroscopic terms of the electronic configuration $2p^12d^1$ is

(a) 6 (b) 9 (c) 12 (d) 15

34. When a hydrogen atom emits a photon of energy 11.80 eV, its angular momentum changes by

(a) $\hbar$ (b) $2\hbar$ (c) $3\hbar$ (d) $4\hbar$

35. An electron is an atom is subjected to a magnetic field of 0.01T. The frequency with which the electron orbit precesses around the magnetic field is

(a) 2.22×10^7 Hz (b) 3.25×10^7 Hz (c) 2.22×10^8 Hz (d) 3.25×10^8 Hz

36. If the rate of stimulated emission for a two level system in thermal equilibrium is $B_{21} = 10^{20}\ s^{-1}$. The stimulating radiation has a frequency of 560 THz. Then, the lifetime of state 2 is

(a) 8.27×10^{-7} s (b) 9.22×10^{-8} s (c) 7.39×10^{-9} s (d) 6.25×10^{-10} s

37. Which one of the following gases of diatomic molecules is Raman active, infrared active and NMR inactive?

(a) $^1H-{}^1H$ (b) $^{12}C-{}^{16}O$ (c) $^1H-{}^{35}Cl$ (d) $^{16}O-{}^{16}O$

38. Consider a hydrogen-like ionized atom with atomic number Z with a single electron. In the emission spectrum of this atom, the photon emitted in the n = 2 to n = 1 transition has energy 74.8 eV higher than the photon emitted in the n = 3 to n = 2 transition. The ionization energy of the hydrogen atom is 13.6 eV. The value of Z is

(a) 9 (b) 3 (c) 2 (d) 4

39. Consider the following statements

(P) The ground state term for the configuration $4p^25s^1$ in L-S coupling is $^2P_{1/2}$.

(Q) Total degeneracy of $4p^25s^1$ levels is 30.

(R) The ground state term for the atom F(z = 9) is $^2P_{3/2}$.

Which of the following statements are correct?

(a) Only P and Q (b) Only Q and R (c) Only P and R (d) None is correct

40. A gas laser cavity is designed to operate at $\lambda = 0.8\ \mu m$ with a cavity of length *d* meters with this setup the frequency is found to be 50 Hz larger than the desired frequency. If the effective length of the cavity is changed by 10^{-13} metres to retune the laser, then the cavity length *d* is

(a) 0.36 m (b) 2.64 m (c) 0.75 m (d) 1.34 m

space for rough work

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Physical Sciences (CSIR-NET/JRF)

Test Series- (D)

Date: 30-11-2018

ANSWER KEY

PART-A

1. (c)	2. (c)	3. (b)	4. (b)	5. (d)	6. (a)	7. (b)
8. (d)	9. (b)	10. (b)				

PART-B

11. (c)	12. (a)	13. (a)	14. (b)	15. (b)	16. (a)	17. (d)
18. (b)	19. (a)	20. (a)	21. (a)	22. (b)	23. (d)	24. (d)
25. (b)	26. (a)	27. (c)	28. (c)	29. (a)	30. (d)	31. (d)
32. (d)	33. (c)	34. (a)	35. (a)	36. (b)	37. (b)	38. (b)
39. (b)	40. (c)					