Signature of Invigilators

1. .....

2. .....

Roll No. | | | | | |

(In figures as in Admit Card)

PHYSICAL SCIENCES

Paper III

Roll No. .....

.....

(In words)

D/03/2

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 કયાંય 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					
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Total Marks Obtained.....

Signature of the co-ordinator.....

(Evaluation)

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·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0 0 1	1 1 2	2 2 2
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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 3	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	3 3 4	4 5 6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1 1 2	3 3 4	4 5 6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1 1 2	3 3 4	4 5 5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1 1 2	3 3 4	4 5 5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1 1 2	3 3 4	4 5 5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1 1 2	3 3 4	4 5 5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1 1 2	3 3 3	4 5 5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1 1 2	3 3 3	4 5 5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1 1 2	3 3 3	4 4 5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1 1 2	3 3 3	4 4 5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1 1 2	3 3 3	4 4 5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1 1 2	3 3 3	4 4 5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1 1 2	3 3 3	4 4 5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1 1 2	3 3 3	4 4 5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1 1 2	3 3 3	4 4 5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1 1 2	3 3 3	4 4 5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1 1 2	3 3 3	4 4 5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1 1 2	3 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. *All* questions are compulsory.

(*ii*) Part B consists of **16** questions of **25** marks each. Attempt any *four* questions from Part B.

PART A

1. Give the Fourier series analysis of finite wave train and establish the uncertainty principle.

2. Show that the electric and magnetic field vectors satisfy

$$\left(\nabla^2 - \frac{1}{v^2}\frac{\partial^2}{\partial t^2}\right)\begin{pmatrix}\vec{E}\\ \vec{H}\end{pmatrix} = 0$$

where $v = c/n$ and n is refractive index of the medium which is source-free. Also show that the Poynting's vector for a plane electromagnetic wave is

$$\vec{S} = \sqrt{\frac{\epsilon}{\mu}}\,|\vec{E}_0|^2\,\frac{\vec{k}}{|\vec{k}|}\cos^2(\vec{k}\,.\,\vec{x} - \omega t)$$

where E_0 is amplitude of the plane wave.

3. State clearly the Biot-Savart law. If two long parallel wires carry a steady current I_1 and I_2 are separated by a distance R, then show that the force per unit length between two wires is proportional to $I_1 I_2/R$.

4. (*a*) Given a virial theorem $<T> = \frac{-1}{2}<\sum_i \vec{F}_i\,.\,\vec{r}_i>$, show that, for potential

$$V = ar^{n+1},\ <T> = \frac{n+1}{2}<V>.$$

(*b*) Define Legendre transform. Show that the Hamiltonian $H(q, p)$ is a Legendre transform of Lagrangian $L(q, \dot{q})$.

5. Consider a motion of a simple pendulum.

   (*a*) How many degrees of freedom are for simple pendulum ?

   (*b*) Write equations of constraints for its motion.

   (*c*) Write Lagrangian for the simple pendulum.

   (*d*) Write Hamiltonian for the simple pendulum and write Hamilton's equations. Solve these equations in small angle approximation ($\sin\theta \approx \theta$).

6. (*a*) Using Heisenberg's uncertainty principle estimate the ground state energy of linear harmonic oscillator.

   (*b*) Establish the commutation relations among the components of orbital angular momentum $\vec{L}$.

7. Considering two-fold degeneracy prove that perturbation removes degeneracy and discuss Stark effect on the first excited state of Hydrogen atom.

8. (*a*) Using canonical distribution, derive Maxwell-Boltzmann velocity distribution for an ideal gas at absolute temperature T.

   (*b*) Find the average energy of the gas at temperature T.

9. Discuss the differences in the detection mechanisms for gamma rays, neutrons and β-particles.

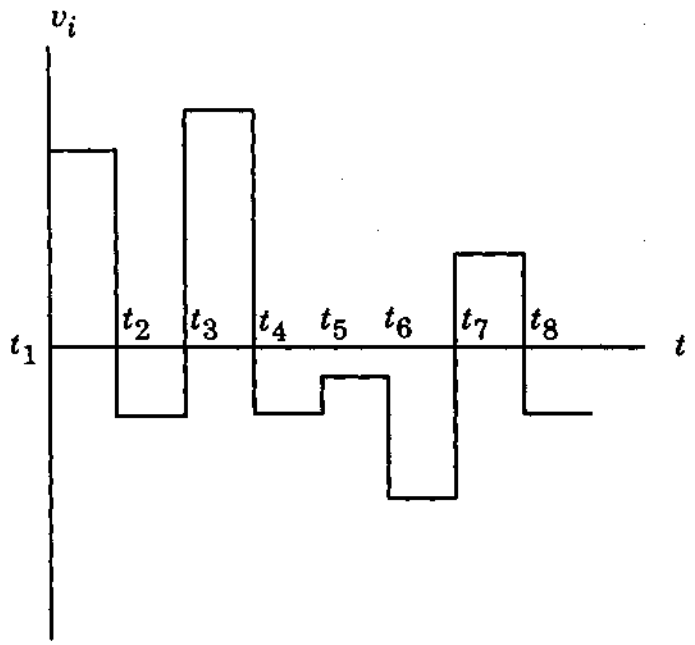
10. Distinguish between the voltage pulse and current pulse at the output of a photomultiplier in a scintillation detector. Use the output circuit network to discuss your answer.

PART B

11. Explain P-N junction *v-i* characteristics. If in a semiconductor diode, the i_{D1} = 10 mA changes to i_{D2} = 100 mA at the two different operating points with corresponding voltages V_{D1} and V_{D2} respectively, calculate the corresponding changes in voltage $\Delta V_D = V_{D1} - V_{D2}$ at room temperature 25°C. Given that Boltzmann constant = 1.38×10^{-23} J/K, e = electron charge = 1.6×10^{-19} coulomb.

12. Draw a clamping circuit using an Op-Amp. Explain its working with appropriate wave-forms.

If an input voltage v_i to the clamping circuit is shown in the figure, draw the output wave-forms from time $t = t_1$ to t_8.



13. Design a voting machine for a corporation that has boardmembers possessing all the stocks distributed as follows :

A	owns	45	percent
B	owns	30	percent
C	owns	15	percent
D	owns	10	percent

Each member has a percentage vote equal to his holdings and a total vote greater than 50 percent required to pass a motion.

14. Construct an astable multivibrator using NOR gates. Draw wave-forms of the outputs v_{01} and v_{02} of two NOR gates and derive the expressions for periods T_1-ON time and T_2-OFF time of its output. Design the multivibrator circuit for the output frequency 2 kHz assuming $T_1 = T_2$.

15. Describe the Stern-Gerlach experiment taking a beam of silver atoms. Why are neutral silver atoms used in this experiment ? If the magnetic moment of the silver atom is 1 Bohr magneton and the field applied is 0.50 T, calculate the energy difference between the magnetic moment orientations in the two spots. What will be the frequency of the radiation that would induce transition between these two states ? Why one needs inhomogeneous field ?

16. Obtain the expression for Compton shift. Show that though the shift is independent of wavelength of incident radiation, the fractional loss of photon energy in case of X-rays is larger than that in the case of visible rays.

17. Obtain the condition for electron spin resonance. Hence show that the population difference between lower and upper levels is proportional to the resonance frequency.

When a system of electron spin is placed in a field of two Wb/m^2 at a certain temperature, the number of spins parallel to the field lines is twice the number of spins antiparallel to the field (Given $\mu_B = 9.27 \times 10^{-24}$ J/T; $K_B = 1.38 \times 10^{-23}$ J/K). Calculate the temperature of the system.

18. Explain the Raman effect. Discuss how it is useful to study the rotational and vibrational levels of a molecule.

19. State, what is Meissner effect in a superconductor. Show that the magnetic field penetration in the superconductor is given by

$$\bar{B}(x) = \bar{B}_0 \, e^{-x/\lambda_L}$$

where

$$\lambda_L = \left(\frac{mc^2}{4\pi nq}\right)^{1/2}$$

where n is the number of superconducting electrons per unit volume and q is their charge.

20. State and prove Bloch's theorem. Explain the origin of energy gap for nearly free electron model using Bragg condition. (Use one-dimensional arguments).

21. What is Bohr magneton ? Consider a series of N spins ($S = \frac{1}{2}\hbar$) at temperature T. Find ratio of equilibrium populations of total up spins $N_\uparrow$ to total number of spins $N = N_\uparrow + N_\downarrow$. Find resultant magnetisation. Take a classical limit and show $\chi = \frac{\text{constant}}{T}$.

22. What is a Bravais lattice ? What are the different space lattices in a cubic system ? How many lattice points per unit cell are there in each of these lattices ?

23. (*a*) Define binding energy of the nucleus. Give the binding energy curve and on the basis of which explain the phenomena of fusion and fission.

(*b*) Define parity of a nucleus. How does it restrict the nucleus from having an electric dipole moment ?

24. (*a*) In natural radioactivity, why an α-particle is emitted and why not two free protons and two free neutrons from the nucleus ?

(*b*) What energy must be imparted to an α-particle to force it into the nucleus of $_{83}Bi^{209}$. (assume suitable data $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ newton.meter^2/coulomb^2). Charge $e = 1.6 \times 10^{-19}$C and $r_0 = 1.3 \times 10^{-15}$ m.

25. (*a*) Derive an expression for $\frac{dE}{dx}$ of heavy charged particles passing through matter. Discuss its implications.

(*b*) Discuss the mechanism by which γ-rays are absorbed in an absorber. Detail the qualities of the best absorber.

26. (*a*) Discuss the electromagnetic structure of nucleons.

(*b*) Discuss SU(3) classification of elementary particles.