Signature of Invigilators

1. .....

2. .....

Roll No. | | | | | |

(In figures as in Admit Card)

PHYSICAL SCIENCES

Paper III

Roll No. .....

.....

(In words)

D—0202

Name of Areas/Section (if any) .....

Time Allowed : $2\frac{1}{2}$ Hours] [Maximum Marks : 200

Instructions for the Candidates

1. Write your Roll number in the space provided on the top of this page.
2. Write name of your Elective/Section if any.
3. Answer to short answer/essay type questions are to be written in the space provided below each question or after the questions in test booklet itself. No additional sheets are to be used.
4. Read instructions given inside carefully.
5. Last page is attached at the end of the test booklet for rough work.
6. If you write your name or put any special mark on any part of the test booklet which may disclose in any way your identity, you will render yourself liable to disqualification.
7. Use of calculator or any other Electronics Devices are prohibited.
8. There is no negative marking.
9. You should return the test booklet to the invigilator at the end of the examination and should not carry any paper outside the examination hall.

પરીક્ષાર્થીઓ માટે સૂચનાઓ :

૧. આ પૃષ્ઠના ઉપલા ભાગે આપેલી જગ્યામાં તમારી ક્રમાંક સંખ્યા (રોલ નંબર) લખો.

૨. તમે જે વિકલ્પનો ઉત્તર આપો તેનો સ્પષ્ટ નિર્દેશ કરો.

૩. ટૂંક નોંધ કે નિબંધ પ્રકારના પ્રશ્નોના ઉત્તર દરેક પ્રશ્નની નીચે આપેલી જગ્યામાં જ લખો. વધારાના કોઈ કાગળનો ઉપયોગ કરશો નહીં.

૪. અંદર આપેલી સૂચનાઓ ધ્યાનથી વાંચો.

૫. આ ઉત્તરપોથીને અંતે આપેલું પૃષ્ઠ કાચા કામ માટે છે.

૬. આ ઉત્તરપોથીમાં ક્યાંય પણ તમારી ઓળખ કરાવી દે એવી રીતે તમારું નામ કે કોઈ ચોકકસ નિશાની કરી હશે તો તમે આ પરીક્ષા માટે ગેરલાયક સાબીત થશો.

૭. કેલકયુલેટર અથવા ઈલેકટ્રોનિકસ સાધનો જેવા ઉપયોગ કરવો નહીં.

૮. નકારાત્મક ગુણાંક પદ્ધતિ નથી.

૯. પ્રશ્નપત્ર લખાઈ રહે એટલે આ ઉત્તરપોથી તમારા નિરીક્ષકને આપી દેવી. પરીક્ષાખંડની બહાર કોઈપણ પ્રશ્નપત્ર લઈ જવું નહીં.

FOR OFFICE USE ONLY
Marks Obtained

Question Number	Marks Obtained	Question Number	Marks Obtained	Question Number	Marks Obtained
1		26			
2					
3					
4					
5					
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7					
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11					
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23					
24					
25					

Total Marks Obtained.....

Signature of the co-ordinator.....
(Evaluation)

ANTILOGARITHMS

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ANTILOGARITHMS

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49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1 2 3	4 4 5	6 7 8

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1 2 3	3 4 5	6 7 8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1 2 3	3 4 5	6 7 8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1 2 2	3 4 5	6 7 7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1 2 2	3 4 5	6 6 7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1 2 2	3 4 5	6 6 7
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1 2 2	3 4 5	5 6 7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1 2 2	3 4 5	5 6 7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1 2 2	3 4 5	5 6 7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1 1 2	3 4 4	5 6 7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1 1 2	3 4 4	5 6 7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1 1 2	3 4 4	5 6 6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1 1 2	3 4 4	5 6 6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1 1 2	3 3 4	5 6 6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1 1 2	3 3 4	5 5 6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1 1 2	3 3 4	5 5 6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1 1 2	3 3 4	5 5 6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1 1 2	3 3 4	5 5 6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1 1 2	3 3 4	5 5 6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1 1 2	3 3 4	4 5 6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1 1 2	2 3 4	4 5 6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1 1 2	2 3 4	4 5 6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1 1 2	2 3 4	4 5 5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1 1 2	2 3 4	4 5 5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1 1 2	2 3 4	4 5 5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1 1 2	2 3 4	4 5 5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1 1 2	2 3 3	4 5 5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1 1 2	2 3 3	4 5 5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1 1 2	2 3 3	4 4 5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1 1 2	2 3 3	4 4 5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1 1 2	2 3 3	4 4 5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1 1 2	2 3 3	4 4 5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1 1 2	2 3 3	4 4 5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1 1 2	2 3 3	4 4 5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1 1 2	2 3 3	4 4 5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1 1 2	2 3 3	4 4 5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1 1 2	2 3 3	4 4 5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1 1 2	2 3 3	4 4 5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0 1 1	2 2 3	3 4 4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0 1 1	2 2 3	3 4 4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0 1 1	2 2 3	3 4 4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0 1 1	2 2 3	3 4 4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0 1 1	2 2 3	3 4 4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0 1 1	2 2 3	3 4 4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0 1 1	2 2 3	3 4 4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0 1 1	2 2 3	3 4 4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0 1 1	2 2 3	3 4 4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0 1 1	2 2 3	3 4 4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0 1 1	2 2 3	3 4 4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0 1 1	2 2 3	3 4 4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0 1 1	2 2 3	3 3 4

PHYSICAL SCIENCES

PAPER III

Note :—(*i*) Part A consists of **10** questions of **10** marks each. Attempt each question in about **200** words (2 pages). *All* questions are compulsory.

(*ii*) Part B consists of **16** questions of **25** marks each. Attempt any *four* questions from Part B. Each question is to be answered in about **500** words (5 pages).

(*iii*) Log tables are allowed, but not a calculator.

PART A

1. (*a*) Prove that

$$\vec{\nabla} \times \psi \vec{\nabla} \psi = 0.$$

(*b*) Show that $\begin{pmatrix} 0 & 1 & -1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$ is a Hermitian matrix. Also find out the eigenvalues and eigen vectors of this matrix.

2. The Lagrangian of a particle of mass m is $L = m\dot{x}\dot{y} - m\omega_0^2 xy$.

(*a*) Write down the equations of motion for this system. What is the physical system represented by this Lagrangian ? What is the energy E of this system ? Express E in terms of coordinates and momenta.

(*b*) Find the Hamiltonian H associated with the above L. Compare E and H. Comment on your result.

3. Show that the total scattering cross-section of point particles from a perfectly rigid sphere of radius R is πR^2.

4. A current I is uniformly distributed over a wire of circular cross-section with

radius R. Find the volume current density $\vec{J}$. If the current density in this wire is proportional to the distance from the axis, find the total current in the wire and establish the continuity equation

$$\vec{\nabla} . \vec{J} + \frac{\partial \rho}{\partial t} = 0.$$

5. Write down Maxwell's equations for an ohmic conducting medium. Obtain the wave equations satisfied by $\vec{E}$ and $\vec{B}$. Assuming plane wave solutions of these equations obtain the relation between the propagation vector $\vec{k}$ and the frequency ω of these solutions in terms of the conductivity σ, the permittivity ϵ and permeability μ of the medium. Obtain an expression for the refractive index in terms of ω, ϵ, μ and σ.

6. (*a*) If the resolving limit of the electron microscope is twice the wavelength of its accelerated electron, find the resolving limit for 60 keV electrons.

   (*b*) Estimate the ground state energy of Hydrogen atom using Heisenberg uncertainty principle.

7. (*a*) Applying the variation method estimate the ground state energy of a two-electron atom.

   (*b*) If the total angular momentum of a system is $\vec{J} = \vec{L} + \vec{S}$, prove that

   $$[J_x, z] = -i\hbar y \quad \text{and} \quad [J_x, y] = i\hbar z.$$

8. A photon gas confined in a volume V is in thermal equilibrium at temperature T. The photon is a massless particle so that $\epsilon = pc$.

   Given that the number of states of photons in volume V with energy between ϵ and $\epsilon + d\epsilon$ is

$$D(\epsilon)\, d\epsilon = \frac{V}{\pi^2 (\hbar c)^3}\, \epsilon^2\, d\epsilon,$$

obtain the Planck distribution law for the spectral energy density along the following lines :

What is the chemical potential of a photon gas ? Show that the temperature dependence of the average energy, $< U >$, of the photon gas is proportional to T^4.

9. Describe a method to determine crystal structure of a polycrystalline material by X-ray diffraction. If X-rays are to be replaced by neutrons, explain why one has to use thermal neutrons.

10. State the principles of least squares. Describe the procedure of least squares for fitting a straight line to a set of five (x_i) assumed experimental points.

PART B

11. What are different types of transistor biasing ? Give the circuit diagram of a common emitter *n-p-n* transistor biasing circuit with a fixed bias to the emitter. Using typical numerical values for the different resistances in the circuit and power supply value, calculate the circuit parameters I_B, I_C and V_{CE}.

12. What is a discriminator ? Give the circuit diagram of the Schmidt trigger and discuss its operation. Illustrate with an example how and where it is used.

13. Draw a circuit diagram of a binary 1 bit memory cell using basic gates. In turn using it as building blocks draw the schematic diagram of a series in-parallel out 5 digit shift register. How to convert it into parallel-in parallel-out register ?

14. What are the drawbacks of a basic R-S Flip-Flop ? How are they rectified to get a perfect Master-Slave Flip-Flop ? Explain the development of the stages using the truth tables.

15. NMR is the nuclear analog of ESR. Discuss this statement keeping in view the nuclear spin and magnetic moment, Bohr magneton and Zeeman splitting. Show that the resonance frequency lies in radio frequency range. Nuclear magnetic resonance in water is due to the protons of hydrogen. Calculate the field when the resonance frequency $\nu_r = 60$ MHz.

[Given : $\mu_B = 5.05 \times 10^{-27}$ ampere . meter^2, $\mu_P = 2.793\ \mu_N$, $I = \frac{1}{2}$].

16. Why is Stark effect more important in molecular spectroscopy than Zeeman effect ? Under what condition the first order Stark effect is observed ? Obtain the expression for energies and discuss the selection rules.

17. Discuss the L-S coupling. How does it lead to Hund's rule ? State the Hund's rules and illustrate the applications of these rules.

18. In spite of having equal probabilities for the absorption and the stimulated emission in a two level system we do not generally observe the latter. Why ? What must we do to observe it ? What are different techniques to achieve it ? Is it a sufficient condition for lasing ? If not, how one can obtain lasing in He-Ne laser ?

19. In dielectric materials effect of polarization reduces the field while in case of ferromagnetic materials effect of polarization increases the field. Discuss.

20. Discuss the salient features of BCS theory. How one can explain Josephson effect on the basis of this theory ?

21. Derive expression for specific heat at constant volume due to the free electrons in metals. Calculate the temperature at which the electronic contribution to C_v of silver eventually become identical to the Dulong-Petit value. E_F and N_F for silver are 5 eV and 10^{28} respectively.

22. Explain the construction of first four Brillouin zone for a simple cubic lattice in two dimensions. Show that for a simple square lattice the kinetic energy of a free electron at the corner of the first Brillouin zone is double than that of an electron at the centre of the side face of the zone.

23. (*a*) Describe the basic nuclear properties and explain how nuclear forces can be accounted for by liquid drop model.

(*b*) Point out validity and limitations of single particle shell model.

24. (*a*) What is a compound nucleus ? Discuss Bohr's theory of compound nucleus.

(*b*) By giving necessary reactions explain how the neutrons are produced. What is the significance of neutron sources ?

25. Discuss Fermi theory of β-decay to explain the β-spectral shapes. What is non-conservation of parity ? Describe how this was established by an experiment on β-decay.

26. (*a*) Give in brief the classification of fundamental forces and elementary particles.

(*b*) State the significance of the quadruple moment of a nucleus and obtain expression for this quantity.

Q. No. .....