TEST SERIES | GATE 2019

BOOKLET SERIES A

M. P. + Nuclear & Particle Physics + Solid State Physics + Electronics

Paper Code: PH

Test Type: TEST SERIES

Duration: 2:30 Hours

PHYSICS-PH

Date: 09-01-2019

Maximum Marks: 100

Read the following instructions carefully:

1. Attempt all the questions.

2. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory. The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.

   The subject specific GATE paper section consists of **55** questions, out of which question numbers 11 to 35 are of 1-mark each, while question numbers 36 to 65 are of 2-mark each.

3. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.

4. Multiple choice type questions will have four choices against (a), (b), (c), (d), out of which only **ONE** is the correct answer.

5. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**.**

6. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of ⅓ marks for a **1-mark** question and ⅔ marks for a **2-mark** question.

7. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.

8. Non-programmable type Calculator is allowed

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Q.1-Q. 5 carry ONE mark each.

1. The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair:

   After : Before ::
   (a) First: Second   (b) Present : Past
   (c) Contemporary : Historic   (d) Successor : Predecessor

2. Renounce a throne or high office of dignity can be said in one word as
   (a) Abolish   (b) accelerate   (c) abdicate   (d) king maker

3. If $x + \dfrac{1}{x} = \sqrt{3}$, then what is the value of $\left(x^{12} + \dfrac{1}{x^{12}} \right)$

   (a) $3\sqrt{3}$ (b) 3   (c) 2   (d) 0

4. What is the accutal discount if successive discount of $33\dfrac{1}{3}\%$, 25% and 10% is given to a customer.

   (a) 38%   (b) 50%   (c) 55%   (d) 60%

5. 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

Q.6-Q. 10 carry TWO marks each.

6. Which of the following expresses the meaning of the idiom "To Zip it".
   (a) To put something in safe place   (b) A rude way of telling someone to shut up
   (c) To move very fast   (d) To ask someone to run

7. The meaning of 'Obdurate' is
   (a) Unyeilding to moral infleunces   (b) To render incomprehensible
   (c) Noisy   (d) Instilling hatred

8. In a hostel there were 20 students. In new academic year 6 more students came and overall expenditure increased by ` 220 while average expenditure decreased by ` 1. What is the new average expenditure ?
   (a) 40   (b) 33   (c) 51   (d) 45

9. Anil goes from home to school with a speed of 20 km/hr after reaching school he find that he has forgotten a book and so he returns home with a speed of 30 km/hr and to reach the school in time he goes with a speed of 60 km/hr. What is the average speed for the whole journey ?
   (a) 35 km/hr   (b) 40 km/hr   (c) 25 km/hr   (d) 30 km/hr

10. Two balls are drawn in random from a container having 3 red balls and 8 white balls. Find the probability that both the balls are red ?
    (a) 5/11   (b) 3/35   (c) 3/55   (d) 2/55

Q.11-Q.35 carry one mark each.

11. In a decay of Λ^0 at rest $\Lambda^0 \longrightarrow P + \pi^-$, the kinetic energy of the resulting proton is equal to _____ MeV. (upto three decimal places).

    [Given: Rest masses of Λ^0, P and π^- are 1116 MeV/c^2, 938 MeV/c^2 and 140 MeV/c^2 respectively]

12. Which of the following transition corresponding to electric dipole γ-transition?

    (a) $\dfrac{3}{2}^+ \rightarrow \dfrac{1}{2}^+$ (b) $\dfrac{3}{2}^+ \rightarrow \dfrac{1}{2}^-$ (c) $1^+ \rightarrow 1^+$ (d) $3^+ \rightarrow 0^-$

13. Which of the following nuclear reaction is forbidden?

    (a) $\mu^- \rightarrow e^- + \overline{v}_e + n_\mu$ (b) $\Lambda^0 \rightarrow p + e^- + \overline{v}_e$

    (c) $\Xi^- \rightarrow \Lambda^0 + \pi^-$ (d) $\Sigma^+ \rightarrow \Lambda^0 + k^+$

14. Deuterons in a cyclotron describes a circle of radius 0.32 m just before emerging from the dees. The frequency of the applied e.m.f. is 10 MHz. The velocity of deutrons emerging out of the cyclotron is _____ $\times 10^7$ m/sec (Upto two decimal places)
[Given: mass of deuteron $= 3.32 \times 10^{-27}$ kg, e $= 1.6 \times 10^{-19}$ c]

15. A meson X^+ has a charm quantum number +1 and strange quantum number +1, then the quark content of the particle is

    (a) $s\overline{c}$ (b) $u\overline{d}$ (c) $c\overline{s}$ (d) ccs

16. Given a complex integral, $I = \int\limits_c \frac{ie^{iz}}{z} dz$ over the contour shown in the figure

    Then, $I =$

    (a) π (b) $-\pi$ (c) 2π (d) -2π
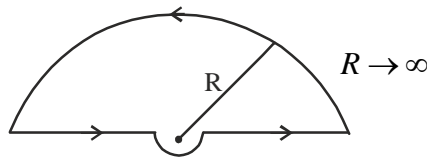
17. Consider the surface,

$$xyz^3 + 2xy + x^3z = 50$$

    the tangent plane to the surface at P(0, 1, –1) is

    (a) $x = 0$ (b) $y = 0$ (c) $x = 1$ (d) $y = 1$

18. If the sum of the digonal elements of a 2×2 matrix is –6, then the maximum possible value of determinant of the matrix is _____ (answer should be an integer).

19. Consider a function, $\vec{f} = \frac{1}{r^4}\hat{r}$, where r is the distance from the origin and $\hat{r}$ is the unit vector in the radial direction. The divergence of this function over a sphere of radius R, which includes the origin, is

    (a) $2\pi R^2$ (b) $\frac{2\pi}{R^2}$ (c) $4\pi R^2$ (d) $\frac{4\pi}{R^2}$

20. The signum function is given by

$$\text{sgn}(x) = \begin{cases} \dfrac{x}{|x|}; & x \neq 0 \\ 0; & x = 0 \end{cases}$$

    The fourier series expansion of the $\text{sgn}(\cos(t))$ for $-\pi < t < \pi$ has

    (a) onle sine terms with all harmonics
    (b) only cosine terms with all harmonics
    (c) only sine terms with even numbered harmonics
    (d) only consine terms with odd numbered harmonics

21. Given $f(z) = g(z) + h(z)$, where f, g, h are complex valued functions of a complex variable z. Which one of the following statements is TRUE?

    (a) If $f(z)$ is differentiable at z_0, then $g(z)$ and $h(z)$ are also differentiable at z_0.

    (b) If $g(z)$ and $h(z)$ are differentiable at z_0, then $f(z)$ is also differentiable at z_0.

    (c) If $f(z)$ is continuous at z_0, then it is differentiable at z_0.

    (d) If the real and imaginary parts of $f(z)$ are differentiable at a point, then $f(z)$ is also differentiable at that point.

22. Consider a signal defined by

$$x(t) = \begin{cases} e^{i10t} & \text{for } |t| \leq 1 \\ 0 & \text{for } |t| > 1 \end{cases}$$

The Fourier transform is

(a) $\dfrac{2\sin(\omega-10)}{(\omega-10)}$ (b) $2\,e^{i10}\dfrac{\sin(\omega-10)}{(\omega-10)}$ (c) $\dfrac{\sin(\omega-10)}{(\omega-10)}$ (d) $2\,e^{i10}\dfrac{\sin(\omega-10)}{(\omega-10)}$

23. A point charge q is uniformly distributed over a sphere, the quadrupole moment is
    (a) always positive   (b) always negative   (c) always zero   (d) undefined

24. Suppose $\vec{E}$ and $\vec{B}$ are the electric and magnetic field in a inertial system, choose the correct statement?

    (a) $\vec{E}\cdot\vec{B}$ is not relativistically invariant

    (b) $\left(\vec{E}^2 - c^2\vec{B}^2\right)$ is not relativistically invariant

    (c) Suppose that in one inertial system $\vec{B} = 0$ and $\vec{E} \neq 0$, then another inertial system $\vec{E}$ must be non-zero

    (d) $\vec{E}\times\vec{B}$ is relativistically invariant

25. Consider a perfectly conducting rectangular waveguide infinitely long along z-axis with a 2 cm along x-axis and 1 cm along y-axis. An electromagnetic wave whose free space wavelength is 3 cm is propagating along the guide in TE_{10} mode. The speed of propagation of electromagnetic energy along the guide is _____ c. (upto two decimal places).

26. A circular coil of a single turn of thin conducting wire has self-inductance L. If the number of turns is increased to 8. The self-inductance would be

    (a) 8L   (b) 64L   (c) L/8   (d) $2\sqrt{2}L$

27. If the radius of the atom is 0.174 nm. The number of atoms per mm^2 on the (111) plane of FCC crystal is _____ $\times 10^{12}$. (Upto two decimal places).

28. The crystal structure of a sample which has one valence electron as shown in figure below.
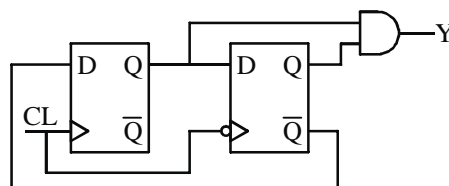

    (Lattice constant, a = 3Å)

    The fermi energy of the crystal is _____ $\times 10^2$ eV. (Upto two decimal places).

29. The critical magnetic fields of a superconductor at temperature 6K and 12K are 14 mA/m and 7 mA/m respectively. The T_c will be
   (a) 20 K   (b) 40K   (c) 30 K   (d) 16K

30. What is the frequency and duty cycle of output Y, when Clock frequency is 1 MHz @ 50 % duty cycle?

    (a) 500 kHz @ 50 % duty cycle   (b) 500 kHz @ 25 % duty cycle
   (c) 250 kHz @ 50 % duty cycle   (d) 250 kHz @ 25 % duty cycle

31. For a 2D free elecron gas the energy (E) dependence of density of state is given by $E^{x-\frac{1}{2}}$, where x _____(upto one decimal places).

32. The below circuit constructed using two 2×1 multiplexers is a/an
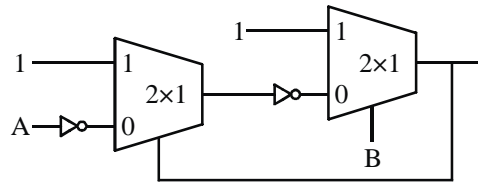
(a) Adder   (b) SR-latch   (c) 4×1 MUX   (d) EX-OR circuit

33. For the regulator circuit shown, maximum load current is 50 mA. The value of R_S for safe operation of zener diode is _____ Ω.
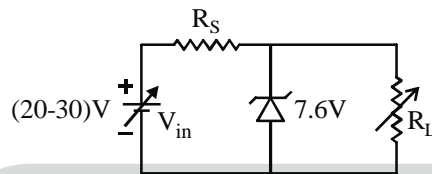
34. A signal $V_t(t) = 10 + 10\sin 100\,\pi t + 10\sin 4000\,\pi t + 10\sin 100000\,\pi t$ is supplied to a filter circuit (shown below) made up of ideal op-amps. The least attenuated frequency component in the output will be
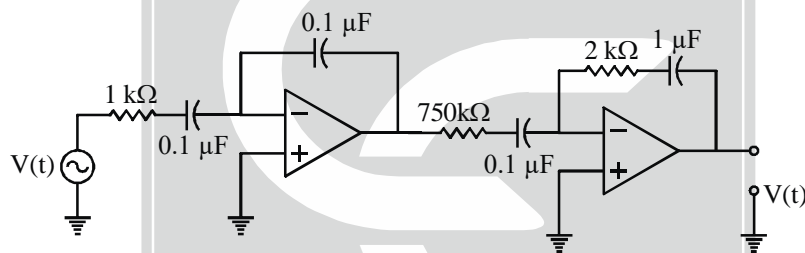
(a) 0 Hz   (b) 50 Hz   (c) 2 kHz   (d) 50 kHz

35. A 4 bit ripple counter and a 4 bit synchronous counter are made using flip-flops having a propagation delay of 10 ns each. If the worst case delay in the ripple counter and the synchronous counter be R and S respectively, then
(a) R = 10 ns, S = 40 ns   (b) R = 40 ns, S = 10 ns
(c) R = 10 ns, S = 30 ns   (d) R = 30 ns, S = 10 ns

Q.36-Q.65 carry TWO marks each.

36. The spins and parity of ground state of $_{19}K^{39}$ and $_{42}Mo^{95}$ nucleus are respectively

(a) $\dfrac{3}{2}^{+}$ and $\dfrac{5}{2}^{-}$ (b) $\dfrac{5}{2}^{+}$ and $\dfrac{3}{2}^{+}$ (c) $\dfrac{3}{2}^{+}$ and $\dfrac{7}{2}^{+}$ (d) $\dfrac{5}{2}^{+}$ and $\dfrac{5}{2}^{+}$

37. From the semi-empirical mass formula, binding energy is given by

$$B = a_1 A - a_2 A^{-2/3} - a_3 z^2 A^{-1/3} - a_4 (A - 2z)^2 A^{-1} \pm \delta$$

If $a_1 = 14.1\,MeV$, $a_2 = 13.0\,MeV$, $a_3 = 0.58\,MeV$, $a_4 = 19.3\,MeV$. The value of z for most stable nuclei for A = 78 is
(a) 33   (b) 34   (c) 35   (d) 36

38. The magnetic dipole moment for ground state of $_{29}Cu^{63}$ in nuclear magneton units is _____(upto two decimal places).
    [Given: g_s for proton is 5.58 and for neutron is –3.83]

39. In a reaction, $_{13}Al^{25} \longrightarrow {}_{12}Mg^{25} + e^+ + v_e$, the atomic masses are given as $m_{Al} = 24.990432\ amu, m_{Mg} = 24.985839\ amu$. The maximum kinetic energy of neutrino emitted as _____MeV. [Upto two decimal places].

40. A baryon is found to have charge +1 and strangeness quantum number –1. Its isospin must be equal to

    (a) $\dfrac{1}{2}$ (b) 0   (c) 1   (d) $\dfrac{3}{2}$

41. The Laplace transform of $f(t) = 2\sqrt{t/\pi}$ is $s^{-3/2}$. The Laplace transform of $g(t) = \sqrt{1/\pi t}$ is

    (a) $\dfrac{3}{2}s^{-5/2}$ (b) $s^{-1/2}$ (c) $s^{1/2}$ (d) $s^{3/2}$

42. Consider the complex function,

    $$f(z) = \frac{e^{-z}}{z-1}$$

    the Laurent series of the function about $z = 1$ is

    (a) $\dfrac{1}{e}\left[\dfrac{1}{z-1} - 1 + \dfrac{(z-1)}{2} - \dfrac{1}{6}(z-1)^2 + ...\right]$ (b) $e\left[\dfrac{1}{z-1} + 1 + \dfrac{(z-1)}{2} - \dfrac{1}{6}(z-1)^2 + ...\right]$

    (c) $e\left[-\dfrac{1}{z-1} + 1 + \dfrac{(z-1)}{2} - \dfrac{1}{6}(z-1)^2 + ...\right]$ (d) $\dfrac{1}{e}\left[-\dfrac{1}{z-1} - 1 - \dfrac{(z-1)}{2} - \dfrac{1}{6}(z-1)^2 + ...\right]$

43. Let M be a 3×3 matrix and suppose that 1, 2 and 3 are the eigenvalues of M. If

    $$M^{-1} = \frac{M^2}{\alpha} - M + \frac{11}{\alpha}I_3$$

    for some scalar, $\alpha \neq 0$, then α is equal to _____(answer should be an integer).

44. Let $y(t)$ be a continuous function on $[0, \infty)$ whose Laplace transform exists. If $y(t)$ satisfies

    $$\int_0^t (1 - \cos(t-\tau)) y(\tau) d\tau = t^4$$

    then $y(1)$ is equal to _____(answer should be an integer).

45. Consider the initial value problem,

    $$x^2 y'' - 6y = 0,\ y(1) = \alpha,\ y'(1) = 6$$

    If $y(x) \to 0$ as $x \to 0^+$, then α is equal to _____(answer should be an integer).

46. The value of $\dfrac{i}{4-\pi}\displaystyle\int_{|z|=4} \dfrac{dz}{z\cos z}$ is equal to _____(answer should be an integer).

47. Mechanical pressure on the surface of a charged conductor having surface charge density σ is

    (a) $\in_0 \sigma^2$ (b) $\sigma^2/2\in_0$ (c) $\sigma^2/\in_0$ (d) $\sigma/2\in_0$

48. Three infinitely long wires are placed on the vertex of a equivalent triangle of side a. The wires are carrying current I_0, I_0, $2I_0$ in the same direction perpendicular to the paper. The magnitude of magnetic field at the centroid of the triangle is given by

(a) zero

(b) $\dfrac{4\sqrt{3}\,I_0}{2\pi a}$

(c) $\dfrac{3\sqrt{3}\,I_0}{2\pi a}$

(d) $\dfrac{\sqrt{3}\,I_0}{2\pi a}$
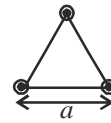
49. Consider two large parallel plates forming a wedge of angle α. The plates are insulated, one is kept at zero potential and the other at ϕ_0. The electric field at any point between the plate is given by

(a) $\dfrac{\phi_0}{r}\hat{\phi}$　　　　(b) $-\dfrac{\phi_0}{\alpha r}\hat{\phi}$　　　　(c) $-\dfrac{\phi_0}{r}\hat{z}$　　　　(d) zero

50. A circular loop of unit radius whose centre is at origin is placed in non-uniform time dependent magnetic field $B(y,t) = By^3\hat{z}$. The magnetic flux passing through the loop in the first quadrant is given by _____ B_0. (Upto second decimal places).

51. Two linear polarizer are placed whose pass axis is making 90° with each other and a half wave plate is introduced between them whose optical axis making angle 60° with the first polarizer. If an unpolarized light of intensity I_0 incident on the optical system from left, the output intensity will be _____ I_0. (Upto three decimal places).

52. An unpolarized electro magnetic wave incident on air dielectric interface (dielectric onstant $\varepsilon_r = 3$) from the air at an angle 60°. If $r_{||}$ and $r_{\perp}$ are the reflection coefficient of P and S polarized wave then,

(a) $r_{||} = 0$ and $r_{\perp} \neq 0$　　(b) $r_{||} \neq 0$ and $r_{\perp} = 0$　　(c) $r_{\perp} = 0$ and $r_{||} = 0$　　(d) $r_{\perp} \neq 0$ and $r_{||} \neq 0$

53. The electrical conductivity of Fe is 80% (lets say) of the electrical conductivity of Cu, while the electron density in Cu is approximately 60% of the electron density in Fe. In Drude's model the value of $\dfrac{\tau_{Fe}}{\tau_{Cu}}$ _____ (where τ_{Fe} and τ_{Cu} are mean collision times in Fe and Cu respectively). (answer upto two decimal places only).

54. Silicon (Si) has diamond cubic (dc) structure. The number of optical Branches in Si is/are _____ (answer should be an integer).
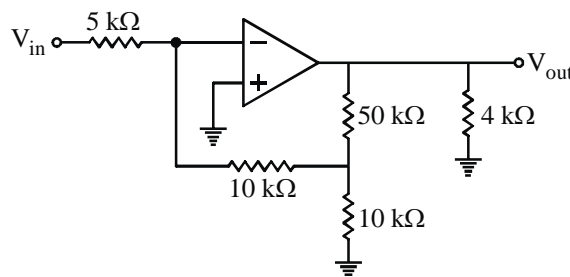
55. The tight-binding energy expression for electron in fcc crystal is

$$E(k) = -E_0 + \alpha\left[\cos\left(\frac{k_x a}{2}\right)\cos\left(\frac{k_y a}{2}\right) + \cos\left(\frac{k_y a}{2}\right)\cos\left(\frac{k_z a}{2}\right) + \cos\left(\frac{k_z a}{2}\right)\cos\left(\frac{k_x a}{2}\right)\right]$$

The effective mass (m^*) of an electron in the crystal at first BZ boundary is

(a) $+\dfrac{4\hbar^2}{\alpha a^2}$　　　　(b) $-\dfrac{2\hbar^2}{\alpha a^2}$　　　　(c) $+\dfrac{2\hbar^2}{\alpha a^2}$　　　　(d) $-\dfrac{4\hbar^2}{\alpha a^2}$

56. Consider the circuit given below:

The differential mode open loop gain of the op-amp is $A_{OL} = 10^4$. Neglect the current into the op-amp and assume output resistance of op-amp is zero. The closed loop voltage gain $A_V = \dfrac{V_0}{V_S}$ is approximately.

(a) −21   (b) −22   (c) −7.5   (d) −11.5

57. In the circuit shown, 'si' diode with $V_\gamma = 0.7\,V$ remains ON state for $5V \le V_i \le 10V$ with minimum diode current of 2mA and maximum power dissipation in the diode not more than 8mW. Then the required values of resistors R_2 and R_1 (in Ω) are
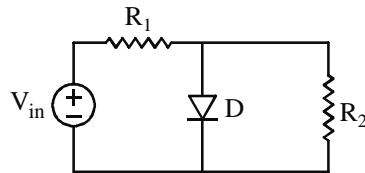
(a) 115 and 530   (b) 115 and 438   (c) 89 and 530   (d) 89 and 438

58. In the following transistor circuit, $V_{BE} \approx 0.7\,V$, $r_e = \dfrac{25\,mV}{I_E}$, β and all the capacitances are very large
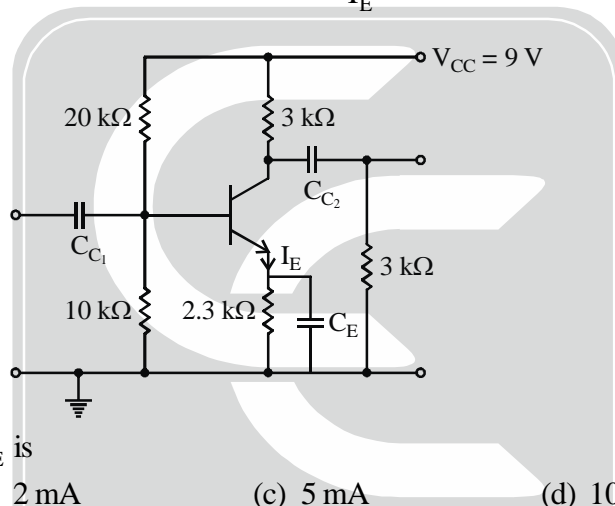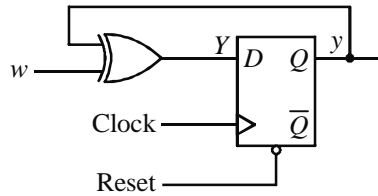

The large of DC current I_E is
(a) 1 mA   (b) 2 mA   (c) 5 mA   (d) 10 mA

59. In the ac equivalent circuit shown, the two BJTs are biased in active region and have identical parameters with $\beta \gg 1$. The open circuit small signal voltage gain is approximately _____.
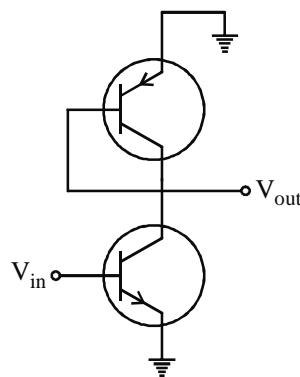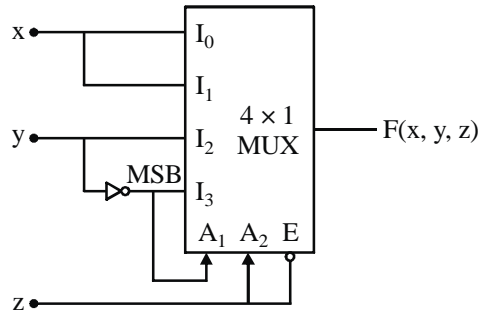
60. Find output sequence for the input sequence w = "0011". Assume that the flip-flop is initially at reset state.
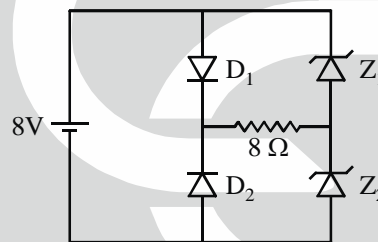

    (a) $y = 0010$ (b) $y = 1111$ (c) $y = 0000$ (d) $y = 0011$

61. For the 4×1 MUX shown below the Boolean expression F(x, y, z) is

    (a) $xy\bar{z}$ (b) $(xy\bar{z} + xyz + z\bar{y})$ (c) $xy\bar{z} + xyz$ (d) None of these

62. For the diode circuit shown $V_r = 0.7$ V, $V_z = 5$ V . Forward resistance of PN junction diode is $5\,\Omega$ and zener resistance is $10\,\Omega$. Then the power dissipation (in mW) in $8\,\Omega$ resistor is _____.

63. A beam of X-ray of intesity I_0 is incident normally on a metal sheet of thickness 3 mm. The intensity of the transmitted beam is $0.45\,I_0$. The linear absorption coefficient of the metal sheet (in m^{-1}) is
    (a) 266.17   (b) 386.45   (c) 437.30   (d) 83850

64. Let $y(x)$ be a solution of the differential equation $(1+e^x)y' + ye^x = 1$. If $y(0) = 2$ then

$y(\ln 2) =$ _____ (Upto two decimal places).

65. The ratio of volume and density of nucleus of $_{29}Cu^{64}$ and $_{12}Mg^{17}$ is
    (a) 3.76   (b) 2   (c) 3   (d) 5

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Space for rough work

PHYSICS-PH

GATE TEST SERIES-A   **Date: 09-01-2019**

M.P. + SOLID STATE PHYSICS + NUCLEAR & PARTICLE PHYSICS + ELECTRONICS

ANSWER KEY

PART-A

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

PART-B

11. (5.412 to 5.415)	**12.** (b)	**13.** (d)	**14.** (2.00 to 2.03)	**15.** (c)
16. (b)	**17.** (a)	**18.** (9)	**19.** (d)	**20.** (d)
21. (b)	**22.** (a)	**23.** (c)	**24.** (c)	**25.** (0.66)
26. (b)	**27.** (9.53)	**28.** (0.23)	**29.** (d)	**30.** (b)
31. (0.5)	**32.** (b)	**33.** (445 to 450)	**34.** (b)	**35.** (b)
36. (c)	**37.** (b)	**38.** (3.77 to 3.81)	**39.** (3.20 to 3.30)	**40.** (c)
41. (b)	**42.** (a)	**43.** (6)	**44.** (28)	**45.** (2)
46. (2)	**47.** (b)	**48.** (d)	**49.** (b)	**50.** (0.13)
51. (0.375)	**52.** (a)	**53.** (0.45 to 0.52)	**54.** (3)	**55.** (c)
56. (a)	**57.** (b)	**58.** (1)	**59.** (-1)	**60.** (b)
61. (d)	**62.** (80)	**63.** (a)	**64.** (1.50 to 1.60)	**65.** (a)