Signature of Invigilators

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Roll No. | | | | | |

(In figures as in Admit Card)

PHYSICAL SCIENCES

Paper III

Roll No. .....

.....

(In words)

J—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 any calculator is 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 માટેની સૂચનાઓ :

૧. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.

૨. જો કોઈ વિકલ્પ/વિભાગ પસંદ કર્યા હોય તો તે યોગ્ય જગ્યાએ દર્શાવો.

૩. ટુંકા પ્રશ્નો/નિબંધ વિષેના જવાબો એ પ્રશ્નની નીચે અગર બાજુમાં આપેલી જગ્યામાં લખો. વધારાના કોઈ પાનાનો ઉપયોગ કરશો નહી.

૪. અંદર આપેલી સૂચનાઓ કાળજીપૂર્વક વાંચો .

૫. બુકલેટની પાછળ આપેલું છેલ્લુ પાનું રફ કામ માટે છે.

૬. બુકલેટ કોઈપણ ઠેકાણે તમારું નામ કે કોઈ ચોકકસ સંજ્ઞા કરવી નહીં કે જે તમારી ઓળખ પૂરી પાડે. આ તમને પરીક્ષા માટે ગેરલાયક ઠેરવશે.

૭. કેલ્કયુલેટર નો ઉપયોગ કરાશે નહી.

૮. નકારાત્મક માર્કીંગ નથી.

૯. પરીક્ષા સમય પૂરો થઈ ગયા પછી આ બુકલેટ જે તે નીરીક્ષકને સોંપી દેવી. કોઈપણ પેપર પરીક્ષા રૂમની બહાર લઈ જવું નહી.

FOR OFFICE USE ONLY
Marks Obtained

Question Number	Marks Obtained	Question Number	Marks Obtained	Question Number	Marks Obtained
1		26			
2					
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Total Marks Obtained.....

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

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 be allowed, but not a calculator.

PART A

1. $f(x) = x^2$ over $-\pi < x < \pi$.

   Expand $f(x)$ in the form of Fourier Series, and using it show that :

$$\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^2} = \frac{\pi^2}{12}.$$

2. Evaluate the following, using contour integration

$$\int_0^{\infty} \frac{x^{1/2}}{1+x^2}\, dx$$

3. The kinetic and potential energies of a conservative system are :

$$T = \frac{1}{2}M\dot{x}^2 + \frac{m(\dot{x}^2 + l^2\dot{\theta}^2 + 2l\,\dot{x}\dot{\theta}\cos\theta)}{2}$$

$$V = -\,mgl\cos\theta.$$

   Obtain the Lagrange's equations of the system.

4. A particle of mass 2 kg moving with a speed of 3 m/s hits another particle of mass 4 kg headon. The collision is perfectly elastic. Find the final speeds of the two particles.

5. A charged particle moving with a uniform velocity $4\hat{i}$ m/s in the region where $\vec{E} = 20\,\hat{j}$ V/m and $\vec{B} = B_0\,\hat{k}$ tesla. Determine B_0 such that the velocity of the particle remains constant.

6. A large number of particles N are distributed in two levels with energy

$$E_1 = -\epsilon/2$$

$$E_2 = +\epsilon/2.$$

Obtain the expression for entropy of such a system as a function of total energy of the system. At what energy is the entropy maximum ?

7. Using the Uncertainty Principle, show that a particle in an infinite square well potential will have finite kinetic energy.

8. Describe Laue's, rotating crystal, and powder methods of X-ray diffraction. What additional information, if any, one can obtain if one carries out neutron diffraction experiment ?

9. Obtain the expression for reflection coefficient for a beam of particles coming from $-\infty$ and incident on a potential step given by :

$$V(x) = 0 \quad \text{for } x < 0$$

$$V(x) = V_0 \text{ for } x > 0$$

[Kinetic energy of particles is larger than V_0 for $x < 0$].

10. Discuss briefly the measurement of energy and time using electronic signals.

PART B

11. (*a*) Explain energy band diagram of an open-circuit PN junction. Show that the contact difference of potential of the PN junction is given by

$$kT \ln \frac{N_D N_A}{n_i^2},$$

where N_D, N_A and n_i are donor, acceptor and intrinsic carrier concentrations respectively.

(*b*) What are the four possible topologies of a feedback amplifier ? Identify the output signal and the feedback signal for each topology.

12. (*a*) What is a comparator circuit ? How does it differ from a clipping circuit ? Draw the circuit of a diode comparator and its output waveform.

(*b*) Explain how to modify a ripple counter so that it divides by N, where N is not a power of 2.

13. (*a*) Using OPAMs, develop a suitable block diagram of an electronic analog computer to program the differential equation

$$\frac{d^2V}{dt^2} + k_1\frac{dV}{dt} + k_2V - v_1 = 0$$

where v_1 is a function of time, k_1 and k_2 are real positive constants.

(*b*) Prove the Boolean identity

$$A + BC = (A + B)\,(A + C).$$

(*c*) Why do we use, at times, D/A converter for realizing A/D converter ?

14. (*a*) Explain the function of a master-slave J-K flip-flop. How is race around condition eliminated in it ?

(*b*) Explain briefly the function of a four stage ring counter.

(*c*) Explain the function of a full adder. How many half adders are required to implement it ?

15. Elaborate the difference between spontaneous and stimulated emissions. Why is stimulated emission used for lasing action ? Explain why population inversion is necessary but not sufficient for a laser ?

16. Discuss the basic principle of NMR. For a magnetic field of 1.5 Tesla, what will be the resonance frequency ? Distinguish between spin-spin and spin-lattice relaxation. Give a block diagram of NMR spectrometer, giving description of each block. [Given : $\mu = 1{\cdot}41 \times 10^{-30}$ J/gauss]

17. What is London interaction ? Prove that the total potential energy of two atoms at separation R in a weakly bonded solid is

$$U(R) = 4\epsilon\left[(\sigma/R)^{12} - (\sigma/R)^6\right].$$

18. Describe Stern-Gerlach experiment for silver atoms. If we use a beam of carbon atoms, how many different beams will emerge ?

19. Describe the Hall effect experiment for a metal having one type of charge carriers. Obtain an expression for the Hall coefficient in terms of charge carrier concentration.

A rectangular block of monoatomic metal of dimensions 2 cm × 3 cm × 4 cm is used for the Hall effect experiment. Constant current of 25 amp. is

allowed to flow normal to one face of the block, and a magnetic field of 1 Tesla is applied normal to another face. Which faces should be chosen for obtaining maximum Hall voltage ?

20. Distinguish between metals, semiconductors, insulators and superconductors. Describe how Brillouin zone helps to understand diffraction phenomena in crystal lattices. Show that for a square two-dimensional lattice, the kinetic energy of free electron at a corner of the first Brillouin zone is higher than that of electron at the midpoint of side-face of the zone by a factor 2.

21. What are different sources of polarizability of a solid ? Prove that the electric field at the site of an atom in the solid is greater than the external field by a factor proportional to the polarization density.

22. Describe the tight binding method for calculation of band structure. Obtain an expression of the energy band in a simple cubic solid using this particular method. Assume nearest neighbour interactions only.

23. Explain the terms :

(*i*) secular equilibrium;

(*ii*) transient equilibrium.

Obtain relevant equations and discuss the necessary conditions.

24. Give the evidence for nuclear shell structure, and explain the detailed structure of nucleus using single particle shell model. What are its limitations ?

25. What do you understand by Q-value of nuclear reaction ? Discuss the compound nucleus theory of nuclear reactions. Give the experimental evidence in support of the theory.

26. Discuss the classification of elementary particles in various families. Why is it necessary to introduce strangeness quantum number ?

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15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3 6 9 3 6 8	11 14 17 11 14 17	20 23 26 19 22 25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3 6 8 3 5 8	11 14 16 10 13 16	19 22 24 18 21 23
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	3 5 8 3 5 8	10 13 15 10 12 15	18 20 23 17 20 22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2 5 7 2 4 7	9 12 14 9 11 14	17 19 21 16 18 21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2 4 7 2 4 6	9 11 13 8 11 13	16 18 20 15 17 19
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2 4 6	8 11 13	15 17 19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2 4 6	8 10 12	14 16 18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2 4 6	8 10 12	14 15 17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2 4 6	7 9 11	13 15 17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2 4 5	7 9 11	12 14 16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2 3 5	7 9 10	12 14 15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2 3 5	7 8 10	11 13 15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2 3 5	6 8 9	11 13 14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2 3 5	6 8 9	11 12 14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1 3 4	6 7 9	10 12 13
30	4774	4786	4800	4814	4829	4843	4857	4871	4886	4900	1 3 4	6 7 9	10 11 13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1 3 4	6 7 8	10 11 12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1 3 4	5 7 8	9 11 12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1 3 4	5 6 8	9 10 12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1 3 4	5 6 8	9 10 11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1 2 4	5 6 7	9 10 11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1 2 4	5 6 7	8 10 11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1 2 3	5 6 7	8 9 10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1 2 3	5 6 7	8 9 10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1 2 3	4 5 7	8 9 10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1 2 3	4 5 6	8 9 10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1 2 3	4 5 6	7 8 9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1 2 3	4 5 6	7 8 9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1 2 3	4 5 6	7 8 9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1 2 3	4 5 6	7 8 9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1 2 3	4 5 6	7 8 9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1 2 3	4 5 6	7 7 8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1 2 3	4 5 5	6 7 8
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LOGARITHMS

	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
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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