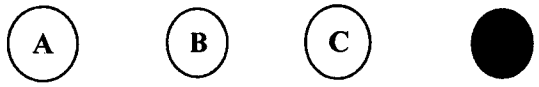
A-52

ENTRANCE EXAMINATIONS 2021
Ph.D. (Electronics Science and Engineering)

Marks: 70

Time: 2.00 hrs Hall Ticket no: [ ]

1. Write your Hall Ticket Number in the space provided above and the OMR Answer Sheet given to you.
2. Read the following instructions carefully before answering the questions.
   A. This Question paper has TWO parts: PART 'A' AND PART 'B'
   B. Part 'A': It consists of 20 objective type questions of 1.75 marks each. There is no negative marking
   C. Part 'B': It consists of 20 objective type questions of 1.75 marks each. There is no negative marking.
   D. 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:



   E. No additional sheets will be provided. Rough work can be done in the question paper itself and rough work sheets provided at the end of the booklet.
   F. Mobile phones, log tables and calculators of any kind are NOT permitted inside the Examination Hall.
3. Values of some physical constants: Planck's constant, $h=6.6\times10^{-34}$ m^2kg/s, speed of light in vacuum, $c= 3\times10^{8}$ m/s, Boltzmann constant $k = 1.38\times10^{-23}$ $m^2kgs^{-2}K^{-1}$, V_T=26 mV at room temperature, free space permittivity $\varepsilon_o = 8.85\times10^{-12}$ F/m, electronic charge, $e= 1.6\times10^{-19}$C.
4. This book contains 12 pages including this cover sheet.

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PART A

1. The first order poles and residues at the first order poles of the function

$$F(z) = \frac{z+1}{z^2-2z}$$ is/are

A. *z= 0; Res(z=0) = -(1/2)*
B. *z = 2; Res(z=2) = 3/2*
C. *z = 0; Res(z=0) = -(1/2)* and *z = 2; Res(z=2) = 3/2*
D. *z=0; Res(z=0) = 1/2* and *z = 2; Res(z=2) = -(3/2)*

2. Which of the following is an example of a set that is neither open nor closed?

A. $0 < |z| < 5$
B. $2 \leq |z - 1| < 5$
C. $0 \leq |z| \leq 5$
D. $\{z \mid z = re^{i\theta},$ for $0 \leq r \leq +\infty$ and $0 \leq \theta \leq \pi/4\}$

3. Let P be the perimeter of a rectangle with dimensions L=5.0(1) cm and width = 8.0(2) cm. The errors are given in the brackets. The perimeter and its uncertainty are respectively

A. 26 cm and $2\sqrt{5}$ cm
B. 26 cm and $\sqrt{10}$ cm
C. 13 cm and $\sqrt{5}$ cm
D. 26 cm and $\sqrt{5}$ cm

4. Which one of the following is a unitary matrix

A. $\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ i & -i \end{bmatrix}$

B. $\frac{1}{\sqrt{3}}\begin{bmatrix} 1 & -2 \\ 2 & 1 \end{bmatrix}$

C. $\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$

D. $\begin{bmatrix} 1+i & 0 \\ 0 & 1-i \end{bmatrix}$

Note: Read the passage below and answer questions 5 and 6

To understand how heat spreads through a material, consider that heat-as well as sound-is actually the motion or vibration of atoms or molecules. Low frequency vibrations correspond to sound while high frequency vibrations correspond to heat. At each frequency, quantum mechanics principles demand that vibrational energy must be a multiple of a basic amount of energy called a quantum that is proportional to the frequency. Physicists call these basic levels of energy as phonons.

5. Which one of the following statements is correct?

A. Sound and heat are frequency dependent phenomena
B. Heat and sound are the same physical quantity
C. Physicists call heat as phonons
D. Physicists call sound as phonons

6. Which one of the following statements is incorrect?

A. Phonons are quanta of vibrational energy
B. Spreading of heat and sound through a material is due to vibration of atoms or molecules
C. Vibrational energy is proportional to frequency.
D. Phonons are a form of atoms or molecules

Note: Read the passage below and answer questions 7 and 8

Wolfgang Pauli (1900-1958) proposed a new rule around 1925, since called the exclusion principle. All particles that have spin ½ and not just electrons, obey the exclusion principle and are called fermions after Enrico Fermi. Particles with spin 0 or 1 do not follow the exclusion principle and are called bosons, after Satyendranath Bose.

7. Which of the following statements is correct?

A. Since it was discovered in 1925, the principle is called exclusion principle
B. Electrons follow Enrico Fermi, so they are called fermions
C. Any particle which has spin ½ is called a fermion
D. The exclusion principle was proposed by Enrico Fermi

8. Which of the following statements is incorrect?

A. Wolfgang Pauli died in 1958
B. All electrons follow the exclusion principle
C. Particles that have spin 0 or 1 do not follow the exclusion principle
D. Particles that have spin 0 or 1 are called bosons because they follow Satyendranath Bose

9. Three independent measuring instruments M1, M2 and M3 produce random errors with standard deviation of 0.5%, 1% and 2% respectively. The least number of measurements that should be taken with M1, M2 and M3 and averaged, so that the standard deviation of the mean is reduced to <0.1% are respectively greater than

A. 5, 5 and 5
B. 25,25 and 25
C. 5,10 and 20
D. 25, 100 and 400

10. If dN/dE, the number of molecules N within an energy interval dE at temperature T is given by the expression(from Maxwell-Boltzmann distribution law)

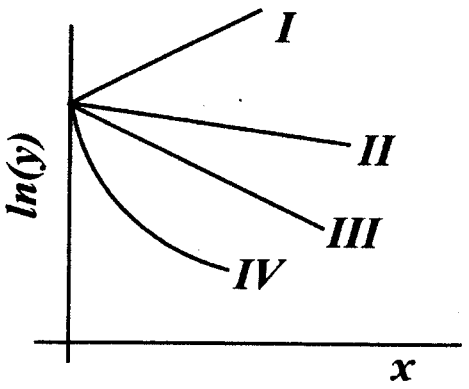
$$\frac{dN}{dE} = \frac{2\pi N}{(\pi kT)^{3/2}} E^{1/2} e^{-E/kT}$$

where k is the Boltzmann constant, then the most probable energy of the molecules at this temperature is

A. (1/2)kT
B. kT
C. (3/2)kT
D. 2πkT

11. Which of the curves shown in figure represent(s) the function y = *A*exp(-*B*x) where the constants *A* and *B* are positive numbers.

A. *I*
B. *I, II, III*
C. *II, III*
D. *IV*



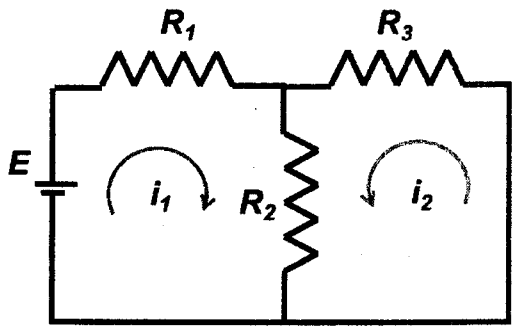
12. Which of the following statements is true?

I. The Schottky barrier diode consists of a metal-semiconductor junction
II. The reverse saturation current in a Schottky barrier diode is generally higher than that in a normal p-n diode
III. The diffusion capacitance in a Schottky barrier diode is infinite
IV. The "i" in a p-i-n diode stands for intrinsic semiconductor

A. I only
B. I and II only
C. I, II and III only
D. I, II and IV only

13. Consider the circuit shown in figure. If I_1 and I_2 are the mesh currents as depicted in figure, the voltage across the resistance R_3 is

A. $(I_1 + I_2)R_3$
B. $(I_1 - I_2)R_3$
C. $(I_1 + I_2)R_2$
D. $(I_1 - I_2)R_2$



14. Which of the following statements is correct?

I. If the channel length of a MOS device is the same order of magnitude as the depletion layer width, it is called a short channel device.
II. The reason for preferring a material with higher dielectric constant than that of SiO_2 as the gate oxide for a MOS device is that it will give lower tunnel leakage current at the same thickness.
III. If the depletion layer width of a MOS device is smaller than the channel length, it is called a short channel device.
IV. The reason for preferring a material with higher dielectric constant than that of SiO_2 as the oxide for a MOS device is that it increases the short channel effect.

A. I only.
B. I and II only.
C. II and III only.
D. IV only.

15. In a series LCR circuit, if the signal voltage across the resistor leads the applied voltage then the frequency of the applied signal can be

A. equal to the resonance frequency only
B. less than the resonance frequency only
C. greater than the resonance frequency only
D. either greater than or less than the resonance frequency

16. A bipolar junction transistor is biased to operate in the active region. If the emitter current is increased by 1.5 times, then the voltage across the base-emitter junction

A. increases by 1.5 times
B. decreases by 1.5 times
C. increases by about 10 mV
D. decreases by about 10 mV

17. There are customers of a gas station who pay either with a credit card (A) or cash(B) or debit card (C). If it is assumed that customers are making independent choices with Probability of A = 0.3, B= 0.2 and C = 0.5 respectively. The mean and variance of the next 100 customers, who do not pay with cash is respectively

A. 30, 14
B. 50, 14
C. 25, 16
D. 80, 16

18. A discrete linear time invariant system is characterized by the impulse response $h(n) = 3^n u(n-4)$. If $u(n)$ is a step signal then the system is

A. stable and causal
B. unstable and causal
C. stable and non-causal
D. un stable and non-causal

19. A total of 10,000 instruments of the same model number are subjected to quality check using a device. It is known that 1% of the instruments are faulty and that the checking device gives 90% true positive and 5% false positive results. If an instrument is reported as faulty by the checking device, then the probability that the instrument is actually faulty is approximately

A. 0.01
B. 0.15
C. 0.05
D. 0.9

20. Which one of the following semiconductors has an optical band gap near the ultra-violet region of the electromagnetic spectrum?

A. GaN
B. GaAs
C. InP
D. Ge

PART B

21. The value of $\int z^2 dz$ along the line $y = x^2$ from (0,0) to (1,1) is [where $z = x + iy$]

A. $-\frac{2}{3}(1-i)$
B. $-\frac{2}{3}(1+i)$
C. $+\frac{2}{3}(1-i)$
D. $+\frac{2}{3}(1+i)$

22. The roots of the indicial equation corresponding to the differential equation

$$(x^2 - y^2)\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 4y = 0$$

are

A. 2, 1
B. 2, 2
C. 2, 0
D. 0, 1

23. The orthogonal trajectory of a family of straight lines is

A. A family of straight lines
B. A family of circles
C. A family of parabolas
D. A family of ellipses

24. Consider a properly biased common collector transistor amplifier. If the common emitter current gain (β) of the transistor is doubled, without affecting the biasing conditions, then which of following is true for the voltage gain (A_V) and the input impedance (Z_{in}) of this amplifier?

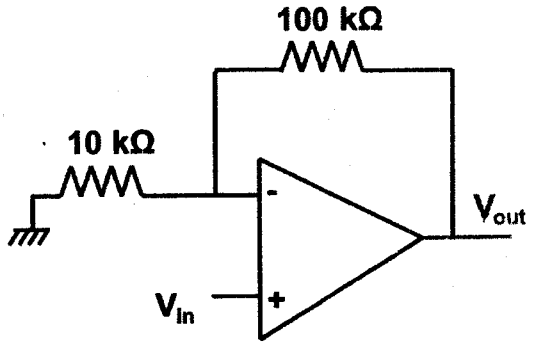
A. A_V will remain unchanged but Z_{in} will be doubled
B. A_V will be doubled but Z_{in} will remain unchanged.
C. Both A_V and Z_{in} remain unchanged.
D. Both A_V and Z_{in} will be doubled.

25. As temperature (T) increases, the effective density of states in the conduction band of a semiconductor

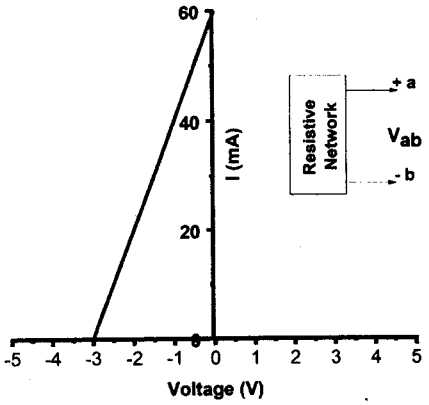
A. remains the same.
B. increases as $T^{3/2}$
C. decreases as $T^{-3/2}$
D. increases as $T^{1/2}$

26. The input offset voltage of the op-amp circuit shown is 10 mV. If the input voltage (V_{in}) is zero then the output voltage (V_{out}) is

A. 0V
B. +110 mV
C. ±110 mV
D. -100 mV



27. The measurement made between the terminals a and b of a two-port resistive network shown below yields the current-voltage characteristics given in the graph. The magnitude of Thevenin resistance for this circuit is



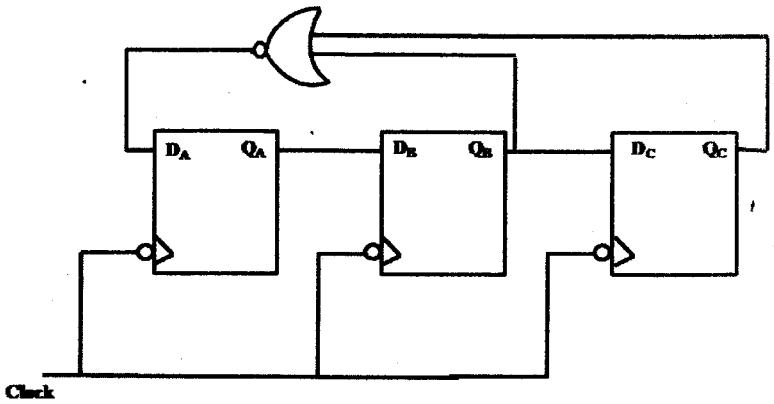
A. 0.05 Ohm
B. 3 Ohm
C. 20 Ohm
D. 50 Ohm

28. In a purely linear network with load Z_L and phase angle θ_L, if Z_{Th} and θ_{Th} are the corresponding Thevenin equivalents then the maximum power transfer happens when

A. $Z_L = Z_{Th}$ and $\theta_L = -\theta_{Th}$
B. $Z_L = Z_{Th}$ and $\theta_L = \theta_{Th}$
C. $Z_L = Z_{Th}$ and $\theta_L = 0$
D. $Z_L = -Z_{Th}$ and $\theta_L = \theta_{Th}$

29. If it is assumed that all the flip-flops in the given circuit are in reset condition initially, the count sequence observed at Q_B is

A. 0 11 000....
B. 00 11 00...
C. 000110...
D. 010101..



30. The maximum amplitude of the Fourier transform of $\exp(-x^2)$ is

A. 1
B. 1/2
C. $\sqrt{2}$
D. $1/\sqrt{2}$

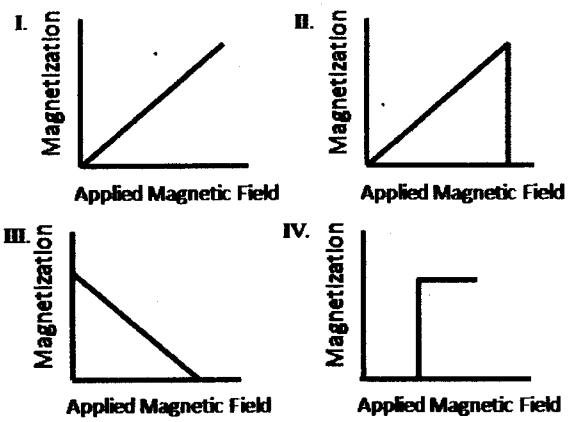
31. The loss tangent of a material with a conduction current density of 5 units and displacement current density of 10 units is

A. 0.5
B. 2.0
C. 2.5
D. 50.0

32. For an electromagnetic wave with propagation constant $\gamma = 0.650+j2.55$, the value of phase velocity at a wave frequency of 1kHz is ?

A. 1.18×10^3 rad/s
B. 1.50×10^3 rad/s
C. 2.46×10^3 rad/s
D. 4.58×10^3 rad/s

33. Which of the following graphs corresponds to the behaviour of a superconductor in the presence of an applied magnetic field?



A. I only
B. I and III only
C. II and III only
D. III and IV only

34. The doping concentration required to fabricate a 2 kΩ thin film resistor of n-type GaAs given that the resistor length is 200 μm, area is 10^{-6} cm^2, the mobility of electrons is 8000 cm^2/V-s and the doping efficiency is known to be 90%, is

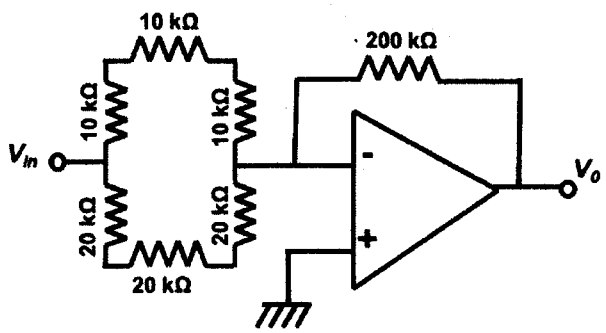
A. 5.0×10^{14} cm^{-3}
B. 6.5×10^{14} cm^{-3}
C. 8.7×10^{15} cm^{-3}
D. 5.0×10^{15} cm^{-3}

35. Which of the following statements is correct for a dual gate MOSFET?

I. Since there are two gates, the unwanted capacitive effects at higher frequencies are decreased.
II. The presence of two gates reduces short channel effects, leading to better scalability and lower sub threshold current.
III. It requires identically sized gates and self-alignment of source and drain to both gates.
IV. Since there are two gates the unwanted capacitive effects at higher frequencies are increased.

A. I and II only
B. I,II and III only
C. II,III and IV only
D. III and IV only

36. The open-loop voltage gain, open-loop input impedance and the open-loop output impedance of the Operational amplifier shown in figure are 200,000; 1 MΩ and 1 Ω respectively. The closed-loop input impedance (Zin_{cl}) and the closed-loop output impedance ($Zout_{cl}$) of this circuit are



A. Zin_{cl}= 1 MΩ *and* $Zout_{cl}$ = 1 Ω

B. Zin_{cl}= 20 GΩ *and* $Zout_{cl}$ = 50 μΩ

C. Zin_{cl}= 20kΩ *and* $Zout_{cl}$ = 200 kΩ

D. Zin_{cl}= 20kΩ *and* $Zout_{cl}$ = 50 μΩ

37. A linear time invariant system has an impulse response h(t) = exp(-2|t|), the frequency response H(ω) of this system is?

A. $\frac{1}{j\omega+2}$

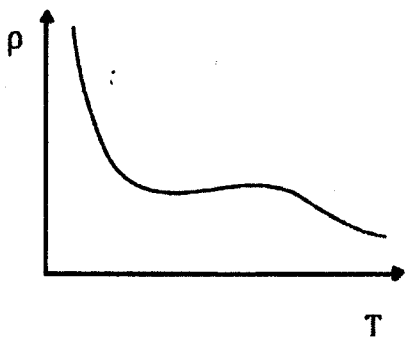
B. $\frac{1}{j\omega-2}$

C. $\frac{4}{4+\omega^2}$

D. $\frac{-1}{j\omega-2}$

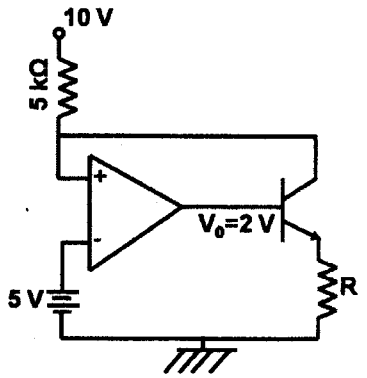
38. The resistivity (ρ) of a material is measured as a function of the temperature (T). If the figure shows a qualitative relation between ρ and T then the material is?

A. a metal.
B. an insulator
C. an intrinsic semiconductor.
D. an extrinsic semiconductor.



39. In the given circuit an ideal op-amp is used and the BJT has $V_{BE} = 0.6$ V and $\beta = 100$. The value of the resistance R is approximately?

A. 5600 Ω
B. 4400 Ω
C. 2600 Ω
D. 1400 Ω



40. An ideal 8-bit successive approximation analog-to-digital converter (ADC) works at 1MHz. The average time taken to convert a byte of data into an analog signal is

A. 1 μs
B. 8 μs
C. 255 μs
D. 256 μs

Ph.D. Electronics Sciences and Engineering

Key PhD(ESE) July 2021

1. C
2. B
3. A
4. C
5. A
6. D
7. C
8. D
9. D
10. A
11. C
12. D
13. C
14. B
15. B
16. C
17. D
18. B
19. B
20. A
21. A
22. B
23. B
24. A
25. B
26. C
27. D
28. A
29. B
30. D
31. A
32. C
33. A
34. C
35. B
36. D
37. C
38. D
39. D
40. B

Thiru
(Thanes Raj M)
6/9/2021