S-57

Entrance Examinations 2018

Ph.D. (Electronics Science)

Marks: 80

Time: 2.00 hrs

Hall Ticket no:

1. Write your Hall Ticket Number on the OMR Answer Sheet given to you. Also write the Hall Ticket Number in the Space provided above.

2. Read the following instructions carefully before answering the questions.

3. This Question paper has TWO parts: PART 'A' and PART 'B'.

   Part 'A': It consists of 20 objective type questions of **TWO** marks each. There is a negative marking of **0.66** marks for every wrong answer.
   Part 'B: It consists of 40 objective type questions of **ONE** mark each with no negative marking.

4. All questions are to be answered. Answers for these questions are to be entered on the OMR sheet, filling the appropriate circle against each question. For example, if the answer to a question is D, it should be marked as below:

5. No additional sheets will be provided. Rough work can be done in the question paper itself.

6. Hand over the OMR answer sheet at the end of the examination to the invigilator.

7. Mobile phones, log tables and calculators of any type are NOT permitted

8. Values of some physical constants: $V_T = 26$ mV, $\epsilon_o = 8.85 \times 10^{-12}\ F/m$

9. This book contains 16 pages including this cover sheet.

PART A

Consider the following statements: L,M,N,O,P, Q and R are sitting around a circle facing the centre. O is sitting between L and R. Q is second to the right of R and P is second to the right of Q. N is not the immediate neighbor of R. Based on these statements, answer the questions 1 and 2 below

1. Which of the following is **not** correct?

A. R is second to the right of L.
B. R is second to the right of Q.
C. O is second to the right of P.
D. L sits opposite toM.

2. How many people are sitting between L and Q if we count in the anti-clockwise direction?

A. 1
B. 2
C. 3
D. 4

Consider the following statements: Superconductors are materials that, when cooled below room temperature exhibit a sudden drop in resistance to zero at a temperature called the critical temperature. Superconductivity is a quantum mechanical phenomenon like magnetism. A theory for superconducting current is that, it is a superfluid of Cooper pairs, pairs of electrons interacting through exchange of photons. It is important to note that while zero resistance is a necessary condition for superconductivity, it is not sufficient. Based on these statements, answer the questions 3 and 4 below

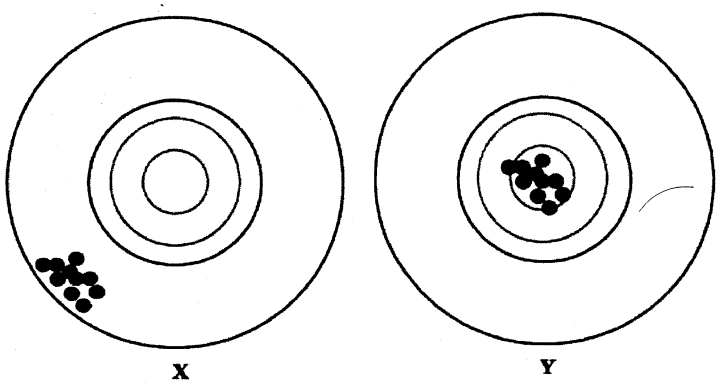
3. Which of the following is correct?

A. Superconductivity occurs only at room temperature.
B. Superconducting materials have zero resistance at all temperatures.
C. Superconductivity occurs below a critical temperature.
D. Superconducting materials are magnetic.

4. Which of the following is **not** correct?

A. Superconductivity is a quantum mechanical phenomenon.
B. Superconducting current can be considered as a superfluid of Cooper pairs.
C. The measurement of resistance as a function of temperature alone cannot be used to prove that a material is superconducting.
D. The measurement of resistance as a function of temperature alone can be used to prove that a material is superconducting.

5. Consider the pattern of concentric circles given below. Each dot on the pattern represents a data point from a measurement with the objective of getting as many points as possible in the central circle.



Then, which one of the following statements is correct about the measurements, respectively.?

A. X is high accuracy and low precision while Y is high accuracy and high precision.
B. X is low accuracy and high precision while Y is high accuracy and high precision.
C. Both X and Y are high accuracy and high precision.
D. Both X and Y are low accuracy and low precision.

6. Which one of the following is an appropriate technique to determine that a given piece of material is metal or semiconductor

A. Measurement of resistivity at room temperature.
B. Measurement of temperature dependence of resistivity.
C. Measurement of voltage dependence of resistivity.
D. Measurement of current dependence of resistivity.

7. The relationship between two physical quantities M and K is given below

$$M = AK^2 + BK$$

where A and B are constants. If an experiment is performed to measure the values of M and K, then the values of A and B can be determined graphically by plotting a graph between

A. M on the y- axis and K on the x-axis with A as the slope and B as the intercept.
B. K on the y- axis and M on the x-axis with A as the slope and B as the intercept.
C. M/K on the y-axis and K on the x-axis with A as the slope and B as the X intercept.
D. M/K on the y-axis and K on the x-axis with A as the slope and B as the Y intercept.

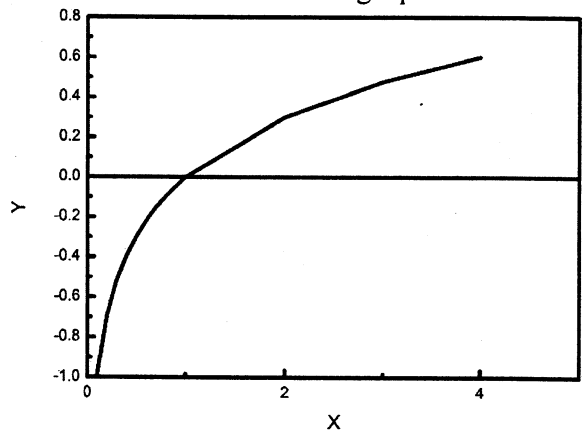
8. In a bag containing white and red balls, half number of the white balls equals one-third the number of red balls and twice the number of balls exceeds three times the number of red balls by 8. The number of white balls and red balls are respectively

A. 3 and 9
B. 16 and 24
C. 4 and 6
D. 16 and 8

9. The missing number in the series 2, 3, 6, 0, 10, -3, 14,... is

A. 18
B. 0
C. -2
D. -6

10. Which one of the following equation describes the graph shown below



A. $Y = \log(X)$.
B. $Y = \ln(X)$.
C. $Y = X^2$.
D. $Y=e^X$.

11. Two students perform an experiment in which they drop a ball from rest, from a known height above the ground and measure the speed of ball just before it strikes the ground. From repeated measurements, the students estimate the uncertainty in the measured velocity to be 10%. Assuming mass of the balls to be negligibly small, the uncertainty in the kinetic energy of the ball is

A. 5%
B. 10%
C. 15%.
D. 20%

12. If a 3.5 digit voltmeter is used in the 1V range, then the maximum and minimum it can display are respectively

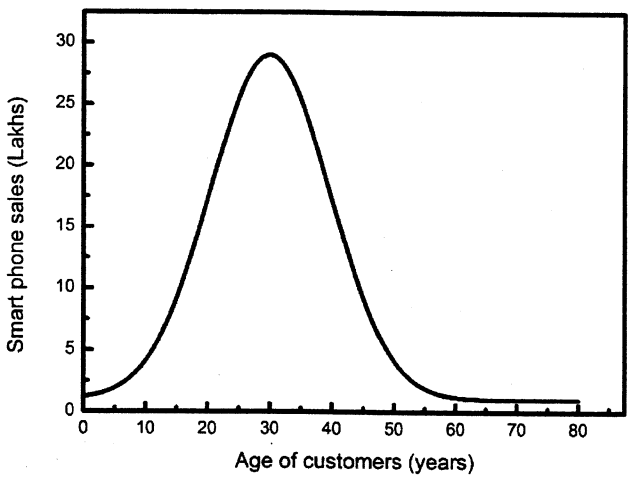
A. 1 V and 0.001 V
B. 0.999 V and 0.01 V
C. 0.999 V and 0.0001V
D. 1 V and 0 V

13. In an artificial language
blor means jump
blorn means jumping
blorend means jumped

Which word below could mean playing

A. wrog
B. wrogn
C. larg
D. crangend

14. Appropriate title of the graph given below is



A. Dependence of smart phone sales on age of the customers.
B. Dependence of age on smart phone sales.
C. Effect of smart phone on age of the customer.
D. Smart phone sales and age of customer.

15. Which one of the following statements can be extracted from the graph above

A. The maximum sale of smart phones is for the age of customers between 25-35 years.
B. Rich people use more smart phones.
C. Only the younger population determines sales of smart phones.
D. Sales of smart phones is determined only by population between 0-30 years.

16. Which one of the following would be an appropriate scientific question that could be tested experimentally?

A. Is the moon blue in color?
B. Does electron know mathematics?
C. Is light a mammal?
D. Are resistors less precious than capacitors in an Integrated Circuits?

17. Consider the data set given below

10, 2, 38, 23, 38, 23, 21

The coefficient of variation of the data is

A. 13.28
B. 22.14
C. 1.66
D. 0.59

18. Given that $x^2 = x + x + x + x + \ldots\ldots$ x times, which of the following statements is true

A. x is a real number.
B. x is a complex number.
C. x is an integer.
D. x is a rational number.

19. The probability of choosing a number c randomly from the set {1,2,3,4.5,6,7,8,9} such that the quadratic equation $x^2+4x+c = 0$ has real roots is

A. 1/9
B. 2/9
C. 3/9.
D. 4/9

20. Two dice are thrown. What is the probability that the sum of the numbers shown by the two dice is 6?

A. 1/36
B. 1/9
C. 1/6
D. 5/36

PART B

21. The harmonic conjugate v(x,y) of the function $u(x,y) = x/(x^2+y^2)$

A. $v(x,y) = y/(x^2+y^2)$
B. $v(x,y) = y^2/(x^2+y^2)$
C. $v(x,y) = x^2/(x^2+y^2)$
D. $v(x,y) = x/(x^2+y^2)$

22. If C is the circle on the complex plane, then the given line integral $\oint_C \frac{dz}{(z-z_0)}$

A. 0
B. 2π
C. $2\pi i$
D. $1/2\pi$

23. If for a closed disc $|z| \leq c$ with $0<c<1$. Then

$$\sum_{n=1}^{\infty} \frac{nz^n}{1-z^n} \quad and \quad \sum_{n=1}^{\infty} \frac{z^n}{(1-z^n)^2}$$

A. both the series diverge uniformly on the disc.
B. both the series converge uniformly on the disc.
C. first series converges while second series diverges.
D. first series diverges while second series converges.

24. The value of $\int_\gamma \frac{e^{-z^2}}{z^2} dz$ where γ is a square with vertices (1+i), (-1+i), (-1-i), (1-i), is

A. $2\pi i$
B. 0
C. πi
D. 2π

25. If vector $\mathbf{A}=5\,\hat{\imath} + 6\,\hat{\jmath} + 10\,\hat{k}$, and vector $\mathbf{B}= 10\,\hat{\imath} + 3\,\hat{\jmath} + 5\,\hat{k}$, then the value of the z-component of **AxB** is

A. 138
B. -45
C. 50
D. 38

26. The expansion of $f(t) = \sin^5 t$ in a Fourier series is

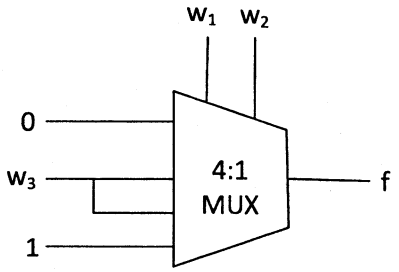
A. ¼[½ (5sin(t)) - ¼ (5sin (3t)) + sin (5t))]
B. ¼[½ (5sin(t)) + ¼ (5sin (3t)) + sin (5t))]
C. ¼[½ (5sin(t)) + ¼ (5sin (3t)) - sin (5t))]
D. ¼[½ (5sin(t)) - ¼(5sin (3t)) - sin (5t))]

27. The energy spectral density of the function f(t) given below is

$$f(t) = \begin{cases} e^{-at} & t \geq 0 \\ 0 & t \leq 0 \end{cases}$$

A. $1/(a^2 + \omega^2)$
B. $a^2/(a^2 + \omega^2)$
C. $\omega^2/(a^2 + \omega^2)$
D. $1/(a^2 + \omega^2)^2$

28. In the following multiplexer-based circuit if W_1 and W_3 correspond to MSB and LSB respectively, then it implements a



A. 3 input OR gate
B. 1-bit full adder
C. 1 input AND gate
D. 3 input majority function

29. Assume a 3-bit down counter is designed using T Flip-Flops. If, due to some fault in the circuit the second Flip-Flop output is short circuited with supply voltage, then at the edge of the 6th clock cycle the count sequence will be (assume each Flip-Flop has zero propagation delay)

A. 010
B. 011
C. 110
D. 111

30. In an ideal CMOS inverter, when the input voltage is equal to half of the supply voltage, then

A. both NMOS and PMOS arein saturation region.
B. NMOS is in triode region and PMOS is in saturation region
C. NMOS is in saturation regionand PMOS is in triode region
D. both NMOS and PMOS are in cutoff region

31. Consider the following statements for the contact between a metal and semiconductor
1. The contact is rectifying in nature.
2. The contact is non-rectifying in nature.
3. There is lowering of barrier height in the presence of an applied field.
4. There is probability of tunneling across the barrier due to heavy doping.

The statement or statements that describe an ohmic contact is (or are)

A. 1 only
B. 1 and 3 only
C. 2 and 3 only
D. 2,3 and 4 only

32. If the unit cell of a Bravais lattice satisfies the following condition $a=b=c$ and $\alpha=\beta=\gamma\neq90°$, where a, b, c are edge lengths and α, β, γ are the internal angles then its structure is

A. Monoclinic.
B. Orthorhombic.
C. Rhombohedral.
D. Hexagonal.

33. Based on symmetry considerations which of the following Miller indices cannot be present in the x-ray diffraction pattern of a body centered cubic crystal

A. (2 0 0)
B. (1 1 0)
C. (1 1 1)
D. (3 2 1)

34. As the donor concentration in an intrinsic semiconductor is increased at a fixed temperature the Fermi levels

A. moves linearly closer to the conduction band.
B. moves linearly away from the conduction band.
C. moves logarithmically closer to the conduction band.
D. moves logarithmically closer to the valence band.

35. The total energy E of an electron in a potential well of width, a, if n is the number of the energy level is proportional to

A. n/a
B. n^2/a
C. n^2a^2
D. n^2/a^2

36. The mobility and effective mass of electrons in GaAs are 8500 cm^2/Vs and $0.067m_0$ respectively. The diffusion coefficient of electrons in GaAs is (m_0=mass of free electron)

A. 221 cm^2/s
B. 569.5 cm^2/s
C. 0.022 cm^2/s
D. 72.25 cm^2/s

37. A piece of Si is doped such that the concentration of free electrons (n) is 1.5×10^{15} cm^{-3}. If the intrinsic carrier concentration ($n_i = p_i$) of Si is 1.5×10^{10} cm^{-3} at 300 K , then the concentration of holes (p) in this sample is,

A. 1.5×10^{10} cm^{-3}
B. 1.5×10^{5} cm^{-3}
C. 2.25×10^{20} cm^{-3}
D. 2.25×10^{8} cm^{-3}

38. Which one of the following statements is true about the effective mass of electrons in solids:

A. It cannot be greater than the free electron mass.
B. It cannot be smaller than the free electron mass.
C. It is always positive quantity.
D. It can be negative.

39. The output $y(t)$ of an LTI system is related to its input $x(t)$ by a differential equation

$$\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + 4y(t) = x(t)$$

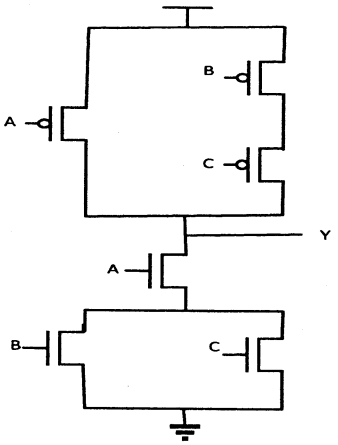
The impulse response of the system is proportional to

A. $t\,e^{2t}u(t)$
B. $e^{-2t}u(t)$
C. $t\,e^{-2t}$
D. $t\,e^{-2t}u(t)$

40. The two-point Discrete Fourier Transforms of two 2-member sequences x[n]: x[0]=2, x[1]= -1 and 0 for all other n, and y[n]: y(0)=4, y[1]=2 and 0 for all other n, are

A. X[k]=8, -2 for k=0 and 1 respectively; Y[k]=4 , -4 for k=0 and 1 respectively.
B. X[k]=0.5, 1.5 for k=0 and 1 respectively; Y[k]=6 , 2 for k=0 and 1 respectively.
C. X[k]=0.5, 1.5 for k=0 and 1 respectively; Y[k]=3 , 1 for k=0 and 1 respectively.
D. X[k]=6,1 for k=0 and 1 respectively; Y[k]= -2, -3 for k=0 and 1 respectively.

41. The output 'Y' of the following CMOS gate is



A. $\overline{A.(B+C)}$
B. $A.(B+C)$
C. $\overline{A+B.C}$
D. $A+B.C$

42. In a *p-n* junction, at the steady state, the hole concentration in a p-type material (p_{po}) and the hole concentration in a n-type material (p_{no}) are 10^{16} cm^{-3} and 10^{4} cm^{-3} respectively. The contact potential difference is

A. 25 V
B. 0.57 V
C. 0.72 V
D. 300 V

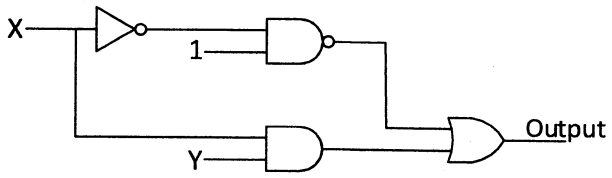
43. In a *p-n* junction, the valence band edge of the *p* material is greater than

A. Conduction band edge of *n* material.
B. Valence band edge of *n* material.
C. Conduction band edge of *p* material.
D. Fermi level of *p* material.

44. If a plane electromagnetic wave traveling along the + z direction has its electric field given by $E_x = 2\cos(\omega t)$ and $E_y = 2\cos(\omega t + 90°)$, then the wave is

A. Linearly polarized.
B. Right circularly polarized.
C. Left circularly polarized.
D. Elliptically polarized.

45. The output of the following logic diagram is



A. X
B. Y
C. $X + Y$
D. $\overline{X} + Y$

46. The depth of penetration of a wave in a lossy dielectric increases with increasing

A. Conductivity.
B. Permeability.
C. Permittivity.
D. Wavelength.

47. In a rectangular waveguide the mode that corresponds to the highest cut-off wavelength is

A. TE_{10}
B. TE_{11}
C. TE_{01}
D. TE_{00}

48. A transmission line of 50Ω characteristic impedance is terminated with a 100Ω resistance. The minimum impedance measured on the line is equal to

A. 0 Ω
B. 25 Ω
C. 50 Ω
D. 100 Ω

49. White light is normally incident on a volume of water stored in a bucket (index of refraction=1.33). A 500 nm layer of oil (index of refraction =1.50) floats on the surface of water, then which one of the following wavelength is a point of constructive interference for the two-layer system?

A. 500 nm
B. 550 nm
C. 600 nm
D. 650 nm

50. An audio signal has a bandwidth of 10 kHz. Which one of the following sampling intervals will result in aliasing?

A. 0.04 ms
B. 0.03 ms
C. 0.06 ms
D. 0.02 ms

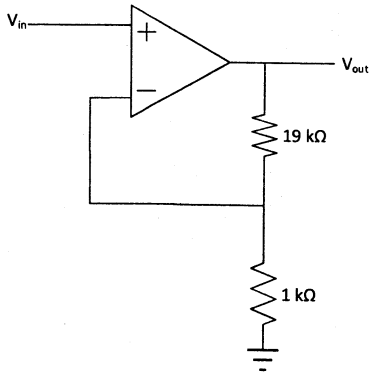
51. A super-heterodyne receiver with intermediate frequency (IF), f_{IF} = 500 KHz and local oscillator frequency (f_{LO}), $3.5<f_{LO}<4.0$ MHz has a tuning dial calibrated to receive signals from 3 to 3.5 MHz. If it is set to receive 3 MHz signal, then the image frequency is at

A. 4 MHz
B. 3.5 MHz
C. 3 MHz
D. 6 MHz

52. An FM broadcast station is limited to a minimum frequency deviation of 75 KHz and the modulating frequencies typically cover 30 Hz to 15 KHz. What is the transmission bandwidth of the FM station?

A. 180 KHz
B. 150KHz
C. 90 KHz
D. 45KHz

53. The op-amp below has open-loop gain, input resistance and output resistance of $2x10^5$, 2 MΩ and 75 Ω respectively. What is the closed-loop input and output resistance of the circuit respectively?

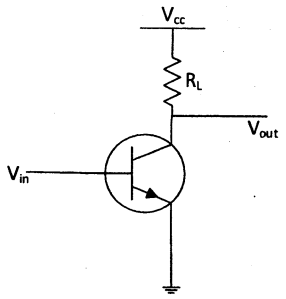


A. 2 MΩ, 7.5 mΩ
B. 20 GΩ, 7.5 mΩ
C. 20 mΩ, 7.5 GΩ
D. 20 MΩ, 750Ω

54. If a PMOS device with a threshold voltage of -0.5 V is biased with a drain voltage of 1 V, bulk voltage of 1.8 V, source voltage of 1.8 V and gate voltage of 1.4 V, then the PMOS will operate in

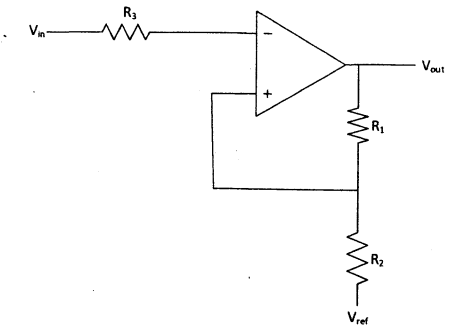
A. Saturation region
B. Cut-off region
C. Triode region
D. Ohmic region

55. If in the circuit given below the DC voltage drop across R_L is 1.3 V, then the approximate small-signal voltage gain is



A. -13
B. -130
C. -50
D. -100

56. A Schmitt trigger circuit is shown in the figure below, where R_1 = 50 KΩ, R_2= 100Ω, V_{ref} = 0V, V_{in} = 1 V peak-to-peak sine wave and saturation voltage is +/- 14 V. The upper and lower triggering voltages V_{UT} and V_{LT} respectively are

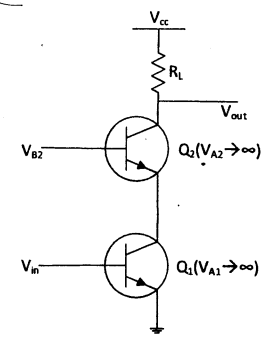


A. V_{UT} = +14mV and V_{LT} = -14mV
B. V_{UT} = +28mV and V_{LT} = -28mV
C. V_{UT} = +7mV and V_{LT} = -7mV
D. V_{UT} = +56mV and V_{LT} = -56mV

57. A MOSFET is fabricated in a technology where oxide thickness, t_{ox} = 4nm, channel length, L = 0.18μm and channel width, W = 0.72 μm. The total capacitance between gate and channel is

A. 10 fF
B. 1.1 fF
C. 2.3 fF
D. 4.2 fF

58. In the circuit shown in the figure below, Q1 and Q2 are BJTs with transconductances of g_{m1} and g_{m2} respectively. The small signal gain is determined by

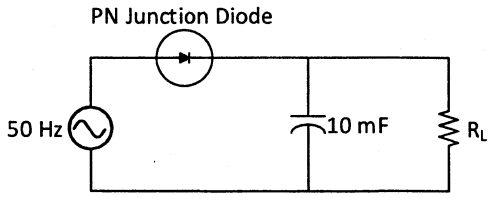


A. g_{m1},g_{m2} and R_L
B. g_{m1} and g_{m2}
C. g_{m1} and R_L
D. g_{m2} and R_L

59. A differential amplifier is designed with a tail current source of I_{ss} and internal resistance of R_{ss}. If the common-mode rejection ratio$\rightarrow\infty$, then

A. $R_{ss}\rightarrow 0$
B. $R_{ss}\rightarrow\infty$
C. $I_{ss}\rightarrow 0$
D. $I_{ss}\rightarrow\infty$

60. A half-wave rectifier connected to a 50 Hz supply generates a peak voltage of 10 V across a 10 mF reservoir capacitor. If this arrangement is connected to a load that takes a constant current of 200 mA, then the peak ripple voltage is



A. 0.4 V
B. 0.8 V
C. 1 V
D. 20 V