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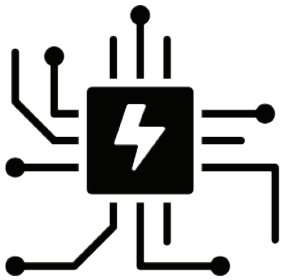
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BASIC ELECTRONICS ENGINEERING

SECTION 1

SYLLABUS

BASICS OF SEMICONDUCTORS; DIODE/TRANSISTOR BASICS AND CHARACTERISTICS; DIODES FOR DIFFERENT USES; JUNCTION & FIELD EFFECT TRANSISTORS (BJTS, JFETS, MOSFETS); TRANSISTOR AMPLIFIERS OF DIFFERENT TYPES, OSCILLATORS AND OTHER CIRCUITS; BASICS OF INTEGRATED CIRCUITS (ICS); BIPOLAR, MOS AND CMOS ICS; BASICS OF LINEAR ICS, OPERATIONAL AMPLIFIERS AND THEIR APPLICATIONS LINEAR/NON-LINEAR; OPTICAL SOURCES/DETECTORS; BASICS OF OPTO ELECTRONICS AND ITS APPLICATIONS.



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NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS - ESE ELECTRONICS

BASIC ELECTRONICS ENGINEERING		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.1	Semiconductor Physics	6	13	9	8	8	11	11	5	9	8	8	4	2
1.2	PN – Junction Diodes	1	2	7	-	1	1	1	4	6	-	1	1	2
1.3	BJT and FET	4	1	3	4	4	3	3	4	5	2	5	3	4
1.4	Special Diodes and Optoelectronic Devices	2	3	5	4	3	4	4	2	2	1	4	4	6
1.5	Power Switching Devices	1	1	1	1	4	3	1	2	-	-	3	4	2
BASIC ELECTRONICS ENGINEERING		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	
1.1	Semiconductor Physics	9	9	9	-	2	-	-	1	2	10	3	3	
1.2	PN – Junction Diodes	-	2	1	-	2	-	-	1	1	3	-	1	
1.3	BJT and FET	8	6	3	3	1	3	-	5	4	1	5	-	
1.4	Special Diodes and Optoelectronic Devices	2	4	3	4	2	-	2	-	1	1	1	1	
1.5	Power Switching Devices	4	4	-	-	-	-	1	-	-	1	-	-	

CHAPTER-1 BASIC ELECTRONICS ENGINEERING

Unit 1.1: Semiconductor Physics

Previous Year Exam Questions

[ESE-2001]

1. As the Fermi energy of silver is 8.8×10^{-19}, the velocity of the fastest electron in silver at $0^{\circ}K$ (Given: Rest mass of electron $= 9.1 \times 10^{-31}$ kg) is

(a) 3.33×10^{5} m/s (b) 1.39×10^{6} m/s
(c) 4.40×10^{7} m/s (d) 3×10^{8} m/s

[ESE-2001]

2. A four-point probe method is used to evaluate the sheet resistance of a semiconductor epitaxial layer. If a probe current of 10 mA produces a voltage drop of 0.22 V between the inner probes, then the sheet resistance of the layer is

(a) 100 Ω/square (b) 215 Ω/square
(c) 572 Ω/square (d) 1000 Ω/square

[ESE-2001]

3. For which of the following semiconductors, resistance does not follow Ohm's law over some specific range of the applied voltage?

(1) Germanium
(2) Gallium arsenide
(3) Indium phosphide

Select the correct answer using the codes given bellow:

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

[ESE-2001]

4. Electron mobility and life-time in a semiconductor at room temperature are respectively $0.36\ m^2/(Vs)$ and $340\ \mu s$. The diffusion length is

(a) 3.13 mm (b) 1.77 mm
(c) 3.55 mm (d) 3.13 cm

[ESE-2001]

5. Consider the following statements:
Impurity diffusion is used in semiconductor to control the conductivity. The nature of the impurity profile should be such that the

1. impurity concentration decreases with diffusion depth.
2. profile results in an internal electric field.
3. impurity concentration is homogeneous with no internal electric field.

Which of these statements are correct?

(a) 1, 2 and 3 (b) 1 and 3
(c) 2 and 3 (d) 1 and 2

[ESE-2001]

6. Which of the following statements relate to the Hall - effect?

1. A potential difference is developed across a current-carrying metal strip when the strip is placed in a transverse magnetic field.
2. The Hall voltage is very weak in metals but is large in semiconductors.
3. The Hall voltage is very weak in semiconductors but is large in metals.
4. It is applied in the measurement of the magnetic field intensity.

Select the correct answer using the codes given bellow:

(a) 1, 2 and 3 (b) 2 and 4
(c) 1, 3 and 4 (d) 1, 2 and 4

[ESE-2002]

7. When a semiconductor bar is heated at one end, a voltage across the bar is developed. If the heated end is positive, the semi-conductor is

(a) p-type (b) n-type
(c) intrinsic (d) highly degenerate

[ESE-2002]

8. In a degenerate semiconductor, the majority carriers are controlled by

(a) Fermi-Dirac statistics
(b) Maxwell-Boltzmann statistics
(c) Bose-Einstein (B-E) statistics
(d) Pauli's exclusion principle

[ESE-2002]

9. Fermions are the particles, which obey

(a) Maxwell-Boltzmann's statistics
(b) Bose-Einstein's statistics
(c) Heisenberg's uncertainty principle
(d) Pauli's exclusion principle

[ESE-2002]

10. Assertion (A): The intrinsic Fermi level of a semiconductor does not lie exactly at the middle of the energy band gap.

Reason (R): The densities of the available states in valance and conduction bands of a semiconductor are equal.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2002]

11. The conductivity of a semiconductor crystal due to any current carrier is NOT proportional to

(a) mobility of the carrier
(b) effective density of states in the conduction band
(c) electronic charge
(d) surface states in the semiconductor

[ESE-2002]

12. Excess carriers are generated in a sample of N-type semiconductor by shining light at one end. The current flow in the sample will be mainly due to

(a) diffusion flow of carriers
(b) drift flow of carriers
(c) both diffusion and drift flow of carriers
(d) neither diffusion nor drift flow of carriers

[ESE-2002]

13. Consider two samples of silicon semiconductors identical in all respects except that one is uniformly doped with $10^{15}\ \mathrm{cm}^{-3}$ donor impurity atoms (sample A) and the other is non-uniformly doped with donors from one side.

Consider the following statements:

1. Sample A will not have any current at equilibrium but current will flow out of sample B.
2. Both samples will have built-in electric field.
3. Sample A will have zero built-in electric field whereas sample B will have a constant built - in electric field.
4. No current will flow at equilibrium from either sample A or sample B.

Which of these statements are correct?

(a) 1 and 2 (b) 1 and 3
(c) 1 and 4 (d) 3 and 4

[ESE-2002]

14. Consider the following statements:

The temperature dependence of resistivity of a sample of N-type silicon is based upon carrier concentration and carrier mobility variations with temperature because

1. the resistivity of silicon increases with temperature.
2. the mobility decreases with temperature
3. the carrier concentration increases with temperature
4. the resistivity of silicon decreases with temperature.

Which of these statements are correct?

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1 and 2 (d) 3 and 4

[ESE-2002]

15. The unit of mobility is

(a) $m^2V^{-1}s^{-1}$ (b) $\mathrm{mV}^{-1}\ \mathrm{s}^{-1}$
(c) Vsm^{-1} (d) Vms^{-1}

[ESE-2002]

16. The Haynes-Shockley experiment enables one to determine the

(a) diffusion coefficient of majority carriers
(b) effective mass of the minority carriers
(c) mobility of the minority carriers only
(d) lifetime of the majority carriers

[ESE-2002]

17. The Hall constant in a p-Si bar is given by $5 \times 10^3\ \mathrm{cm}^3$/Coulomb. The hole concentration in the bar is given by

(a) $1.00 \times 10^{15}/\mathrm{cm}^3$ (b) $1.25 \times 10^{15}/\mathrm{cm}^3$
(c) $1.50 \times 10^{15}/\mathrm{cm}^3$ (d) $1.6 \times 10^{15}/\mathrm{cm}^3$

[ESE-2002]

18. In an extrinsic semiconductor, the Hall coefficient R_H

(a) increases with increase of temperature
(b) decreases with increase of temperature
(c) is independent of the change of temperature
(d) changes with the change of magnetic field

[ESE-2002]

19. Consider a semiconductor bar having square cross-section. Assume that holes drift in the positive x-direction and magnetic field is applied perpendicular to the direction in which holes drift. The sample will Show

(a) a negative resistance in positive y-direction
(b) a positlve voltage in positive y-direction
(c) a negative voltage in positive y-direction
(d) a magnetic field in positive y-direction

[ESE-2003]

20. Consider the following statements for an n-type semiconductor:

1. Donor level ionization decreases with temperature
2. Donor level ionization increases with temperature
3. Donor level ionization is independent of temperature

4. Donor level ionization increases as E_D (donor energy level) moves towards the conduction band at a given temperature.

Which of these statements is/are correct?

(a) 1 only (b) 2 only
(c) 2 and 4 (d) 3 only

[ESE-2003]

21. Consider the following statements for an n-type semiconductor:

1. E_F lies below E_D at a room temperature (T).
2. E_F lies above E_D as $T \to 0$
3. $E_F = E_D$ at some intermediate temperature
4. E_F is invariant with temperature.

Where E_F is Fermi energy and E_D is donor level energy. Which of these statement(s) is/are correct?

(a) 1 and 2 (b) 2 and 3
(c) 4 only (d) 1, 2 and 3

[ESE-2003]

22. Assume $n_i = 1.45 \times 10^{10}/\text{cm}^3$ for silicon. In an n-type silicon sample, the donor concentration at 300 K is $5 \times 10^{14}/\text{cm}^3$ and corresponds to 1 impurity atom for 10^8 silicon atoms. The electron and hole concentrations in the sample will be

(a) $n = 5 \times 10^{14}/\text{cm}^3$ $p = 4.2 \times 10^5/\text{cm}^3$
(b) $n < 5 \times 10^{14}/\text{cm}^3$ and $p > 4.2 \times 10^5/\text{cm}^3$
(c) $n > 5 \times 10^{14}/\text{cm}^3$ and $p < 4.2 \times 10^5/\text{cm}^3$
(d) $n < 5 \times 10^{14}/\text{cm}^3$ and $p < 4.2 \times 10^5/\text{cm}^3$

[ESE-2003]

23. The resistivity at room temperature of intrinsic silicon is $2.3 \times 10^3\ \Omega\text{m}$ and that of an n-type extrinsic silicon sample is $8.33 \times 10^{-2}\ \Omega\text{m}$. A bar of this extrinsic silicon $50 \times 100\ \text{mm}$ and a steady current of $1\ \mu\text{A}$ exists in the bar. The voltage across the bar is found to be 50 mV. If the same bar is of intrinsic silicon, the voltage across the bar will be about

(a) 1400 V (b) 140 V
(c) 14 V (d) 1.4 V

[ESE-2003]

24. A semiconductor specimen of thickness d, width w and carrying current I is placed in a magnetic field B to develop Hall voltage V_H in a direction perpendicular to I and B. V_H is NOT proportional to

(a) B (b) I
(c) $1/w$ (d) $1/d$

[ESE-2003]

25. Assertion (A): The conductivity of a semiconductor is decided by the level of its doping and is almost independent of its band gap value irrespective of temperature.

Reason (R): The carrier concentration due to doping is independent of temperature, if it is not too low.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2003]

26. The correct sequence of the following materials in the increasing order of conductivity is

(a) Silicon doped with boron - Silver Aluminium - Intrinsic silicon
(b) Intrinsic silicon - Aluminium - Silver - Silicon doped with boron
(c) Aluminium - Intrinsic silicon - Silicon doped with boron – Silver
(d) Intrinsic silicon - Silicon doped with boron Aluminium – Silver

[ESE-2003]

27. Even though carbon is in the IV group of the Periodic Table, it is not used as a semiconductor because it has

(a) High dielectric constant
(b) Large energy gap > 5 eV
(c) Low temperature coefficient
(d) Low thermal conductivity

[ESE-2003]

28. Assertion (A): Every material has a different value of energy band gap except metals which have no band gap.

Reason (R): The energy band gap is decided by the equilibrium lattice constant which is different in different materials.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2004]

29. Match List-I (Material) with List-II (Band Gap) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Metal	1. 9 eV
B. Semimetal	2. 0.05 eV
C. Semiconductor	3. 1.5 eV
D. Insulator	4. 0 or less

Codes:

	A	B	C	D
(a)	4	2	3	1
(b)	4	3	2	1
(c)	1	2	3	4
(d)	3	2	4	1

[ESE-2004]

30. The electrical resistivity of sodium silicate glass is $10^5\,\Omega m$ whereas that of pure silicate glass is $10^{17}\Omega m$. This vast difference of 12 orders of magnitude is due to which one of the following reasons?

(a) The loosely-bound sodium ions in the silicate
(b) The impurities in silica
(c) The difference in the crystal structures
(d) The presence of free electrons in the silicate

[ESE-2004]

31. What is the approximate mobility of holes in Germanium at room temperature?

(a) $4500\ \text{cm}^2/\text{V}\cdot\text{s}$ (b) $2400\ \text{cm}^2/\text{V.s}$
(c) $1800\ \text{cm}^2/\text{V}\cdot\text{s}$ (d) $900\ \text{cm}^2/\text{V.s}$

[ESE-2004]

32. The diffusion of both electrons and holes occurs in a semiconductor (with $q =$ charge of electron/ Hole; $D_n, D_p =$ diffusion constant for electrons/ holes; $\partial n/\partial x, \partial p/\partial x =$ gradient for electrons/holes).
What is the total diffusion current (J_{diff}) ?

(a) $qD_n\frac{\partial n}{\partial x} + qD_p\frac{\partial p}{\partial x}$
(b) $qD_n\frac{\partial}{\partial x}\left(\frac{\partial n}{\partial x}\right) + qD_p\frac{\partial}{\partial x}\left(\frac{\partial p}{\partial x}\right)$
(c) $qD_n\frac{\partial}{\partial x}\left(\frac{\partial n}{\partial x}\right) - qD_p\frac{\partial}{\partial x}\left(\frac{\partial p}{\partial x}\right)$
(d) $qD_n\frac{\partial n}{\partial x} - qD_\rho\frac{\partial p}{\partial x}$

[ESE-2004]

33. Consider the following statements
The intrinsic concentration of a semiconductor
1. depends on doping
2. increases exponentially with decrease of band gap of the semiconductor
3. increases non-linearly with increase of temperature
4. Increases linearly with increase of temperature

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 1 and 3
(c) 2 and 3 (d) 2 and 4

[ESE-2004]

34. Consider the following statements:
During an electron transition across the energy gap in an indirect energy gap material like silicon
1. the momentum of the electron changes
2. the direction of motion of the electron changes
3. the potential energy of the electron changes
4. the kinetic energy of the electron changes

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2 and 4

[ESE-2004]

35. Match List-I (Equation) with List-II (Relation between/Description) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Continuity equation	1. Relates diffusion constant with mobility
B. Einstein's equation	2. Relates charge density with electric field
C. Poisson's equation	3. Relates flow with rate of change of concentration in space
D. Diffusion equation	4. Rate of change of minority carrier density with time

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	4	1	2	3
(c)	1	4	2	3
(d)	1	4	3	2

[ESE-2004]

36. Assertion (A): The concentration measured by Hall effect does not have much significance if the semiconductor is non-homogeneously doped.
Reason (R): The current density is uniform throughout the thickness of the semi-conductor.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2005]

37. Silicon and Germanium are not suitable for fabrication of laser diodes because:

(a) Their absorption coefficients are very high
(b) Their emission coefficients are very low
(c) They have direct band gap
(d) They have indirect band gap

[ESE-2005]

38. The mobility of electrons in a semiconductor is defined as the

(a) Diffusion velocity per unit electric field
(b) Diffusion velocity per unit magnetic field
(c) Drift velocity per unit magnetic field
(d) Drift velocity per unit electric field

[ESE-2005]

39. The free electron density in a conductor is $(1/1.6) \times 10^{22}\ \text{cm}^{-3}$ The electron mobility is $10\ \text{cm}^2/\text{Vs}$. What is the value of its resistivity?
(a) $10^{-4}\ \Omega\ \text{m}$ (b) $1.6 \times 10^{-2}\ \Omega\ \text{m}$
(c) $10^{-4}\ \Omega\ \text{cm}$ (d) 10^{4}mho cm^{-1}

[ESE-2005]

40. The intrinsic concentration in a semi-conductor at 300°K is $10^{13}\ \text{cm}^{-3}$. When it is doped with donor type impurities, the majority carrier concentration becomes $10^{17}\ \text{cm}^{-3}$. What is the value of its minority carrier density?
(a) $0.999 \times 10^{17}\ \text{cm}^{-3}$ (b) 10^{17}cm^{-3}
(c) $10^{4}\ \text{cm}^{-3}$ (d) $10^{9}\ \text{cm}^{-3}$

[ESE-2005]

41. Which one of the following is the correct relationship between the band gap of a material used in a photo detector and the energy of the incident photon?
(a) $E_g \geq hc/\lambda$ (b) $hv^2/\lambda \geq E_g$
(c) $hv \geq E_g$ (d) $1/2hv \leq E_g$
(The symbols have usual meanings)

[ESE-2005]

42. Two pure specimen of a semiconductor material are taken. One is doped with $10^{18}\ \text{cm}^{-3}$ number of donors and the other is doped with $10^{16}\ \text{cm}^{-3}$ number of acceptors. The minority carrier density in the first specimen is $10^{7}\ \text{cm}^{-3}$. What is the minority carrier density in the other specimen?
(a) $10^{16}\ \text{cm}^{-3}$ (b) $10^{27}\ \text{cm}^{-3}$
(c) $10^{18}\ \text{cm}^{-3}$ (d) $10^{9}\ \text{cm}^{-3}$

[ESE-2005]

43. Match List-I (Type of Conductor) with List-II (Position of Fermi Level) and select the correct answer using the codes given below the lists:

List-I	List-II
A. n-type semiconductor	1. Middle of band gap
B. p-type semiconductor	2. Above conduction band
C. Intrinsic semiconductor	3. Near but below conduction band
D. Degenerate n-type semiconductor	4. Near but above valence band

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	1	4	3	2
(d)	3	2	1	4

[ESE-2005]

44. Which one of the following statements is correct in respect of the use of Direct Gap (DG) and Indirect Gap (IG) semiconductors in fabrication of Light Emitting diode?
(a) Both DG and IG semiconductors are suitable
(b) Only DG semiconductor is suitable
(c) DG semiconductor is suitable and some IG materials having proper dopants are also used
(d) only IG semiconductors are suitable

[ESE-2006]

45. Consider the following statements:
Electrical conductivity of a metal has negative temperature coefficient since
1. electron concentration increases with temperature
2. electron mobility decreases with temperature
3. electron-lattice scattering increases with temperature

Which of the statements given above are correct?
(a) 1, 2 and 3 (b) Only 1 and 2
(c) Only 2 and 3 (d) Only 1 and 3

[ESE-2006]

46. Match List-I (Material) with List-II (Carrier Concentration/m^3) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Intrinsic semiconductor	1. 10^{28}
B. Insulator	2. 10^{22}
C. Extrinsic semiconductor	3. 10^{18}
D. Conductor	4. 10^{14}

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	2	1	3	4
(c)	3	1	2	4
(d)	2	4	3	1

[ESE-2006]

47. Mobility is defined as
(a) diffusion velocity per unit field
(b) drift velocity per unit field
(c) displacement per unit field
(d) number of free electrons/number of bound electrons

[ESE-2006]

48. Assertion (A): An n-type semiconductor behaves as an intrinsic semiconductor at very high temperatures.
Reason (R): The breaking of the covalent bonds becomes a significant phenomenon at high temperatures.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2006]

49. Assertion (A): Electron mobility in metals decreases with increasing temperature.
Reason (R): In metals electron concentration is high.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2006]

50. Consider a Ge diode operating at $27^{\circ}C$ and just beyond the threshold voltage of Ge. What is the value of dV/dT?
(a) $-1.9\ \text{mV}/^{\circ}\text{C}$
(b) $-2.0\ \text{mV}/^{\circ}\text{C}$
(c) $-2.1\ \text{mV}/^{\circ}\text{C}$
(d) $-2.3\ \text{mV}/^{\circ}\text{C}$

[ESE-2006]

51. Which of the following can be determined by using a Hall crystal?
1. Concentration of holes in a p-type semiconductor.
2. Concentration of electrons in an n-type semiconductor
3. Temperature of the set-up with any type of semiconductor
4. Diffusion constant and life-time of minority carriers of any type of semiconductor

Select the correct answer using the code given below:
(a) Only 1 and 2 (b) 1, 2 and 4
(c) Only 3 and 4 (d) Only 2 and 4

[ESE-2006]

52. Match List-I (Current) with List-II (Variation) and select the correct answer using the code given below the lists:

List I	List II
A. Hole diffusion current	1. $n \cdot E$
B. Electron drift current	2. $p \cdot E$
C. Hole drift current	3. $-dp/dx$
D. Electron diffusion current	4. dn/dx

Codes:

	A	B	C	D
(a)	2	1	3	4
(b)	3	4	2	1
(c)	2	4	3	1
(d)	3	1	2	4

[ESE-2006]

53. The electron concentration in a silicon sample doped with $10^{15}\ \text{cm}^{-3}$ P atoms, will vary, in the temperature range of $4.2 - 1000K$, as follows:
(a) It will be $10^{15}\ \text{cm}^{-3}$ over the whole range
(b) It will be $10^{15}\ \text{cm}^{-3}$ upto a temperature T at which intrinsic concentration is $10^{15}\ \text{cm}^{-3}$ and then it will increase exponentially
(c) It will first increase exponentially upto a temperature T then remain constant at $10^{15}\ \text{cm}^{-3}$ over the remaining range
(d) It will first increase exponentially upto a temperature T_1 then remain constant at $10^{15}\ \text{cm}^{-3}$ upto a temperature T_2 and then increase exponentially

[ESE-2006]

54. In addition to conduction, which one of the following mechanisms can account for the transport of charges in a semiconductor (not ordinarily encountered in metals)?
(a) E.M.F. generated within the body of the semiconductor
(b) Mutual attraction between charges
(c) Mutual repulsion between charges
(d) Diffusion

[ESE-2006]

55. Match List-I (Material) with List-II (Energy Level) and select the correct answer using the code given below the lists:

List-I	List-II
A. p-type semiconductor at 0°K temperature	1. Donor energy level is close to the conduction band
B. Intrinsic semiconductor at 0°K temperature	2. Acceptor energy level is close to the valence band

C. n-type semiconductor at room temperature	3. Fermi-level is very close to valence band
D. p-type semiconductor at room temperature	4. Fermi-level is half-way between the valence band and the conduction band

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	1	4	3	2
(d)	3	2	1	4

[ESE-2007]

56. For a semiconductor, the conductivity is a function of the products of the number of charge carriers and their nobilities. As a result, if the temperature of a slab of intrinsic silicon increases, how does its conductivity vary?

(a) Decreases
(b) Increases as a non-linear variation
(c) Remains unaffected
(d) Increases or decreases depending upon the rise in temperature

[ESE-2007]

57. An n-type semiconductor is illuminated by a steady flux of photons with energy greater than the band gap energy. The change in conductivity $\Delta\sigma$ obeys which relation?

(a) $\Delta\sigma = 0$ (b) $\Delta\sigma = e(\mu_n + \mu_p)\Delta n$
(c) $\Delta\sigma = e(\mu_n \Delta n - \mu_p \Delta p)$ (d) $\Delta\sigma = e\mu_n \Delta n$

[ESE-2007]

58. A Si sample is doped with a fixed number of group V Impurities. The electron density n is measured from 4 K to 1200 K for the sample. Which one of the following is correct?

(a) n remains constant over the temperature range
(b) n increases monotonically with increasing temperature
(c) n increases first, remains constant over a range and again increases with increasing temperature
(d) n increases, shows a peak and then decreases with rise in temperature

[ESE-2007]

59. Assertion (A): A heavily doped semiconductor can exhibit positive temperature coefficient of resistance.
Reason (R): The carrier mobility decreases with increase of temperature.

(a) Both (A) and (R) are individually true and (R) is the correct explanation of (A).
(b) Both (A) and (R) tare individually true but (R) is not the correct explanation of (A).
(c) (A) is true but (R) is false.
(d) (A) is false but (R) is true.

[ESE-2007]

60. Which one of the following expressions may be used to correctly describe the temperature (T) variation of the intrinsic carrier density (n_i) of a semiconductor?

(a) $n_i(T) = (A/T)\exp(-E_g/kT^2)$
(b) $n_i(T) = A(E_g/kT)^{10}$
(c) $n_i(T) = A\exp(-E_g/2kT)$
(d) $n_i(T) = AT^{3/2}\exp(-E_g/2kT)$

E_g is the band gap, A is pre-factor, k is Boltzmann constant.

[ESE-2007]

61. An intrinsic semiconductor (intrinsic electron density $= 10^{16}\ \mathrm{m}^{-3}$) is doped with donors to a level of $10^{22}\ \mathrm{m}^{-3}$. What is the hole density assuming all donors to be ionized?

(a) $10^7\ \mathrm{m}^{-3}$ (b) $10^8\ \mathrm{m}^{-3}$
(c) $10^{10}\ \mathrm{m}^{-3}$ (d) $10^6\ \mathrm{m}^{-3}$

[ESE-2007]

62. In a homogeneously doped n-type semiconductor bar, holes are injected at one end of the bar. How will the holes flow to the other end?

(a) By drift mechanism only
(b) By diffusion mechanism only
(c) By combination of drift and diffusion mechanisms
(d) By recombination mechanism

[ESE-2007]

63. The drift velocity of electrons in silicon varies with applied electric field in which one of the ways?

(a) It monotonically increases with increasing field
(b) It first increases linearly, then sub linearly increases and finally attains saturation with increasing field
(c) It first increases, then decreases showing a negative differential region, again increases and finally saturates
(d) The drift velocity remains unchanged with increase in field

[ESE-2007]

64. Why does the mobility of electrons in a semiconductor decrease with increasing donor density?

(a) Doping increases the effective mass of electrons
(b) Doping decreases the relaxation time of electrons
(c) Electrons are trapped by the donors
(d) More holes are generated so that the effective mobility decreases

[ESE-2007]

65. Match List-I (Item) with List-II (Position) and select the correct answer using the code given below the lists:

List-I	List-II
A. Donor energy band	1. At the middle of the forbidden energy gap
B. Fermi level of p-type semiconductor at room temperature	2. Close to the conduction band
C. Acceptor energy band	3. Very close to the valence band
D. Fermi level intrinsic semiconductor	4. Close to the valence band

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	3	4	1

[ESE-2007]

66. The electron and hole concentrations, n and p respectively obey the relation $np = n_i^2$ where n_i is the intrinsic carrier density. This expression is valid for which of the following?
(a) For all semiconductors under any condition
(b) For direct band gap semiconductor only
(c) For non-degenerate semiconductor under thermal equilibrium condition
(d) For degenerate semiconductors having excess electrons and holes

[ESE-2008]

67. An intrinsic semiconductor is doped lightly with p-type impurity. It is found that the conductivity actually decreases till a certain doping level is reached. Why does this occur?
(a) The mobility of holes decreases
(b) The mobility of both electrons and holes decreases
(c) The hole density actually reduces
(d) Effect of reduction in electron due to increase in holes compensates more than the effect of increase in holes on conductivity

[ESE-2008]

68. Assuming that the electron mobility in intrinsic silicon is $1500\ \text{cm}^2/\text{Vs}$ at room temperature ($T = 300^\circ\text{K}$) and the corresponding 'volt equivalent of temperature' $V_T = 25.9\ \text{mV}$, what is the approximate value of the electron diffusion constant?
(a) $40\ \text{cm}^2/\text{s}$ (b) $4\ \text{cm}^2/\text{s}$
(c) $400\ \text{cm}^2/\text{s}$ (d) $4000\ \text{cm}^2/\text{s}$

[ESE-2008]

60. An intrinsic semiconductor with energy gap 1 eV has a carrier concentration N at temperature 200 K. Another intrinsic semiconductor has the same value of carrier concentration N at temperature 600 K. What is the energy gap value for the second semiconductor?
(a) $\left(\frac{1}{3}\right)$ eV (b) $\left(\frac{3}{2}\right)$ eV
(c) 3 eV (d) 9 eV

[ESE-2008]

70. Consider the following statements:
n-type of silicon can be
(1) formed by adding impurity of phosphorous
(2) formed by adding impurity of arsenic
(3) formed by adding impurity of boron
(4) formed by adding impurity of aluminium
Which of the statements given above are correct?
(a) 1 and 3 only (b) 3 and 4 only
(c) 1 and 2 only (d) 1, 2, 3 and 4

[ESE-2008]

71. The doping concentration on the n - side of a $p - n$ junction diode is enhanced. Which one of the following will get affected?
(a) Width of the depletion region on n-side
(b) Width of the depletion region on p-side
(c) Width of the depletion region on both sides
(d) No change in width of depletion regions

[ESE-2009]

72. What is the chemical bonding in silicon semiconductor?
(a) Metallic (b) Ionic
(c) Covalent (d) Van der Waals

[ESE-2009]

73. Which one of the following is a trivalent material?
(a) Antimony (b) Phosphorus
(c) Arsenic (d) Boron

[ESE-2009]

74. In a material, the Fermi-level is located between the centre of the forbidden band and the conduction band. Then what is that material?

(a) A p-type semiconductor
(b) An n-type semiconductor
(c) An intrinsic semiconductor
(d) An insulator

[ESE-2009]

75. Consider the following statements:
(1) Acceptor level is formed very close to the conduction band.
(2) The effective mass of the free electron is same as that of a hole.
(3) The magnitude of the charge of a free electron is same as that of a hole.
(4) Addition of donor impurities adds holes to the semiconductor.

Which of the above statements are correct?
(a) 1 and 3 (b) 3 only
(c) 2 and 4 (d) 3 and 4

[ESE-2009]

76. Diffusion current of holes in a semiconductor is proportional to (with $p =$ concentration of holes/unit volume)
(a) $\frac{dp}{dx^2}$ (b) $\frac{dp}{dx}$
(c) $\frac{dp}{dt}$ (d) $\frac{d^2p}{dx^2}$

[ESE-2009]

77. As per Hall effect, if any specimen carrying a current I is placed in a transverse magnetic field B, then an electric field E is induced in the specimen in the direction
(a) parallel to I
(b) perpendicular to B and parallel to I
(c) parallel to I and B
(d) perpendicular to both I and B

[ESE-2009]

78. Which of the following quantities cannot be measured/determined using Hall effect?
(a) Type of semiconductor (p or n)
(b) Mobility of charge carriers
(c) Diffusion constant
(d) Carrier concentration

[ESE-2009]

79. The minimum energy of a photon required for intrinsic excitation is equal to
(a) energy of bottom of conduction band
(b) energy of top of valence band
(c) forbidden gap energy
(d) Fermi energy

[ESE-2009]

80. Consider the following statements:
The conductivity of a metal has negative temperature coefficient since:
(1) The electron concentration increases with temperature.
(2) The electron mobility decreases with temperature.
(3) The electron-lattice scattering rate increases with temperature.

Which of the above statements is/are correct?
(a) 1 only (b) 1 and 2
(c) 2 and 3 (d) 3 only

[ESE-2010]

81. Atomic number of silicon is
(a) 12 (b) 13
(c) 14 (d) 15

[ESE-2010]

82. When donor atoms are added to semi-conductor, it
(a) Increases the energy band gap of the semiconductor
(b) Decreases the energy band gap of the semiconductor
(c) Introduces a new narrow band gap near the conductor band
(d) Introduces a new discrete energy level below the conduction band

[ESE-2010]

83. The diffusion length for holes L_p, is the
(a) Average distance which an injected hole travels before recombining with an electron
(b) Maximum distance travelled by a hole before recombining with an electron
(c) Length of the region in which diffusion takes places
(d) Minimum distance travelled by a hole before it recombines with an electron

[ESE-2010]

84. Assertion (A): In an intrinsic semiconductor, electron mobility in conduction band is different from hole mobility in valence band.
Reason (R): In an intrinsic semiconductor, electrons and holes are created solely by thermal excitation across the energy gap.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

85. Assertion (A): At very high temperatures, both p and n-type semiconductors behave as intrinsic semiconductor.
Reason (R): In n-type semiconductor the majority carriers are electrons and in a p-type semiconductor the majority carriers are holes, whereas in an intrinsic semiconductor the number of holes and electrons are equal.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

86. Assertion (A): In an intrinsic semiconductor, the concentration of electrons and holes increases with increase in the temperature.
Reason (R): Law of mass action holds good in case of semiconductors.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but B is false Windows
(d) A is false but R is true.

[ESE-2010]

87. Assertion (A): Many semiconductors where minimum energy in the conduction band and maximum energy in the valence band occur at the same value of $\vec{k}$ (wave vector), are preferred for optical lenses.
Reason (R): For such semiconductors, the efficiency of carrier generation and recombination is very high.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

88. Assertion (A): At low temperature, the conductivity of a semiconductor increases with increase in the temperature.
Reason (R): The breaking of the covalent bonds increases with increase in the temperature, generating increasing number of electrons and holes.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2011]

89. An intrinsic semiconductor has the following properties:
(1) Its electron concentration equals its hole concentration.
(2) Its carrier density increases with temperature.
(3) Its conductivity decreases with temperature.
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 and 3 only
(c) 1 and 3 only (d) 1 and 2 only

[ESE-2011]

90. A 'hole' in a semiconductor has
(1) Positive charge equal to the electron charge.
(2) Positive mass equal to the mass of the electron.
(3) An 'effective mass' greater than the effective mass of electron.
(4) Negative mass and positive charge equal to the charge in nucleus.
Which of these statements are correct?
(a) 1, 2, 3 and 4 (b) 2 and 3 only
(c) 2 and 4 only (d) 3 and 4 only

[ESE-2011]

91. On applying an electric field of intensity $10\ \mathrm{V/cm}$ across a semiconductor at a certain temperature the average drift velocity of free electrons is measured to be $70\ \mathrm{m/s}$. Then the electron mobility is
(a) $7 \times 10^4\ \mathrm{cm^2/Vs}$
(b) $700\ \mathrm{cm^2/Vs}$
(c) $7\ \mathrm{m^2/Vs}$
(d) $700\ \mathrm{cm/Vs}$

[ESE-2011]

92. Consider the following statements with regard to semiconductors:
(1) In n type material free electron concentration is nearly equal to density of donor atoms.
(2) 1 part in 10^8 donor type impurity added to Ge improves its conductivity at $30^\circ\mathrm{C}$ by a factor 12.
(3) Phosphorus is an example of n type impurity.
(4) Conductivity of Si is more sensitive to temperature than Ge.
Which of these statements are correct?
(a) 1, 2 and 3 only (b) 1/3 and 4 only
(c) 2 and 4 only (d) $1, 2, 3$ and 4

[ESE-2011]

93. The diffusion constant for holes in silicon is $13\ \mathrm{cm^2/s}$. What is the diffusion current if the gradient of the hole concentration $\frac{dP}{dx} = -2 \times 10^{14}$ holes per $\mathrm{cm^3}$ per cm?

(a) $-0.416\ mA$ (b) -3.2×10^{-5} A
(c) $32\ \mu A$ (d) 0.416 mA

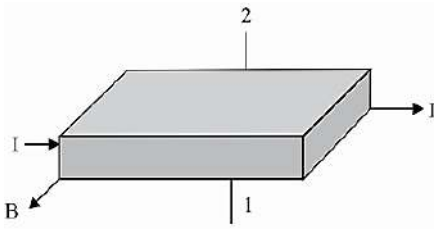
[ESE-2011]

94. Given that at room temperature the volt equivalent of temperature $V_T = 26\mathrm{mV}$, hole mobility $\mu_P = 500\ \mathrm{cm^2/Vs}$ and the life time of holes is 130 ns , in a sample of n-type silicon bar that is exposed to radiation at one end at low-injection level, what is the diffusion length of holes?

(a) 1300 microns (b) 100 Armstrongs
(c) 169 microns (d) 100 microns

[ESE-2011]

95. Consider a semiconductor carrying current I and placed in a transverse magnetic field B, as shown below. The measured potential across 1 and 2 surfaces is positive at 2. What is the type of material?



(a) Intrinsic Si material
(b) n-type semiconductor material
(c) p-type semiconductor material
(d) no such conclusion can be drawn

[ESE-2011]

96. Doping intrinsic Silicon with Arsenic as an impurity

(a) Only increases the conductivity of Silicon by increasing the number of free electrons available
(b) Produces a semiconductor in which the charge carriers are predominantly electrons but holes are also present
(c) Produces a semiconductor in which the charge carriers are predominantly holes but free electrons also present
(d) Produces a semiconductor in which the charge carriers contain nearly equal number of electrons and holes

[ESE-2012]

97. Hall-effect is useful for the measurement of a semiconductor's

(a) mobility, carrier, concentration and temperature.
(b) type (n-type or p-type), conductivity and temperature.
(c) type (n-type or p-type), mobility and carrier concentration.
(d) mobility, conductivity and temperature.

[ESE-2012]

98. Given

$N(E)$: Density of states

$f(E)$: Probability that a quantum state with energy E is occupied by an electron.

E_c : Energy level of conduction band.

The expression $\int_{E_c}^{\infty} N(E) f(E) dE$ gives

(a) minimum number of electrons in conduction band
(b) concentration of electrons in conduction band
(c) energy of electron concentration in conduction band
(d) conductivity of electrons in conduction band

[ESE-2012]

99. If the drift velocity of holes under a field gradient of $200\ \mathrm{V/m}$ is 100 m/s, their mobility in SI units is

(a) 0.5 (b) 0.05
(c) 50 (d) 500

[ESE-2012]

100. The concentration of hole electron pairs in pure silicon at $T = 300\ \mathrm{K}$ is 7×10^{15} per cubic metre. Antimony is doped into silicon in a proportion of 1 atom in 10^7 atoms. Assuming that half of the impurity atoms contribute electrons in the conduction band, the factor by which the number of charge carriers increases due to doping (the number of silicon atoms per cubic metre is 5×10^{28}) is

(a) 14×10^{15} (b) 0.5×10^{21}
(c) 2.5×10^{21} (d) 3.6×10^{5}

[ESE-2013]

101. Medium doping in Silicon and Germanium corresponds to impurity of the order of

(a) 1 part in 10^6 (b) 1 part in 10^5
(c) 1 part in 10^4 (d) 1 part in 10^8

[ESE-2013]

102. An electric field is applied to a semiconductor. Let the number of charge carrier be n and the average drift speed be v. If the temperature is increased then

(a) both n and v will increase
(b) n will increase but v will decrease
(c) v will increase but n will decrease
(d) both n and v will decrease

[ESE-2014]

103. For a particular material, the Hall coefficient is found to be zero. The material is
(a) intrinsic semiconductor
(b) extrinsic semiconductor
(c) metal
(d) insulator

[ESE-2014]

104. At very high temperature, an n-type semiconductor behave like
(a) a p-type semiconductor
(b) an intrinsic semiconductor
(c) a superconductor
(d) an n-type semiconductor

[ESE-2014]

105. The Fermi level in a p-type semiconductor lies close to
(a) top of the valence band
(b) bottom of the valence band
(c) top of the conduction band
(d) bottom of the conduction band

[ESE-2014]

106. Covalent bond energy in germanium is about
(a) 7.4 eV (b) 31 eV
(c) 3.4 eV (d) 20.4 eV

[ESE-2014]

107. In degenerately doped n - type semiconductor, the Fermi level lies in conduction band when
(a) concentration of electrons in the conduction band exceeds the density of states in the valence band.
(b) concentration of electrons in the valence band exceeds the density of states in the conduction field.
(c) concentration of electrons in the conduction band exceeds the product of the density of states in the valence band and conduction band.
(d) None of the above

[ESE-2014]

108. The electrical conductivity and electron mobility for aluminium are 3.8×10^7 (ohm-m) $^{-1}$ and $0.0012\ \mathrm{m^2/V\text{-}s}$, respectively. What is the Hall voltage for an aluminium specimen that is 15 mm wide for a current of 25 A and a magnetic field of 0.6 Tesla (imposed in a direction perpendicular to the current) for the given value of Hall coefficient, R_H as $-3.16 \times 10^{-11}\ \mathrm{V-m/A\text{-}Tesla}$?
(a) -316×10^{-8} V (b) -3.16×10^{-8} V
(c) 316×10^{-8} V (d) 3.16×10^{-8} V

[ESE-2014]

109. A p-type silicon sample has an intrinsic carrier concentration of $1.5 \times 10^{10}/\mathrm{cm^3}$ and a hole concentration of $2.25 \times 10^{15}\ \mathrm{cm^{-3}}$. Then the electron concentration is
(a) $1.5 \times 10^{25}/\mathrm{cm^3}$ (b) $10^5/\mathrm{cm^3}$
(c) $10^{10}/\mathrm{cm^3}$ (d) 0

[ESE-2014]

110. Statement (I): With a small additional energy, usually thermal, the valence electrons in germanium can become free electrons.
Statement (II): The valence electrons in germanium are in the fourth orbit and are at high energy level.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2014]

111. The majority carriers in an n-type semiconductor have an average drift velocity V_d in a direction perpendicular to a uniform magnetic field B. The electric field E induced due to Hall Effect acts in the direction
(a) $V_d \times B$ (b) $B \times V_d$
(c) Along V_d (d) Opposite to V_d

[ESE-2015]

112. At temperature of 298 Kelvin, Silicon is not suitable for most electronic applications, due to small amount of conductivity. This can be altered by
(a) Gettering (b) Doping
(c) Squeezing (d) Sintering

[ESE-2015]

113. The energy gap in the energy band structure of a material is 9 eV at room temperature. The material is
(a) Semiconductor (b) Conductor
(c) Metal (d) Insulator

[ESE-2015]

114. By doping Germanium with Gallium, the types of semiconductors formed are:
(1) N type (2) P type
(3) Intrinsic (4) Extrinsic
Which of the above are correct?
(a) 1 and 4 (b) 2 and 4
(c) 1 and 3 (d) 2 and 3

[ESE-2015]

115. An n-type silicon can be formed by adding impurity of:

(1) Phosphorous
(2) Arsenic
(3) Boron
(4) Aluminium

Which of the above are correct?

(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

[ESE-2015]

116. According to Einstein's relationship for a semiconductor, the ratio of diffusion constant to the mobility of the charge carriers is

(a) Variable and is twice the volt equivalent of the temperature
(b) Constant and is equal to the volt equivalent of the temperature
(c) Equal to the two and is twice the volt equivalent of the temperature
(d) Equal to one and is equal to the volt equivalent of the temperature

[ESE-2015]

117. The number of holes in an N-type silicon with intrinsic value $1.5 \times 10^{10}/\text{cm}^3$ and doping concentration of $10^{17}/\text{cm}^3$, by using mass-action law is

(a) 6.67×10^{6}/cc (b) 4.44×10^{-25}/cc
(c) 1.5×10^{-24}/cc (d) 2.25×10^{3}/cc

[ESE-2015]

118. A continuity equation is also called as the law of conservation of

(a) Mass (b) Energy
(c) Charge (d) Power

[ESE-2015]

119. Statement (I): Hall voltage is given by $V_H = R_H \frac{I \cdot H}{t}$ where I is the current, H is the magnetic field strength, t is the thickness of probe and R_H is the Hall constant.

Statement (II): Hall effect does not sense the carrier concentration.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2015]

120. For which one of the following materials, is the Hall coefficient closest to zero?

(a) Metal (b) Insulator
(c) Intrinsic semiconductor (d) Alloy

[ESE-2016]

121. Which one of the following statements is correct?

(a) For insulators the band-gap is narrow as compared to semiconductors
(b) For insulators the band-gap is relatively wide whereas for semiconductors it is narrow
(c) The band-gap is narrow in width for both the insulators and conductors
(d) The band-gap is equally wide for both conductors and semiconductors

[ESE-2016]

122. In an extrinsic semiconductor the conductivity significantly depends upon

(a) Majority charge carriers generated due to impurity doping
(b) Minority charge carriers generated due to thermal agitation
(c) Majority charge carriers generated due to thermal agitation
(d) Minority charge carriers generated due to impurity doping

[ESE-2016]

123. A Ge sample at room temperature has intrinsic carrier concentration $n_i = 1.5 \times 10^{13}\ \text{cm}^{-3}$ and is uniformly doped with acceptor of $3 \times 10^{16}\ \text{cm}^{-3}$ and donor of $2.5 \times 10^{15}\ \text{cm}^{-3}$. Then, the minority charge carrier concentration is

(a) $0.918 \times 10^{10}\ \text{cm}^{-3}$ (b) $0.818 \times 10^{10}\ \text{cm}^{-3}$
(c) $0.918 \times 10^{12}\ \text{cm}^{-3}$ (d) $0.818 \times 10^{12}\ \text{cm}^{-3}$

[ESE-2016]

124. Assume that the values of mobility of holes and that of electrons in an intrinsic semiconductor are equal and the values of conductivity and intrinsic electron density are $2.32/\Omega\text{m}$ and $2.5 \times 10^{19}/\text{m}^3$ respectively. Then, the mobility of electron/hole is approximately

(a) $0.3\ \text{m}^2/\text{Vs}$ (b) $0.5\ \text{m}^2/\text{Vs}$
(c) $0.7\ \text{m}^2/\text{Vs}$ (d) $0.9\ \text{m}^2/\text{Vs}$

[ESE-2016]

125. A silicon sample A is doped with 10^{18} atom/cm^3 of Boron and another silicon sample B of identical dimensions is doped with 10^{18} atom/cm^3 of Phosphorous. If the ratio of electron to hole mobility is 3, then the ratio of conductivity of the sample A to that of B is

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

[ESE-2016]

126. The Hall-coefficient of a specimen of doped semiconductor is $3.06 \times 10^{-4}\ \mathbf{m^3C^{-1}}$ and the resistivity of the specimen is $6.93 \times 10^{-3}\ \Omega\mathbf{m}$. The majority carrier mobility will be
(a) $0.014\ m^2V^{-1}s^{-1}$ (b) $0.024\ m^2V^{-1}s^{-1}$
(c) $0.034\ m^2V^{-1}s^{-1}$ (d) $0.044\ m^2V^{-1}s^{-1}$

[ESE-2016]

127. Doped silicon has Hall-coefficient of $3.68 \times 10^{-4}\ \mathbf{m^3C^{-1}}$ and then its carrier concentration value is
(a) $2.0 \times 10^{22}\ m^{-3}$ (b) $2.0 \times 10^{-22}\ m^{-3}$
(c) $0.2 \times 10^{22}\ m^{-3}$ (d) $0.2 \times 10^{-22}\ m^{-3}$

[ESE-2016]

128. The position of the intrinsic Fermi level of an undoped semiconductor (E_{F_i}) is given by
(a) $\frac{E_C-E_V}{2}+\frac{kT}{2}\ln\frac{N_V}{N_C}$ (b) $\frac{E_C+E_V}{2}-\frac{kT}{2}\ln\frac{N_V}{N_C}$
(c) $\frac{E_C+E_V}{2}+\frac{kT}{2}\ln\frac{N_V}{N_C}$ (d) $\frac{E_C-E_V}{2}-\frac{kT}{2}\ln\frac{N_V}{N_C}$

[ESE-2016]

129. The electrical conductivity of pure semiconductor is
(a) Proportional to temperature
(b) Increases exponentially with temperature
(c) Decreases exponentially with temperature
(d) Not altered with temperature

[ESE-2018]

130. A sample of germanium is made p-type by addition of indium at the rate of one indium atom for every 2.5×10^8 germanium atoms. Given, $n_i = 2.5 \times 10^{19}/m^3$ at 300 K and the number of germanium atoms/$m^3 = 4.4 \times 10^{28}$. What is the value of n_p?
(a) $3.55 \times 10^{18}/m^3$ (b) $3.76 \times 10^{18}/m^3$
(c) $7.87 \times 10^{18}/m^3$ (d) $9.94 \times 10^{18}/m^3$

[ESE-2018]

131. Silicon devices can be employed for a higher temperature limit (190 °C to 200 °C) as compared to germanium devices (85 °C to 100 °C). With respect to this, which of the following are incorrect?
1. Higher resistivity of silicon
2. Higher gap energy of silicon
3. Lower intrinsic concentration of silicon
4. Use of silicon devices in high-power applications

Select the correct answer using the code given below.
(a) 1, 2 and 4 (b) 1, 2 and 3
(c) 1, 3 and 4 (d) 2, 3 and 4

[ESE-2021]

132. Statement (I): Ge and Si are said to have negative temperature coefficient of resistivity.
Statement (II): Ge and Si show a reduction in resistance with increase in temperature.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true, but Statement (II) is false.
(d) Statement (I) is false, but Statement (II) is true.

[ESE-2022]

133. Which one of the following statements is not correct regarding carrier lifetime in semiconductors?
(a) Carrier lifetime ranges from nanoseconds to hundreds of microseconds.
(b) On an average, a hole (an electron) will exist for τ_p sec before recombination.
(c) τ_n is the time, it takes the total concentration to fall to approximately 63% of its initial value.
(d) τ_p is the time, it takes the injected concentration to fall to approximately 37% of its initial value.

[ESE-2022]

134. At what condition does the Fermi energy level (E_F) lie exactly between the band gap for intrinsic semiconductor?
(a) The effective masses of a hole and a free electron are the same
(b) The effective mass of a free electron is less than the effective mass of a hole
(c) The effective mass of a free electron is greater than the effective mass of a hole
(d) The effective mass of a hole is always in the centre of the forbidden energy band

[ESE-2023]

135. The longest wavelength that can be absorbed by silicon, which has the band gap of 1.12 eV, is 1.1 um. If the longest wavelength that can be absorbed by another material is 0.87 µm, then the band gap of this material is approximately
(a) 1.416 eV (b) 0.886 eV
(c) 2.854 eV (d) 3.706 eV

[ESE-2023]

136. The band gap of germanium at room temperature is
(a) 2.3 eV (b) 0.7 eV
(c) 1.1 eV (d) 3.4 eV

[ESE-2023]

137. Silicon is doped with boron to a concentration of $4 \times 10^{17}\ \text{atoms/cm}^3$. Assume the intrinsic carrier concentration of silicon to be $1.5 \times 10^{10}/\text{cm}^3$ and the value of KT/q to be 25 mV at 300 K. Compared to undoped silicon, the Fermi level of doped silicon

(a) goes down by 0.13 eV
(b) goes up by 0.13 eV
(c) goes down by 0.427 eV
(d) goes up by 0.427 eV

[ESE-2023]

138. The resistivity of a uniformly doped n-type silicon sample is 0.50 Ω-cm. If the electron mobility (μ_n) is $1250\ \text{cm}^2/\text{V} - \text{sec}$ and the charge of an electron is 1.6×10^{-19} coulomb, the donor impurity concentration (N_D) in the sample is

(a) $2 \times 10^{16}/\text{cm}^3$ (b) $1 \times 10^{16}/\text{cm}^3$
(c) $2.5 \times 10^{15}/\text{cm}^3$ (d) $2 \times 10^{15}/\text{cm}^3$

[ESE-2023]

139. A silicon sample A is doped with $10^{18}\ \text{atoms/cm}^3$ of boron. Another sample B of identical dimensions is doped with $10^{18}\ \text{atoms/cm}^3$phosphorus. The ratio of electron to hole mobility is 3. The ratio of conductivity of the sample A to that of sample B is

(a) 1/2 (b) 1/3
(c) 2/3 (d) 1/4

[ESE-2023]

140. According to the Einstein relation, for any semiconductor, the ratio of diffusion constant to mobility of carriers

(a) depends upon the temperature of the semiconductor
(b) depends upon the type of the semiconductor
(c) varies with lifetime of the semiconductor
(d) increases the velocity of the charge carriers

[ESE-2023]

141. A heavily doped n-type semi-conductor has the following characteristics:
Hole-electron mobility ratio: 0.4
Doping concentration:
$4.2 \times 10^8\ \text{atoms/m}^3$
Intrinsic concentration:
$1.5 \times 10^4\ \text{atoms/m}^3$
The ratio of conductance of the n-type semiconductor to that of the intrinsic semiconductor of same material and at the same temperature is given by

(a) 50×10^3 (b) 2×10^3
(c) 10×10^3 (d) 20×10^3

[ESE-2023]

142. A silicon bar is doped with donor impurities $N_D = 2.25 \times 10^{15}\ \frac{\text{atoms}}{\text{cm}^3}$. Given the intrinsic carrier concentration of silicon at T = 300 K is $1.5 \times 10^{10}/\text{cm}^3$. Assuming complete impurity ionization, the equilibrium electron and hole concentrations are respectively

(a) $n_0 = 1.5 \times \frac{10^{10}}{\text{cm}^3}, p_0 = 1 \times 10^5/\text{cm}^3$
(b) $n_0 = 1.5 \times \frac{10^{10}}{\text{cm}^3}, p_0 = 1.5 \times 10^{10}/\text{cm}^3$
(c) $n_0 = 2.25 \times \frac{10^{15}}{\text{cm}^3}, p_0 = 1.5 \times 10^{10}/\text{cm}^3$
(d) $n_0 = 2.25 \times \frac{10^{15}}{\text{cm}^3}, p_0 = 1 \times 10^5/\text{cm}^3$

[ESE-2023]

143. According to the properties of intrinsic semiconductors at room temperature, the intrinsic resistivity of germanium is

(a) 25 Ω-cm (b) 35 Ω-cm.
(c) 45 Ω-cm (d) 55 Ω-cm

[ESE-2023]

144. In Auger Recombination Process, recombination in an $n-$ type semi-conductor involves the interaction of

(a) two electrons and one hole
(b) one electron and one hole
(c) two holes and one electron
(d) two holes and three electrons

[ESE-2024]

145. Consider the following statements regarding the semiconductor diode:

1. PIV rating for the silicon is near about 1000 V.
2. Maximum PIV rating for the germanium is closer to 200 V.
3. Germanium can be used for applications in which the temperature may rise to about 200°C.

Which of the above statements are not correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2024]

146. Consider the following statements regarding the semiconductor diode:

1. Ac or dynamic resistance can be defined as $r_d = \frac{26\ \text{mV}}{I_d}$
2. The lower the Q-point of operation, the lower is the ac resistance.
3. As with the dc and ac resistance levels, the lower the level of currents used to determine the average resistance, the higher is the resistance level.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2024]

147. A potential difference of 10 V is maintained across the ends of a copper wire 2 m in length. If the mean time between collisions is 2.7×10^{-14} s, then what is the drift velocity of the free electrons?

(a) $33.23 \times 10^{-2}\overrightarrow{a_z}$ m/s

(b) $42.12 \times 10^{-4}\overrightarrow{a_z}$ m/s

(c) $23.74 \times 10^{-3}\overrightarrow{a_z}$ m/s

(d) $20.74 \times 10^{-2}\overrightarrow{a_z}$ m/s

Answer Key									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(b)	(a)	(a)	(b)	(d)	(d)	(b)	(a)	(d)	(c)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(d)	(a)	(d)	(c)	(a)	(c)	(b)	(c)	(c)	(b)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(d)	(c)	(a)	(c)	(d)	(d)	(b)	(b)	(a)	(b)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(c)	(d)	(c)	(c)	(b)	(b)	(d)	(d)	(c)	(d)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(c)	(d)	(b)	(c)	(c)	(a)	(b)	(a)	(b)	(d)
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
(a)	(d)	(d)	(d)	(b)	(b)	(b)	(c)	(a)	(d)
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
(c)	(b)	(b)	(b)	(d)	(c)	(d)	(a)	(a)	(c)
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
(c)	(c)	(d)	(b)	(b)	(b)	(d)	(c)	(c)	(c)
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
(c)	(d)	(a)	(b)	(b)	(b)	(c)	(a)	(d)	(b)
91	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
(b)	(d)	(d)	(a)	(b)	(b)	(c)	(b)	(a)	(d)
101	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**
(a)	(b)	(d)	(b)	(a)	(c)	(b)	(b)	(b)	(b)
111	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
(b)	(b)	(d)	(b)	(a)	(b)	(d)	(c)	(c)	(b)
121	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**
(b)	(a)	(b)	(a)	(c)	(d)	(a)	(c)	(a)	(a)
131	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**
(b)	(a)	(c)	(a)	(a)	(b)	(c)	(b)	(b)	(a)
141	**142**	**143**	**144**	**145**	**146**	**147**			
(d)	(d)	(c)	(a)	(c)	(b)	(c)			

EXPLANATIONS

1. Explanation: (b)

Energy is

$E = \frac{1}{2}mv^2$

$v^2 = \frac{2E}{m}$

$v = \sqrt{\frac{2E}{m}}$

$v = \sqrt{\frac{2\times8.8\times10^{-19}}{9.1\times10^{-31}}} = 1.39 \times 10^6 \text{ m/s}$

2. Explanation: (a)

Sheet resistance of the layer is

$R = 4.53 \times \frac{V}{I} = 4.53 \times \frac{0.22}{10 \times 10^{-3}}$

$R = 100\ \Omega$

3. Explanation: (a)

Germanium, Gallium arsenide and Indium phosphide

4. Explanation: (b)

$\frac{D}{\mu} = V_T = \frac{kT}{q}$

$\mathrm{D} = \frac{0.36 \times 1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}}$

$D = 9.315 \times 10^{-3} \text{ mm}^2/\text{sec}$

Diffusion length is

$\mathrm{L} = \sqrt{D\tau}$

$\mathrm{L} = \sqrt{9.315 \times 10^{-3} \times 340 \times 10^{-6}}$

$\mathrm{L} = 1.77 \text{ mm}$

5. Explanation: (d)

The diffusion hole-current density is

$J_p = -qD_p \frac{dp}{dx}$

6. Explanation: (d) The Hall voltage is very weak in metals but is large in semiconductors.

7. Explanation: (b)

N - type

8. Explanation: (a)

Fermi-Dirac statistics

9. Explanation: (d) Fermions are the particles, which obey Pauli's exclusion principle.

10. Explanation: (c)

A is true but R is false

11. Explanation: (d)

Conductivity of a semiconductor is

$\sigma = (\mathrm{n}\mu_\mathrm{n} + \mathrm{p}\mu_\mathrm{p})\mathrm{e}$

$n = N_c e^{-(E_c - E_f)/kT}$

12. Explanation: (a) When light shines on one end of an **N-type semiconductor**, **excess electron-hole pairs** are generated due to **photo - generation**. This creates a **concentration gradient** of minority carriers and also affects majority carriers near the illuminated region. Light creates **non-uniform carrier concentrations** and **no external electric field** is mentioned in the question. So, carriers move from **high to low concentration** regions, hence **diffusion current dominates**.

13. Explanation: (d)

Sample A will have zero built-in electric field whereas Sample B will have a constant built - in electric field and no current will flow at equilibrium from either sample A or sample B.

14. Explanation: (c)

(i) The resistivity of silicon decreases with temperature. So, the semiconductors have negative temperature coefficient of resistance.

(ii) Mobility μ varies as T^{-m} over a temperature range of 100 to 400°K.

15. Explanation: (a)

The unit of mobility is $m^2V^{-1}s^{-1}$

16. Explanation: (c)

The Haynes-Shockley experiment enables one to determine the mobility of the minority carriers only

17. Explanation: (b)

Hall coefficient is

$R_H = \frac{1}{pq}$

$p = \frac{1}{R_H \mathrm{q}} = \frac{1}{5\times10^3\times1.6\times10^{-19}}$

Hole concentration is

$\mathrm{p} = 1.25 \times 10^{15} \text{ /cm}^3$

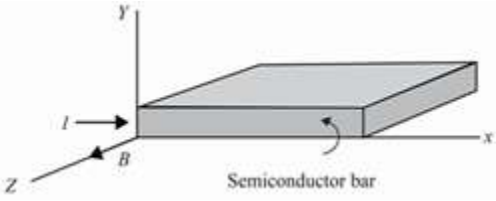
18. Explanation: (c)

For an extrinsic semiconductor, the Hall coefficient is

$$R_H = \frac{1}{\text{Charge} \times \text{Carrier concentration}}$$

In extrinsic semiconductor, carrier concentration is majority carrier concentration and it is independent of temperature and hence R_H is independent of temperature.

19. Explanation: (c) The principle of Hall effect is that if a specimen carrying a current I is placed in a transverse magnetic field B, an electric field E is induced in the direction perpendicular to both I and B.



In the diagram shown, the electric field is induced in the negative y-direction. So, the sample will show a positive voltage in negative y-direction and a negative voltage in positive y-direction.

20. Explanation: (b) As the temperature increases, more electrons are donated to the conduction band. So, the donor level ionization increases.

21. Explanation: (d) E_F is varied with temperature. For an n-type semiconductor, the concentration of electrons in conduction band is

$n = N_C e^{-(E_C - E_F)/kT}$ (N_C = effective density of states)

$$\frac{E_C - E_F}{kT} = -\ln(n/N_C)$$

$$E_F = E_C + kT\ln(n/N_C)$$

22. Explanation: (c)

$n_i = 1.45 \times 10^{10}/\text{cm}^3$

$N_\text{D} = 5 \times 10^{14}/\text{cm}^3$

In n-type silicon sample

$n > N_\text{D}$

$n > 5 \times 10^{14}/\text{cm}^3$

$p = \frac{n_i^2}{n} = \frac{(1.45\times10^{10})^2}{5\times10^{14}}$

$p = 4.20 \times 10^5/\text{cm}^3$

Since, $n > N_\text{D}$

$p < 4.20 \times 10^5/\text{cm}^3$

23. Explanation: (a)

The Hall voltage is

$V_H \propto R_H \propto \rho$

Therefor, $V_H \propto \rho$.

By putting values

$$\frac{V_1}{50\times10^{-3}} = \frac{2.3\times10^3}{8.33\times10^{-2}}$$

$$V_1 = 1380.55 \text{ V}$$

24. Explanation: (c)

The **Hall voltage** V_H in a semiconductor is

$$V_H = \frac{BI}{qnd}$$

Where:

- B: magnetic field (perpendicular to current)
- I: current through the sample
- q: charge of carriers
- n: carrier concentration
- d: **thickness** of the sample **in the direction of Hall voltage**
- V_H : Hall voltage measured perpendicular to both current and magnetic field
- V_H is **directly proportional** to:
  - Magnetic field B
  - Current I
- V_H is **inversely proportional** to:
  - Carrier concentration n
  - Charge q
  - **Thickness** d
- **Width** w of the specimen **does not appear** in the expression for V_H. So, V_H **is not proportional to** 1/w.

25. Explanation: (d)

A is false but R is true

26. Explanation: (d) When an intrinsic silicon is doped with impurities, its conductivity increases. Metals have more conductivity than semiconductors. Conductivity of silver is more than aluminium and it is best known electrical conductor.

27. Explanation: (b)

It has large energy gap > 5 eV.

28. Explanation: (b)

Assertion (A): *Every material has a different value of energy band gap except metals which have no band gap.*

True

- **Insulators** and **semiconductors** have **finite band gaps**, which **vary from material to material**.
- **Metals**, by definition, have **overlapping valence and conduction bands**, or a **partially filled conduction band**, so they have **no band gap**.

So, this **statement is true**.

Reason (R): *The energy band gap is decided by the equilibrium lattice constant which is different in different materials.*

True

- The **band structure** of a material arises from the **interaction of atomic orbitals** in the periodic **crystal lattice**.
- The **equilibrium lattice constant** affects the **extent of orbital overlap**, and hence the **energy separation** between bands.
- A smaller or larger lattice constant changes the **crystal potential**, thereby modifying the **band structure**, including the **band gap**.

So, this **reason is true and correctly explains the assertion**.

Hence, **Both A and R are true and R is the correct explanation of A**

29. Explanation: (a)

A-4, B-2,C-3,D-1

30. Explanation: (b)

On doping impurities in the pure semiconductor, the resistivity decreases very rapidly.

31. Explanation: (c)

$1800\ \mathrm{cm^2/V \cdot s}$

32. Explanation: (d)

$$J_{diff} = qD_n \frac{\partial n}{\partial x} - qD_\rho \frac{\partial p}{\partial x}$$

33. Explanation: (c)

The intrinsic concentration of a semiconductor is independent of doping.

$n_i^2 = AT^3 e^{-E_{GO}/kT}$

Hence, n_i increases non-linearly with increase in temperature.

34. Explanation: (c) During an electron transition across the energy gap in an indirect energy gap material, both momentum and energy of electron change.

35. Explanation: (b)

$A-4, B-1, C-2, D-3$

36. Explanation: (b) Both A and R are true but R is NOT the correct explanation of A

37. Explanation: (d)

They have indirect band gap

38. Explanation: (d)

Drift velocity per unit electric field

39. Explanation: (c)

$$\rho = \frac{1}{n\mu_n e} = \frac{1}{\frac{1}{1.6} \times 10^{22} \times 10 \times 1.6 \times 10^{-19}}$$

$$\rho = 10^{-4}\ \Omega\ \mathrm{cm}$$

40. Explanation: (d)

By mass action law

$np = n_i^2$

$p = \frac{n_i^2}{n} = \frac{(10^{13})^2}{10^{17}} = 10^9\ \mathrm{cm^{-3}}$

41. Explanation: (c)

$$hv \geq E_g$$

42. Explanation: (d)

$n_1 p_1 = n_2 p_2$

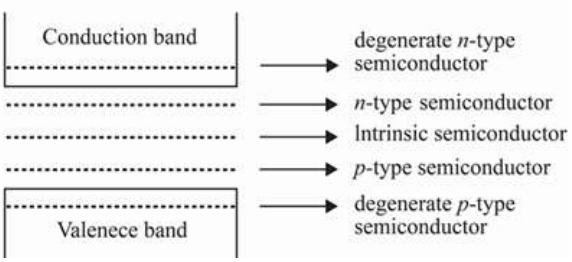
$10^{18} \times 10^7 = n_2 \times 10^{16}$

$n_2 = 10^9\ \mathrm{cm^{-3}}$

43. Explanation: (b)

$A-3, B-4, C-1, D-2$

The position of fermi level is shown in various semiconductors.



44. Explanation: (c) DG semiconductor is suitable and some IG materials having proper dopants are also used

45. Explanation: (c) All electrons are free in a metal. Therefore, electron concentration remains same even if the temperature is raised. On increasing the temperature, the mobility of electrons decreases due to the more vibrations of electrons. Therefore, electrical conductivity of a metal has negative temperature coefficient.

46. Explanation: (a)

$A-3, B-4, C-2, D-1$

47. Explanation: (b)

$\mu = v_d/E$

48. Explanation: (a) At very high temperature, n_i is much greater than N_D, and the intrinsic carriers dominate.

Therefore, an n-type semiconductor behaves as an intrinsic semiconductor at very high temperature.

49. Explanation: (b) When the temperature of a metal increases, its electron mobility decreases not because of its high electron concentration but because of the increased vibrations of the electrons in the metal.

50. Explanation: (d)

$\frac{\mathrm{dV}}{\mathrm{dT}} = -2.5\ \mathrm{mV/^\circ C}$

51. Explanation: (a)

Hall effect is used to determine whether a semiconductor is n-type or p-type and to find the carrier concentration.

52. Explanation: (d)

$\mathrm{A}-3, \mathrm{B}-1, \mathrm{C}-2, \mathrm{D}-4$

53. Explanation: (d)

Firstly, as the temperature is raised, the donor electrons are donated to the conduction band and at temperature T_1 (about 100 K) all the donor atoms are ionized. This temperature range is called the ionization region in which electron concentration increases exponentially.

When every available extrinsic electron has been transferred to the conduction band, the conduction band electron concentration n_0 is virtually constant with temperature until the concentration of intrinsic carriers n_i becomes comparable to the extrinsic concentration N_d.

Finally, at higher temperature, n_i is much greater than N_d and the intrinsic carriers dominate. The electron concentration increases exponentially again now as

$n_i^2 = AT^3 e^{-E_{G_0}/kT}$

54. Explanation: (d)

In metals, there is no diffusion.

55. Explanation: (b)

$\mathrm{A}-3, \mathrm{B}-4, \mathrm{C}-1, \mathrm{D}-2$

56. Explanation: (b)

Conductivity of a semiconductor is

$\sigma = (n\mu_n + p\mu_p)q$

In an intrinsic semiconductor,

$n = p = n_\mathrm{i}$

n_i increases exponentially with increase in temperature since

$n_\mathrm{i}^2 = AT^3 e^{-E_{G_0}/kT}$

Therefore, the conductivity of a semiconductor increases with increase in temperature.

57. Explanation: (b) When the semiconductor is illuminated by a steady flux of photons, the number of new hole-electron pairs is proportional to the number of incident photons.

$\Delta n = \Delta p$

So, change in conductivity

$\Delta\sigma = e(\mu_n + \mu_p)\Delta n$

58. Explanation: (c) Firstly, as the temperature is raised, the donor electrons are donated to the conduction band and at temperature T_1 all the donor atoms are ionized. This temperature range is called the ionization region in which electron concentration increases exponentially.

When every available extrinsic electron has been transferred to the conduction band, the conduction band electron concentration n_0 is virtually constant with temperature until the concentration of intrinsic carriers n_i becomes comparable to the extrinsic concentration N_d. Finally, at higher temperature, n_i is much greater than N_d and the intrinsic carriers dominate. The electron concentration increases exponentially again now as

$n_i^2 = AT^3 e^{-E_{G_0}/kT}$

59. Explanation: (a) A heavily doped semiconductor can exhibit a positive temperature coefficient of resistance, for under these circumstances the material acquires metallic properties and the resistance increases because of the decrease in carrier mobility with temperature.

60. Explanation: (d)

$n_i^2(T) = A'T^3 \exp(-E_g/kT)$

$n_i(T) = AT^{3/2} \exp(-E_g/2kT)$

61. Explanation: (c)

By mass-action law

$np = n_i^2$

$p = \frac{(10^{16})^2}{10^{22}} = 10^{10}\ \mathrm{m^{-3}}$

62. Explanation: (b) The diffusion current is due to a non uniform concentration gradient. Since the holes are injected at one end of a homogeneous semiconductor, there will be a concentration gradient which results in a diffusion current.

63. Explanation: (b)

$$v_d = \mu E$$

The mobility is a function of electric field intensity as given below:

$\mu =$ constant if $E < 10^3$ V/cm

$\mu \propto E^{-1/2}$ if $10^3 < E < 10^4$ V/cm

$\mu \propto E^{-1}$ if $E > 10^4$ V/cm

For higher fields, the carrier speed approaches the constant value of 10^7 cm/s.

64. Explanation: (b)

Doping decreases the relaxation time of electrons

65. Explanation: (d)

A-2, B-3, C-4, D-1

66. Explanation: (c) For non-degenerate semiconductor under thermal equilibrium condition

67. Explanation: (d) Effect of reduction in electron due to increase in holes compensates more than the effect of increase in holes on conductivity

68. Explanation: (a)

Einstein's relationship is

$$\frac{D_n}{\mu_n} = V_T$$

$$D_n = 1500 \times 25.9 \times 10^{-3} = 38.85 \text{ cm}^2/\text{s}$$

69. Explanation: (a)

$\left(\frac{1}{3}\right)$ eV

70. Explanation: (c) Antimony, phosphorus and arsenic are pentavalent impurities while boron, gallium and indium are trivalent impurities.

71. Explanation: (c)

Width of the depletion region on both sides

72. Explanation: (c)

Covalent

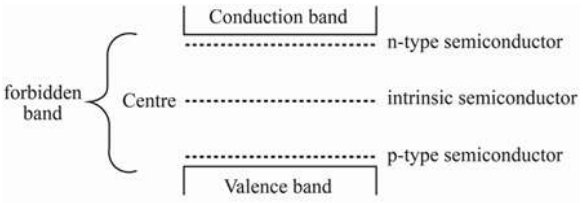
73. Explanation: (d)

Boron is a trivalent material

Trivalent material: Boron, Aluminum, Indium.

Pentavalent material: Nitrogen, Phosphorus, Arsenic, Antimony.

74. Explanation: (b) The position of Fermi level in different semiconductors is shown below



75. Explanation: (b)

(i) Acceptor level is formed very close to the valence band.

(ii) Addition of donor impurities adds electrons and reduces holes to the semiconductor.

76. Explanation: (b) The diffusion current density of holes is proportional to the concentration gradient.

$$J_p = -qD_p \frac{dp}{dx}$$

77. Explanation: (d) Hall effect is used to determine whether a semiconductor is n-or p-type and to find the carrier concentration

78. Explanation: (c) Hall effect is used to determine whether a semiconductor is n-type or p-type and to find the carrier concentration or mobility of charge carriers.

79. Explanation: (c) The minimum energy of a photon required for intrinsic excitation is equal to forbidden gap energy

80. Explanation: (c) Electrons are free to move in a metal. So the electron concentration remains constant with increase in temperature.

81. Explanation: (c) Atomic number of silicon is 14

82. Explanation: (d) Introduces a new discrete energy level below the conduction band

83. Explanation: (a) The **diffusion length** of minority carriers in a semiconductor is

$$L_p = \sqrt{D_p \tau_p}$$

84. Explanation: (b)

Assertion (A): In an intrinsic semiconductor, electron mobility in conduction band is different from hole mobility in valence band.

True

- Electron mobility and hole mobility differ due to:
- Different effective masses of electrons and holes
- Different band structures for conduction and valence bands
- In silicon, for example, $\mu_e = 1350\ cm^2/V.sec$ and $\mu_e = 480\ cm^2/V.sec$

So, the assertion is true.

Reason (R): In an intrinsic semiconductor, electrons and holes are created solely by thermal excitation across the energy gap.

True

- In intrinsic semiconductors, there are no dopants.
- So, all charge carriers arise from thermal generation across the band gap.

The reason is true.

But R is not the correct explanation of A

- The difference in mobility is due to material properties like effective mass, scattering mechanisms, and band structure, not because of generation of carriers.

Hence, Both A and R are true but R is NOT the correct explanation of A

85. Explanation: (b) Both A and R are true but R is NOT the correct explanation of A

86. Explanation: (b) Both A and R are true but R is NOT the correct explanation of A

87. Explanation: (c) A is true but R is false

88. Explanation: (a) Both A and R are true and R is the correct explanation of A

89. Explanation: (d) Conductivity of intrinsic semiconductor increases with temperature.

90. Explanation: (b)

A hole in a semiconductor has positive charge equal to electron charge and an effective mass greater than the effective mass of electron.

91. Explanation: (b)

$Given, \quad E = 10\ \text{V/cm}$

$v_d = 70\ \text{m/sec} = 7000\ \text{cm/sec}$

$v_d = \mu \text{E}$

$\mu = \frac{V_d}{E}$

$\mu = \frac{7000\ \text{cm/sec}}{10\ \text{V/cm}} = 700\ \text{cm}^2/\text{V} - \text{sec}$

92. Explanation: (d)

- Conductivity of Ge is increased as follows with different doping levels:

1 part in 10^8 donor type impurity added; conductivity increases by 12 times.

1 part in 10^7 donor type impurity added; conductivity increases by 120 times.

1 part in 10^6 donor type impurity added; conductivity increases by 1200 times.

- For 1°C rise in temperature, conductivity of Ge increases by 6% while that of Si increases by 8%.

93. Explanation: (d)

$D_p = 13\ \text{cm}^2/\text{s}$

$\frac{dP}{dx} = -2 \times 10^{14}$ holes per cm^3 per cm

$I_{diff} = -qD_\rho \frac{dP}{dx}$

$I_{diff} = -1.6 \times 10^{-19} \times 13 \times (-2 \times 10^{14})$

$I_{diff} = 0.416\ \text{mA}$

94. Explanation: (a)

$\frac{D_\rho}{\mu_\rho} = V_T$

$D_\rho = \mu_0 V_T$

$D_\rho = 500 \frac{\text{cm}^2}{V\text{sec}} \times 26 \times 10^{-3}\ \text{V}$

$D_\rho = 13 \frac{\text{cm}^2}{\text{sec}}$

Diffusion length of holes is

$L_p = \sqrt{D_p \tau}$

$L_p = \sqrt{13 \times 130 \times 10^{-9}}\ \text{cm}$

$L_p = 13 \times 10^{-4}\ \text{cm} = 1300$ microns

95. Explanation: (b) As per Hall effect majority carriers will be forced towards plate (1). As given that measured potential across (1) and (2) surfaces is positive at (2); hence electrons are accumulated at surface (1). So material is n-type semiconductor.

96. Explanation: (b)

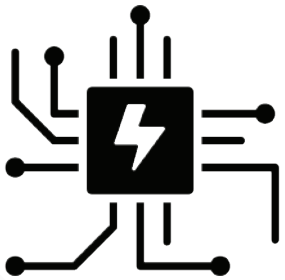
Arsenic is a pentavalent impurity so n-type semiconductor will be produced.

NETWORK THEORY

SECTION 5

SYLLABUS

NETWORK GRAPHS & MATRICES; WYE -DELTA TRANSFORMATION; LINEAR CONSTANT COEFFICIENT DIFFERENTIAL EQUATIONS- TIME DOMAIN ANALYSIS OF RLC CIRCUITS; SOLUTION OF NETWORK EQUATIONS USING LAPLACE TRANSFORMS- FREQUENCY DOMAIN ANALYSIS OF RLC CIRCUITS; 2-PORT NETWORK PARAMETERS -DRIVING POINT & TRANSFER FUNCTIONS; STATE EQUATIONS FOR NETWORKS; STEADY STATE SINUSOIDAL ANALYSIS.



NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS - ESE ELECTRONICS

NETWORK THEORY		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
5.1	Basics of Network	2	3	5	6	2	1	1	4	1	6	2	5	8
5.2	Steady State Sinusoidal Analysis and Resonance	1	5	1	3	6	1	1	6	4	3	3	1	3
5.3	Network Theorems	3	3	2	-	4	3	3	5	1	5	2	6	3
5.4	Transient Analysis	5	5	5	-	2	2	1	2	4	8	5	3	5
5.5	Two Port Network	-	-	3	3	3	6	6	2	4	6	4	6	5
5.6	Graph Theory and Magnetically Coupled Circuits	2	3	1	2	2	2	2	2	2	-	1	1	2
5.7	Network Synthesis and Filters	6	1	1	4	-	3	7	3	6	2	6	1	5

NETWORK THEORY		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
5.1	Basics of Network	6	6	1	2	3	3	4	4	3	4	1	3
5.2	Steady State Sinusoidal Analysis and Resonance	5	4	2	4	3	5	5	2	-	3	-	1
5.3	Network Theorems	2	3	2	-	1	-	1	4	1	1	-	-
5.4	Transient Analysis	2	1	-	1	1	2	1	1	4	3	2	-
5.5	Two Port Network	2	3	2	2	1	4	6	1	2	3	1	1
5.6	Graph Theory and Magnetically Coupled Circuits	2	2	4	3	-	1	2	2	3	4	-	3
5.7	Network Synthesis and Filters	1	2	5	-	-	-	-	5	-	-	-	-

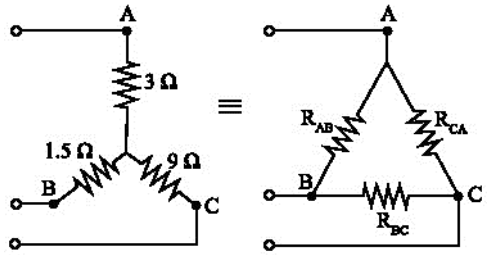
CHAPTER-5 NETWORK THEORY

Unit 5.1 Basics of Network

Previous Year Exam Questions

[ESE-2001]

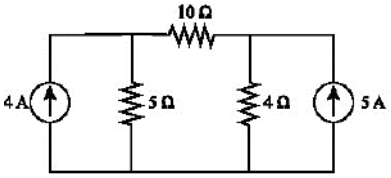
1. For the equivalent Δ Figure circuit shown in the given figure, the values of R_{AB} and R_{BC} are respectively



(a) 5 Ω and 15 Ω
(c) 30 Ω and 5 Ω
(b) 15 Ω and 30 Ω
(d) 20 Ω and 35 Ω

[ESE-2001]

2. In the circuit shown in the given figure, power dissipated in the 5 Ω resistor is



(a) zero
(b) 80 W
(c) 125 W
(d) 405 W

[ESE-2002]

3. Consider the following:
Energy storage capability of basic passive elements is due to the fact that
(1) resistance dissipates energy
(2) capacitance stores energy
(3) inductance dissipates energy Which of the above is/are correct?

(a) 1, 2 and 3
(b) 1 and 3
(c) 3 alone
(d) 1 and 2

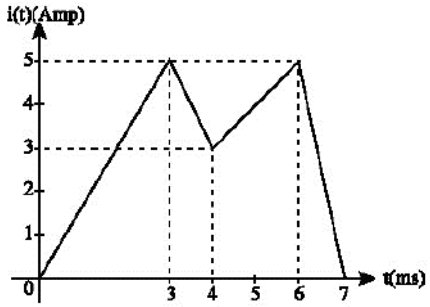
[ESE-2002]

4. $\sqrt{\frac{L}{C}}$ has the dimension of

(a) time
(b) capacitance
(c) inductance
(d) resistance

[ESE-2002]

5. A current $i(t)$ as shown in the figure is passed through a capacitor.

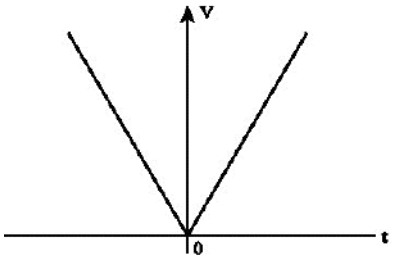


The charge (in micro-coulomb) acquired by the capacitor after 5 μs is

(a) 7.5
(b) 13.5
(c) 14.5
(d) 15

[ESE-2003]

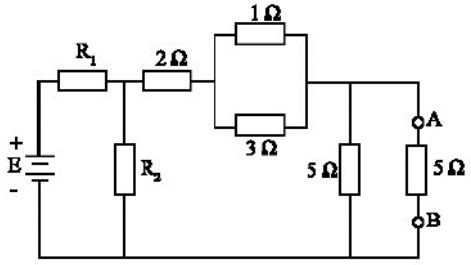
6. The $v - i$ characteristic of an element is shown in the below figure. The element is



(a) Non-linear, active, non-bilateral
(b) Linear, active, non-bilateral
(c) Non-linear, passive, non-bilateral
(d) Non-linear, active, bilateral

[ESE-2003]

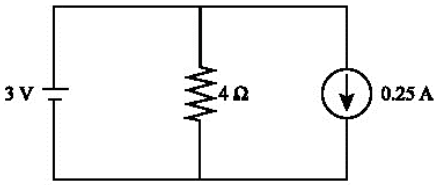
7. In the circuit shown below, the voltage across 2 Ω resistor is 20 V. The 5 Ω resistor connected between the terminals A and B can be replaced by an ideal



(a) Voltage source of 25 V with + terminal upward
(b) Voltage source of 25 V with + terminal downward
(c) Current source of 2 A upward
(d) Current source of 2 A downward

[ESE-2003]

8. The current flowing through the voltage source in the circuit shown below is



(a) 1.0 A (b) 0.75 A
(c) 0.5 A (d) 0.25 A

[ESE-2003]

9. Match List-I (Quantities) with List-II (Units) and select the correct answer:

List-I	List-II
A. R/L	1. Second
B. $1/LC$	2. Ohm
C. CR	3. (Radian/Second) ^{2}
D. $\sqrt{L/C}$	4. (Second)$^{-1}$

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	3	4	2	1
(c)	4	3	2	1
(d)	3	4	1	2

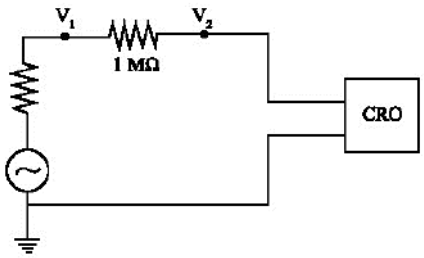
[ESE-2003]

10. Assertion (A): Kirchhoff's voltage law states that a closed path in a network, the algebraic sum of all voltages in a single direction is zero.
Reason (R): Law of conservation of charge is the basis of this law.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2004]

11. Consider the following circuit:

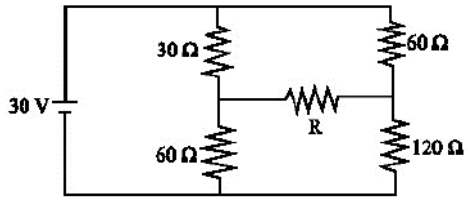


If $V_1 = 5$ V and $V_2 = 3$ V, then what is the input impedance of the CRO in the above circuit?

(a) 1 MΩ (b) 1.5 MΩ
(c) 3 MΩ (d) 5 MΩ

[ESE-2004]

12. Consider the following circuit:

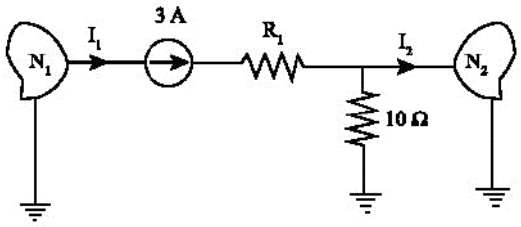


What is the power delivered to resistor R in the above circuit?

(a) -15 W
(b) 0 W
(c) 15 W
(d) Cannot be determined unless the value of R is known

[ESE-2004]

13. Consider the following circuit:



In the above circuit, the current I_2 is 2 A when the value of R_1 is $20\ \Omega$. What will be the value of I_2, when R_1 is changed to $10\ \Omega$?

(a) 1 A (b) 2 A
(c) 3 A (d) 4 A

[ESE-2004]

14. Consider the following network:

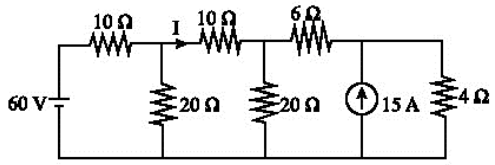


Which one of the following is the differential equation for v in the above network?

(a) $C\frac{dv}{dt} + Gv = 0$ (b) $G\frac{dv}{dt} + Cv = 0$
(c) $\frac{1}{C}\frac{dv}{dt} + Gv = 0$ (d) $C\frac{dv}{dt} - Gv = 0$

[ESE-2004]

15. Consider the following circuit:



What is the current I in the above circuit?

(a) 0 A (b) 2 A

(c) 5 A (d) 6 A

[ESE-2004]

16. Which one of the following statements is correct? In a four-branch parallel circuit, 50 mA current flows in the each branch. If one of the branches opens, the current in the other branches

(a) increase (b) decrease

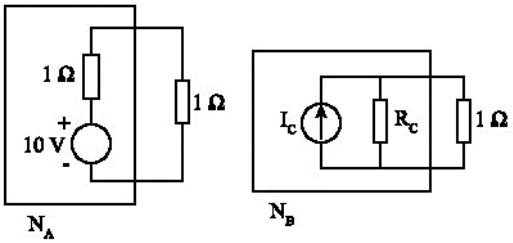
(c) are unaffected (d) double

[ESE-2005]

17. Consider the following statements:

Network N_A in Fig. (a) can be replaced by the network N_B shown in Fig. (b) below, when I_c and R_c, respectively, are:

N_A



(1) 5 A and 2 Ω (2) 10 A and 1 Ω

(3) 15 A and $\frac{1}{2}\Omega$ (4) 30 A and $\frac{1}{5}\Omega$

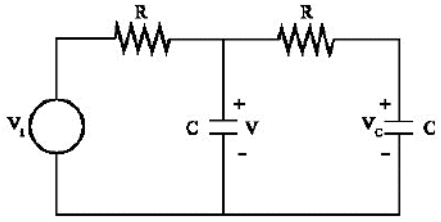
Which of the following statements given above is/are correct?

(a) 1 only (b) 2, 3 and 4

(c) 1, 2, 3 and 4 (d) 2 and 3

[ESE-2005]

18. For the circuit given below, what is the expression for the voltage?

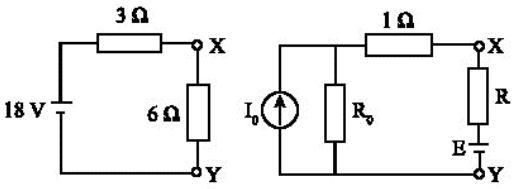


(a) $v + v_c$ (b) v_c

(c) $RC\frac{dv_c}{dt} - v_c$ (d) $RC\frac{dv_c}{dt} + v_c$

[ESE-2006]

19. If the two circuits shown below are equivalent, then which of the following is/are correct?



(1) $E = 2$ V, $R = 5\Omega$ (2) $E = 4$ V, $R = 4\Omega$

(3) $E = 6V, R = 3\Omega$ (4) $E = 10$ V, $R = 1\Omega$

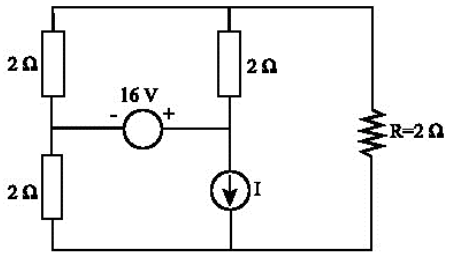
Select the correct answer using the codes given below:

(a) Only 1 and 2 (b) Only 3

(c) 1, 2, 3 and 4 (d) None of these

[ESE-2007]

20. In the circuit shown below, if the current through the resistor R is zero, what is the value of I?

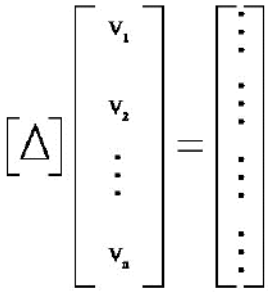


(a) 1 A (b) 2 A

(c) 3 A (d) 4 A

[ESE-2008]

21. Consider a circuit which consists of resistors and independent current sources, and one independent voltage source connected between the nodes i and j. The equations are obtained for voltage of n unknown nodes with respect to one reference node in the form



What are the elements of the?

(a) All conductances

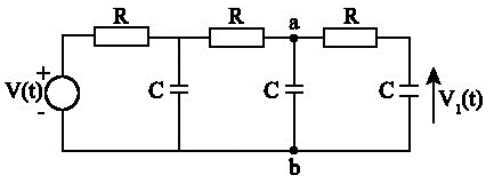
(b) All resistances

(c) Mixed conductances

(d) Mixed conductances and resistances

[ESE-2008]

22. In the circuit shown below, what is the voltage $v_{ab}(t)$?



(a) $\frac{dv_1}{dt} + v_1$ (b) v_1

(c) $\frac{dv_1}{dt} + RCv_1$ (d) $RC\frac{dv_1}{dt} + v_1$

[ESE-2008]

23. In a network containing active components, output voltage

(a) will always be greater than input voltage

(b) will always be equal to the input voltage

(c) can be less than or greater than input voltage only

(d) will be less than, equal to or greater than input voltage

[ESE-2008]

24. Assertion (A): The Kirchhoff's current law states that the sum of currents entering at any node is equal to the sum of currents leaving that node.

Reason (A): The Kirchhoff's current law is based on the law of conservation of charge.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2009]

25. Assertion (A): Ideal current sources and ideal voltage sources do not exist in reality.

Reason (R): All sources have finite internal impedances.

(a) Both A and R are true and R is the correct explanation of A

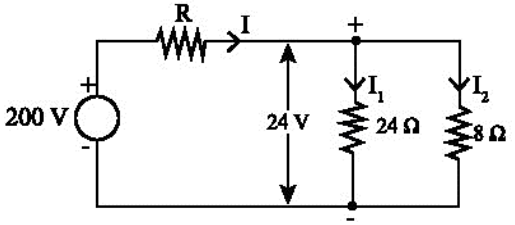
(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2010]

26. The value of R in the below circuit is

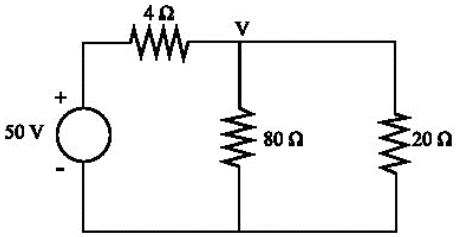


(a) 4 Ω (b) 40 Ω

(c) 44 Ω (d) 440 Ω

[ESE-2010]

27. The value of current in 80 Ω resistor of below circuit is

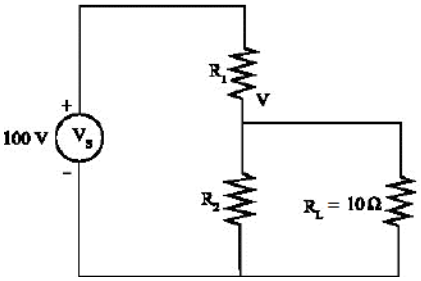


(a) 0.5 A (b) 2.0 A

(c) 5.0 A (d) 20.0 A

[ESE-2010]

28. What is the voltage across the load resistance, R_L in the below circuit? The value of each resistor connected in the circuit is 10 Ω.



(a) 3.33 V (b) 33.33 V

(c) 333.33 V (d) 0 V

[ESE-2010]

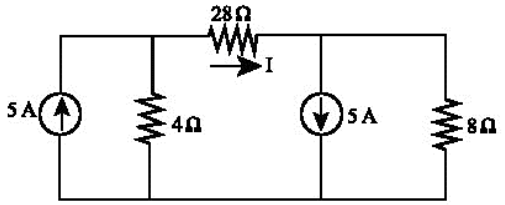
29. In the circuit shown below, the current through R_L is

(a) 6 A (b) 4 A

(c) 2 A (d) 0

[ESE-2010]

30. In the circuit shown below, the current I is



(a) 1 A (b) 1.5 A

(c) 2.5 A (d) 4 A

[ESE-2010]

31. It is required to find the current through a particular branch of a linear bilateral network without mutual coupling when the branch impedance takes four different values. Which one of the following methods will be preferred?

(a) Mesh analysis

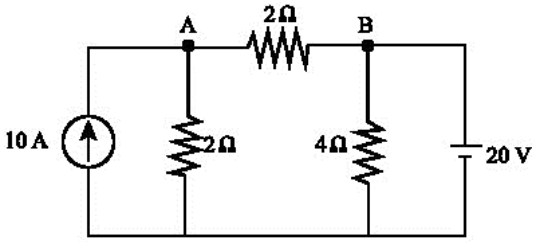
(b) Thevenin's equivalent circuit

(c) Nodal analysis

(d) Superposition theorem

[ESE-2011]

32. The current through the branch AB in the figure shown is

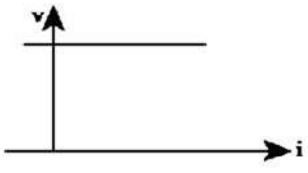


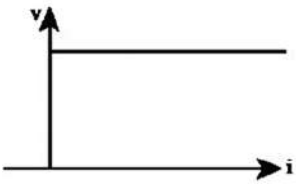
(a) 10 A , from A to B (b) 10 A , from B to A
(c) 0 (d) $20A$, from B to A

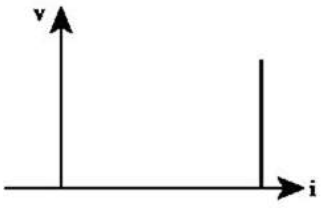
[ESE-2011]

33. Which one of the following gives the V-I characteristic of an ideal voltage source?

(a)


(b)


(c)


(d)


[ESE-2012]

34. The effective capacitance across AB of the infinite ladder shown in the below figure is

(a) $(1+\sqrt{3})C$ (b) $(1+\sqrt{7})C$
(c) $(1+\sqrt{5})C$ (d) $\frac{(1+\sqrt{5})}{2}C$

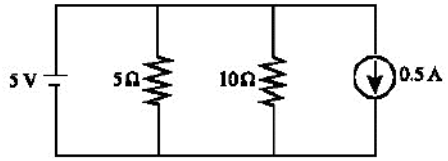
[ESE-2012]

35. A capacitor of capacitance C is charged by connecting it to a battery of emf E. The capacitor is now disconnected and reconnected to the battery with the polarity reversed. The heat developed in the connecting wires is

(a) $0.5CE^2$ (b) CE^2
(c) $2CE^2$ (d) $3CE^2$

[ESE-2012]

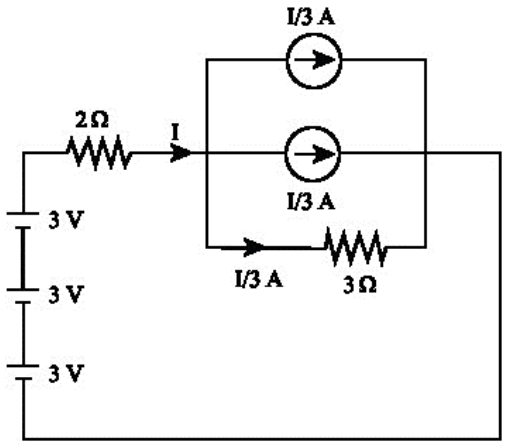
36. The total resistance faced by the voltage source having zero internal resistance in the circuit is



(a) 10 Ω (b) 5 Ω
(c) 2.5 Ω (d) 1.5 Ω

[ESE-2012]

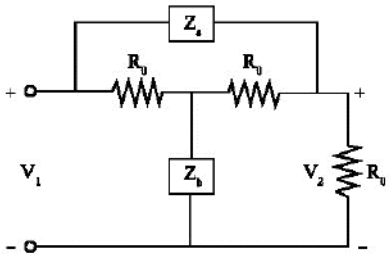
37. In the circuit, the voltage across 3 Ω resistance is



(a) 1 V (b) 3 V
(c) 6 V (d) 9 V

[ESE-2012]

38. The condition under which the input impedance at port 1 for the below network will be equal to R_0 is



(a) $Z_a + Z_b = R_o$ (b) $Z_a Z_b = R_o^2$
(c) $Z_a/Z_b = 1$ (d) $Z_b/Z_a = 1/2$

[ESE-2013]

39. A coil of inductance 2 H and resistance 1 Ω is connected to a 10 V battery with negligible internal resistance. The amount of energy stored in the magnetic field is

(a) 8 J (b) 50 J
(c) 25 J (d) 100 J

[ESE-2013]

40. The total capacitance of two capacitors is 25 F when connected in parallel and 4 F when connected in series. The individual capacitances of the two capacitors are

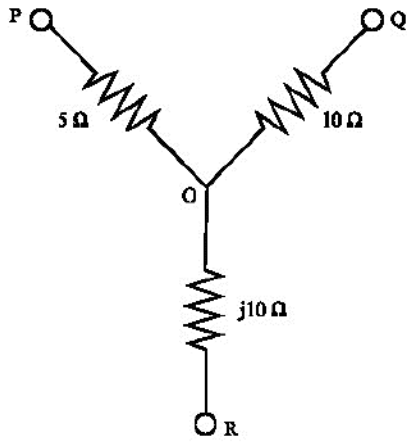
(a) 1 F and 24 F (b) 3 F and 21 F
(c) 5 F and 20 F (d) 10 F and 15 F

[ESE-2013]

41. Two lamps each of 230 V and 60 W rating are connected in series across a single phase 230 V supply. The total power consumed by the two lamps would be
(a) 120 W (b) 60 W
(c) 30 W (d) 15 W

[ESE-2013]

42. In the delta equivalent of the below star connected circuit, Z_{QR} is equal to



(a) $40\ \Omega$ (b) $(20 + j10)\ \Omega$
(c) $\left(5 + j\frac{10}{3}\right)\ \Omega$ (d) $(10 + j30)\ \Omega$

[ESE-2013]

43. The number of branches in a network is b, the number of nodes is n and number of dependent loop is l. The number of independent current equations will be
(a) $n - l - 1$ (b) $b - l$
(c) $b - n$ (d) $n - 1$

[ESE-2013]

44. If a capacitor is energized by a symmetrical square wave current source, then the steady state voltage across the capacitor will be a
(a) square wave (b) triangular wave
(c) step function (d) impulse function

[ESE-2013]

45. A network N consists of resistors and independent voltage and current sources. Its value of the determinant based on the node analysis
(1) cannot be negative
(2) cannot be zero
(3) is independent of the values of voltages and current sources
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

[ESE-2013]

46. A battery is connected to a resistance causing a current of 0.5 A in the circuit. The current drops to 0.4 A when an additional resistance of $5\ \Omega$ is connected in series. The current will drop to 0.2 A when the resistance is further increased by
(a) $10\ \Omega$ (b) $15\ \Omega$
(c) $25\ \Omega$ (d) $40\ \Omega$

[ESE-2014]

47. How many $6\ \mu\text{F}, 200\ \text{V}$ capacitors are needed to make a capacitor of $18\ \mu\text{F}, 600\ \text{V}$?
(a) 18 (b) 9
(c) 3 (d) 27

[ESE-2014]

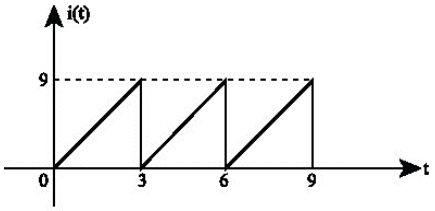
48. A 12 V automobile light is rated at 30 W. The total charge that flows through the filament in one minute is
(a) 30 C (b) 12 C
(c) 150 C (d) 180 C

[ESE-2014]

49. A capacitor of $100\ \mu\text{F}$ stores 10 mJ of energy. What is the amount of charge (in Coulomb) stored in it?
(a) 1.414×10^{-6} (b) 1.414×10^{-3}
(c) 2.303×10^{-6} (d) 2.303×10^{-3}

[ESE-2014]

50. The current waveform $i(t)$ in a pure resistor of $20\ \Omega$ is shown in the figure.



The power dissipated in the resistor is
(a) 135 W (b) 270 W
(c) 540 W (d) 14.58 W

[ESE-2014]

51. A network N consists of resistors, dependent and independent voltage and current sources. If the current in one particular resistance is A, it will be doubled if the values of all the
(a) independent voltage sources are doubled
(b) independent current sources are doubled
(c) dependent and independent voltage and current sources are doubled
(d) independent voltage and current sources are doubled

[ESE-2014]

52. Consider the following statements:
Any element is redundant if connected in

(1) series with an ideal current source
(2) parallel with an ideal current source
(3) series with an ideal voltage source
(4) parallel with an ideal voltage source

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 1, 2, 3 and 4 (d) 2 and 4 only

[ESE-2015]

53. The four band colour code on a carbon composite resistor is as follows:

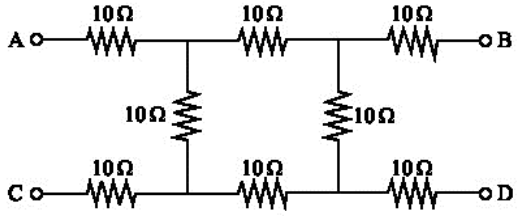
First band colour: Yellow
Second band colour : Violet
Third band colour : Red
Fourth band colour: Silver

The specification of the resistor is

(a) $35\ \text{k}\Omega \pm 10\%$ (b) $4.7\ \text{k}\Omega \pm 10\%$
(c) $6.7\ \text{k}\Omega \pm 5\%$ (d) $46\ \text{k}\Omega \pm 2\%$

[ESE-2015]

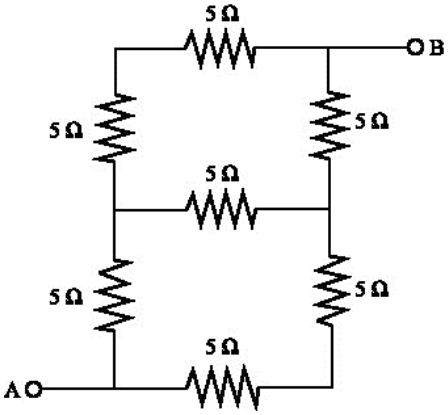
54. The equivalent resistance between the points A and D is



(a) 3 Ω (b) 11 Ω
(c) 15 Ω (d) None of the above

[ESE-2015]

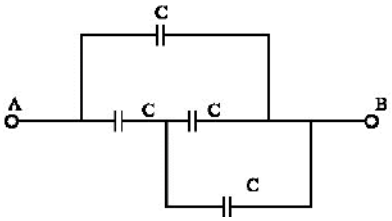
55. Seven resistances each 5 Ω are connected as shown in the figure. The equivalent resistance between the points A and B is



(a) 3 Ω (b) 11 Ω
(c) 15 Ω (d) None of the above

[ESE-2015]

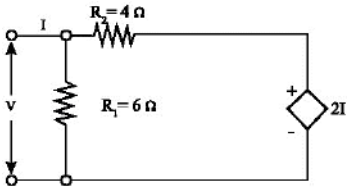
56. The capacitance of each capacitor is $C = 3\ \mu\text{F}$ in the figure shown. The effective capacitance between points A and B is



(a) $2\ \mu\text{F}$ (b) $3\ \mu\text{F}$
(c) $4\ \mu\text{F}$ (d) $5\ \mu\text{F}$

[ESE-2015]

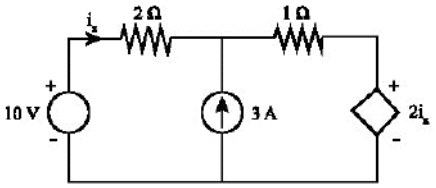
57. For the active network shown in figure, the value of V/I is



(a) 2 Ω (b) 2.4 Ω
(c) 3.6 Ω (d) 10 Ω

[ESE-2015]

58. In the circuit the value of i_x is



(a) 2 A (b) -0.6 A
(c) 2.6 A (d) 1.4 A

[ESE-2016]

59. If the three resistors in a delta network are all equal in values i.e. R_{DELTA}, then the value of the resultant resistors in each branch of the equivalent star network i.e. R_{STAR} will be equal to

(a) $\frac{R_{\text{DELTA}}}{3}$ (b) $\frac{R_{\text{DELTA}}}{2}$
(c) $2R_{\text{DELTA}}$ (d) R_{DELTA}

[ESE-2017]

60. Consider the following factors:

1. Number of turns of the coil
2. Length of the coil
3. Area of cross-section of the coil
4. Permeability of the core

On which of the above factors does inductance depend?

(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 1, 2, 3 and 4 (d) 2 and 4 only

[ESE-2017]

61. A network in which all the elements are physically separable is called a

(a) distributed network (b) lumped network
(c) passive network (d) reactive network

[ESE-2018]

62. The Kirchhoff's current law works on the principle of conservation of

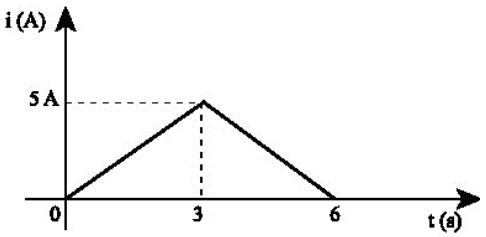
1. charge
2. energy
3. power

Which of the above is/are correct?

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

[ESE-2018]

63. A waveform shown in the figure is applied to a resistor of 20 Ω. The power dissipated in the resistor is



(a) 100 W (b) 600 W
(c) 900 W (d) 1000 W

[ESE-2018]

64. A coil of wire of $0.01\ mm^2$ area of 1000 turns is wound on a core. It is subjected to a flux density of $100\ mWb/mm^2$ by a 1 A current. The energy stored in the coil is

(a) 2.0 J (b) 1.5 J
(c) 1.0 J (d) 0.5 J

[ESE-2019]

65. Two resistances, one of 30 Ω and another of unknown value, are connected in parallel. The total power dissipated in the circuit is 450 W when the applied voltage is 90 V. The unknown resistance is

(a) 45Ω (b) 35 Ω
(c) 30 Ω (d) 20 Ω

[ESE-2019]

66. A heater element is made of nichrome wire having resistivity equal to $100x10^{-8}\ \Omega m$ and diameter of 0.4 mm. The length of the wire required to get a resistance of 40 Ω will be nearly

(a) 9 m (b) 7 m
(c) 5 m (d) 3 m

[ESE-2019]

67. A coil having resistance of 10 Ω inductance of 1 H is switched on to a direct voltage of 100 V. The steady-state value of the current will be

(a) 10 A (b) 15 A
(c) 20 A (d) 25 A

[ESE-2020]

68. According to Kirchhoff's voltage law, the algebraic sum of all the voltage in any closed loop of a network is always

(a) Negative
(b) Positive
(c) Zero
(d) Determined by the battery emf

[ESE-2020]

69. Ohm's law is applicable to

(a) DC circuit only
(b) AC circuit only
(c) DC circuit as well as AC circuit, provided account is taken of the induced emf resulting from the self-inductance of circuit and of the distribution of current in cross-section of circuit
(d) DC circuit as well as AC circuit, provided account is taken of the induced emf resulting from mutual-inductance of circuit and of the distribution of current in cross-section of circuit

[ESE-2020]

70. Two coils are connected in parallel and a voltage of 200 V is applied to the terminals. The total current taken is 15 A and the power dissipated in one of the coils is 1500 W, the resistance of each coil will be nearly

(a) 26.7 Ω and 23.4 Ω (b) 22.4 Ω and 23.4 Ω
(c) 26.7 Ω and 26.7 Ω (d) 22.4 Ω and 26.7 Ω

[ESE-2020]

71. The value of total potential difference created between the electrodes, when the cell is not connected to an external circuit is known as its

(a) Electromotive force
(b) Electrostatic force
(c) Electromagnetic force
(d) Electrochemical force

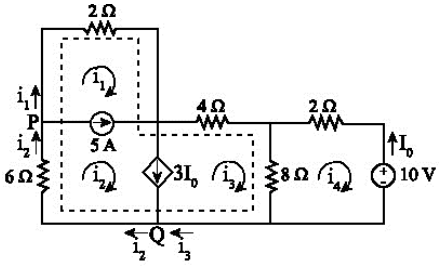
[ESE-2021]

72. A wire of resistor $10\ \Omega$ is drawn out so that its length is increased to twice its original length. Then, the new resistance is

(a) 20 Ω (b) 5 Ω
(c) 30 Ω (d) 40 Ω

[ESE-2021]

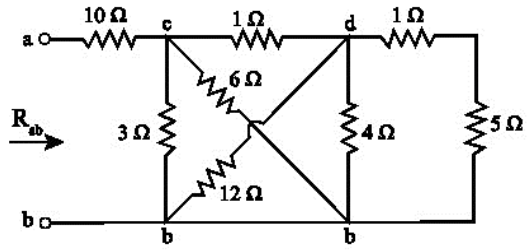
73. For the given circuit, the currents i_1 and i_3



(a) $i_1 = -2.5$ A and $i_3 = 3.93$ A
(b) $i_1 = -7.5$ A and $i_3 = -2.5$ A
(c) $i_1 = 3.93$ A and $i_3 = 2.14$ A
(d) $i_1 = -7.5$ A and $i_3 = 3.93$ A

[ESE-2021]

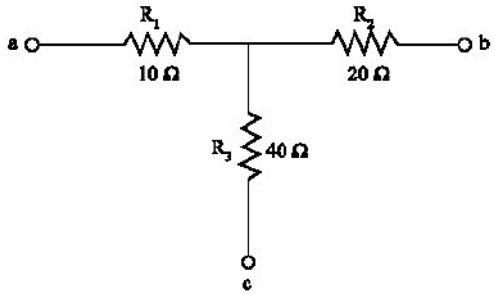
74. What is the equivalent resistance R_{ab} in the given circuit?



(a) 37.08 Ω (b) 11.20 Ω
(c) 42.16 Ω (d) 17.82 Ω

[ESE-2021]

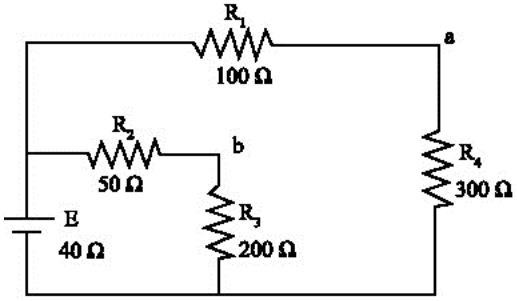
75. What are the values of R_a, R_b and R_c respectively, after transforming the Wye network shown in the figure to a delta network?



(a) 140 Ω, 70 Ω and 45 Ω
(b) 70 Ω, 140 Ω and 35 Ω
(c) 140 Ω, 70 Ω and 35 Ω
(d) 40 Ω, 70 Ω and 25 Ω

[ESE-2022]

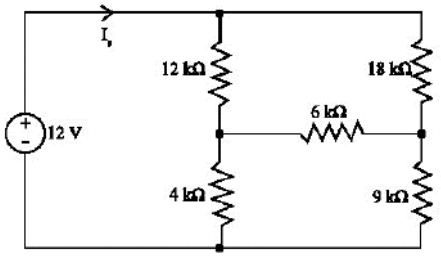
76. In the figure given below, the value of voltage drop across the resistor R_1 is



(a) 100 V (b) 10 V
(c) 1 V (d) 0.1 V

[ESE-2022]

77. What is the value of the source current (I_s) of the given network in the figure?



(a) 1.2 A (b) 12 A
(c) 1.2 mA (d) 12 mA

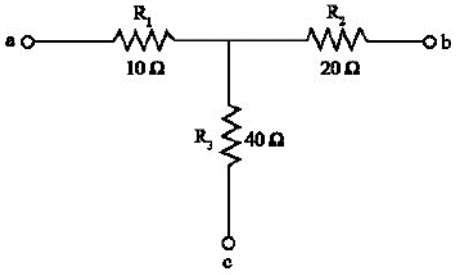
[ESE-2022]

78. Statement (I): Voltage (or potential difference) is the energy required to move a unit charge through an element.
Statement (II): Power is the time rate of expending or absorbing energy.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2023]

79. What are the values of delta-connected branch resistances R_{ab}, R_{bc} and R_{ac} of the star - connected network shown in the figure using star to delta trans-formation respectively?



(a) 35 Ω, 140 Ω and 70 Ω
(b) 35 Ω , 60 Ω and 70 Ω
(c) 70 Ω, 60 Ω and 35 Ω
(d) 70 Ω, 150 Ω and 35 Ω

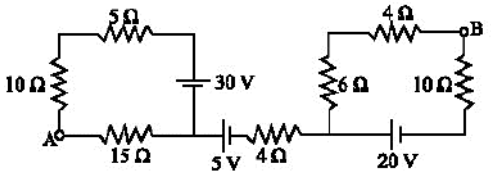
[ESE-2023]

80. A coil consists of 1000 turns of copper wire having a cross-sectional area of $0.8\ mm^2$. The mean length per turn is 80 cm and the resistivity of copper is $0.02\ \mu\Omega - m$. What are the values of resistance of the coil and power absorbed by the coil when connected across 100 V DC supply respectively?

(a) 20 Ω and 250 W (b) 40 Ω and 250 W
(c) 20 Ω and 500 W (d) 40 Ω and 500 W

[ESE-2023]

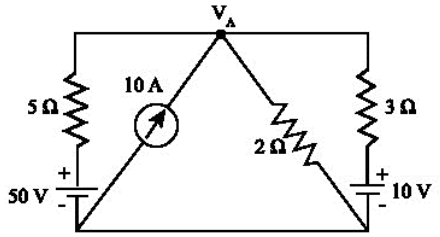
81. What is the value of voltage between points A and B of the network shown in the figure?



(a) 15 V (b) 30 V
(c) -30 V (d) -15 V

[ESE-2023]

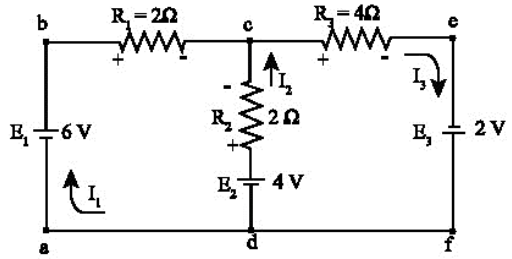
82. What is the value of voltage at node V_A shown in the network below?



(a) 21.65 V (b) 22.65 V
(c) -21.65 V (d) -22.65 V

[ESE-2024]

83. The current (I_2) of the circuit given below is



(a) 2 mA (b) 20 mA
(c) 0.2 A (d) 2 A

[ESE-2025]

84. Two resistances, one of $30\ \Omega$ and another of unknown value, are connected in parallel; The total power dissipated in the circuit is 450 W, when the applied voltage is 90 volts. The value of the unknown resistance will be

(a) $35\ \Omega$ (b) $40\ \Omega$
(c) $45\ \Omega$ (d) $50\ \Omega$

[ESE-2025]

85. A voltmeter has a resistance of $20000\ \Omega$. When connected in series with an external resistance across a 230 V supply, the instrument reads 160 V. The value of the external resistance will be

(a) $8750\ \Omega$ (b) $8560\ \Omega$
(c) $8370\ \Omega$ (d) $8160\ \Omega$

[ESE-2025]

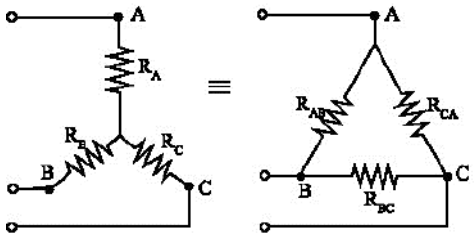
86. An impedance $Z_1 = (2 - j5)\ \Omega$ is connected in parallel with another impedance of $Z_2 = (1 + j)\ \Omega$. If the applied voltage is $17\angle 0^\circ$ V, then the currents through Z_1 and Z_2 are respectively

(a) $3.16\angle 68.2^\circ$ A and $10.02\angle -35^\circ$ A
(b) $2.16\angle 48.2^\circ$ A and $10.02\angle -35^\circ$ A
(c) $3.16\angle 48.2^\circ$ A and $12.02\angle -45^\circ$ A
(d) $2.16\angle 48.2^\circ$ A and $12.02\angle -45^\circ$ A

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(a)	(b)	(d)	(d)	(d)	(a)	(a)	(a)	(a)	(c)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(b)	(b)	(b)	(a)	(a)	(c)	(b)	(d)	(c)	(d)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(a)	(d)	(c)	(a)	(a)	(c)	(a)	(b)	(a)	(b)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(b)	(c)	(b)	(d)	(c)	(c)	(b)	(b)	(d)	(c)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(c)	(d)	(d)	(b)	(a)	(c)	(d)	(c)	(b)	(c)
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
(d)	(b)	(b)	(c)	(d)	(d)	(c)	(d)	(a)	(c)
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
(b)	(a)	(*)	(d)	(a)	(c)	(a)	(c)	(c)	(c)
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
(a)	(d)	(d)	(c)	(c)	(b)	(c)	(b)	(a)	(c)
81	**82**	**83**	**84**	**85**	**86**				
(b)	(b)	(c)	(c)	(a)	(c)				

EXPLANATIONS

1. Explanation: (a)



By converting star to delta network

$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

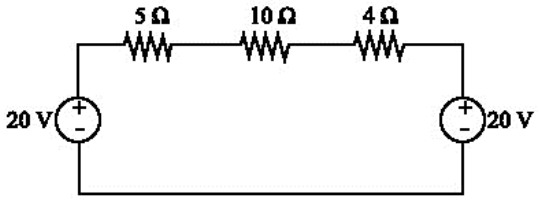
$$R_{AB} = 3 + 1.5 + \frac{3 \times 1.5}{9}$$

$$= 3 + 1.5 + 0.5 = 5\ \Omega$$

$$R_{BC} = 9 + 1.5 + \frac{9 \times 1.5}{3}$$

$$R_{BC} = 9 + 1.5 + 4.5 = 15\ \Omega$$

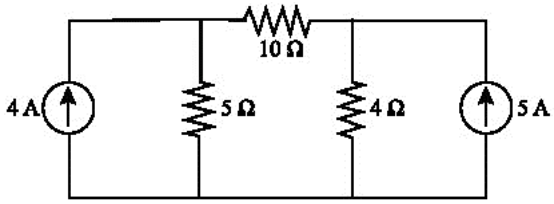
2. Explanation: (b) By applying source transformation, the circuit can be redrawn as



Net current in 10 Ω resistor is zero.

$$I_{10\,\Omega} = \frac{20-20}{19} = 0\ A$$

The whole 4 A current flows only through 5 Ω resistor.



Power dissipated through 5 Ω resistor is

$$P = (4)^2 5 = 80\ \text{W}$$

3. Explanation: (d) Resistance dissipates energy, while inductor and capacitor are energy storing elements

4. Explanation: (d) Voltage across inductor is

$$V_L = L\frac{di}{dt}$$

$$L = V_L\frac{dt}{di}\ V - \text{sec/A}$$

$$i = C\frac{dv}{dt}$$

$$\text{C} = i \times \frac{dt}{dv}\ \text{A} - \text{sec/V}$$

$$\sqrt{\frac{L}{C}} = \sqrt{\frac{\text{Vsec/A}}{\text{Asec/V}}}$$

$$\sqrt{\frac{L}{C}} = \sqrt{\frac{\text{V sec}}{\text{A}}} \times \frac{V}{\text{A sec}} = \frac{V}{R} = R$$

5. Explanation: (d)

Charge is area under the curve

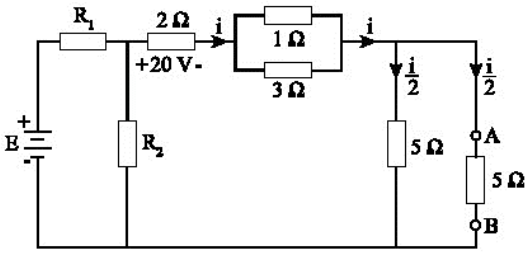
$$q(t) = \int_0^5 i(t)dt$$

$$q(t) = \frac{1}{2} \times 5 \times 3 + \frac{1}{2} \times (5+3) \times 1 + \frac{1}{2} \times (3+4) \times 1$$

$$q(t) = \frac{1}{2}(15+8+7)\ \mu\text{C} = 15\ \mu\text{C}$$

6. Explanation: (a) Non-linear, active, non-bilateral

7. Explanation: (a)



Current through 2 Ω resistor is

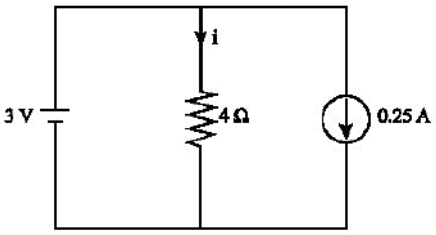
$$i = \frac{20}{2} = 10\ \text{A}$$

By current division rule, current divides equally in both 5 Ω resistors.

$$V_{AB} = 5 \times 5 = 25\ \text{V}$$

So, the 5 Ω resistor connected between the terminals A and B can be replaced by an ideal voltage source of 25 V with + ve terminal upward.

8. Explanation: (a)



$$i = \frac{3}{4} = 0.75\ \text{A}$$

Current flowing through the voltage source is

$$i_{3\,V} = \text{i} + 0.25 = 0.75 + 0.25 = 1\ \text{A}$$

9. Explanation: (a)

(i) Time constant is

$\tau = \frac{L}{R} = CR$ (measured in seconds)

(ii) $\omega = \frac{1}{\sqrt{LC}}$ (measured in rad/s)

(iii) $\sqrt{\frac{L}{C}} = R$ (measured in Ohms)

10. Explanation: (c)

(i) KVL is based on the law of conservation of energy.

(ii) KCL is based on the law of conservation of charge.

11. Explanation: (b)

Current flowing through 1 MΩ resistor is

$$i = \frac{V_1 - V_2}{10^6} = \frac{5-3}{10^6} = 2\ \mu\text{A}$$

Input impedance of the CRO is

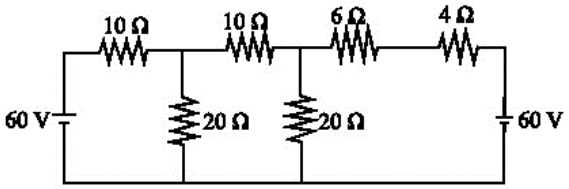
$$Z_{\text{in}} = \frac{V_2}{i} = \frac{3}{2} = 1.5\ \text{M}\Omega$$

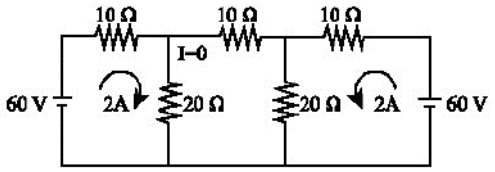
12. Explanation: (b) Since, the bridge is balanced. So the current through R is zero, hence power delivered to R is also zero.

13. Explanation: (b)
I_2 is independent of R_1. So, I_2 will remain 2 A whatever be the value of R_1.

14. Explanation: (a) Current through the capacitor is
$i = C\frac{dv}{dt}$
By KVL
$\frac{1}{G}i + v = 0$
$i + Gv = 0$
$C\frac{dv}{dt} + Gv = 0$

15. Explanation: (a) By applying source transformation, the circuit is redrawn as

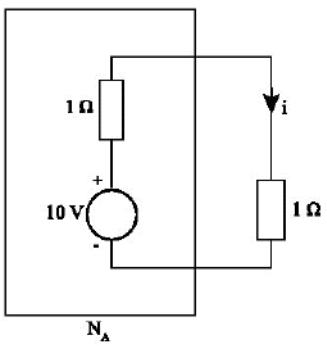




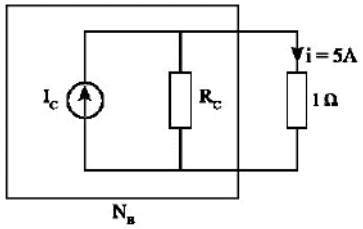
Since, it is a symmetrical network. So, $I = 0$ A

16. Explanation: (c)
Since, it is a parallel circuit, the voltage across each branch is fixed and will not change on opening one of the branches. Since $V = iR$, therefore currents in the other branches are also unaffected.

17. Explanation: (b)



$i = \frac{10}{1+1} = 5$ A

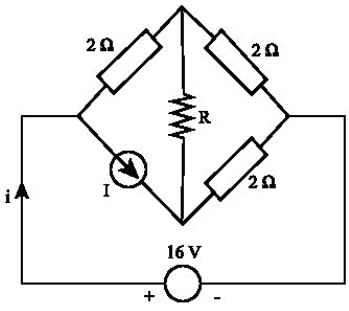


By current division rule
$i = 5 = \frac{R_C}{R_C + 1} \cdot I_C$
Following values satisfy the above equation.
(i) 10 A and 1 Ω
(ii) 15 A and $\frac{1}{2}$ Ω
(iii) 30 A and $\frac{1}{5}$ Ω

18. Explanation: (d)
Current through capacitor is
$i_c = C\frac{dv_c}{dt}$
By KVL
$-v + Ri_c + v_c = 0$
$-v + RC\frac{dv_c}{dt} + v_c = 0$
$v = RC\frac{dv_c}{dt} + v_c$

19. Explanation: (c)
$V_{XY} = \frac{6}{6+3} \times 18 = 12$ V
Current through the terminal XY is
$I = \frac{18}{9} = 2\ A.$
$V_{XY} = IR + E$
$V_{XY} = 2R + E$
By putting the given values
(i) $2 \times 5 + 2 = 12$
(ii) $2 \times 4 + 4 = 12$
(iii) $2 \times 3 + 6 = 12$
(iv) $2 \times 1 + 10 = 12$
All values satisfy the equations.

20. Explanation: (d)
By rearranging the circuit



The given circuit is a Wheatstone's bridge. So, the current source I can be replaced by 2 Ω.

$i = \frac{16}{R_{eq}}$

where, $R_{eq} = (2+2)\|(2+2) = 2\ \Omega$

$i = \frac{16}{2} = 8$ A

Since the network is symmetrical, so the current i divides equally

Hence, $= 4$ A.

21. Explanation: (a) All conductances

22. Explanation: (d)

By KVL

$v_{ab}(t) = Ri + v_1(t)$

$i = C \cdot \frac{dV_1(t)}{dt}$

So, $v_{ab}(t) = RC\frac{dv_1}{dt} + v_1$

23. Explanation: (c) Active element has property of internal amplification.

24. Explanation: (a)

Assertion (A): The Kirchhoff's current law states that the sum of currents entering at any node is equal to the sum of currents leaving that node.

True.

This is the standard definition of KCL.

Reason (R): The Kirchhoff's current law is based on the law of conservation of charge.

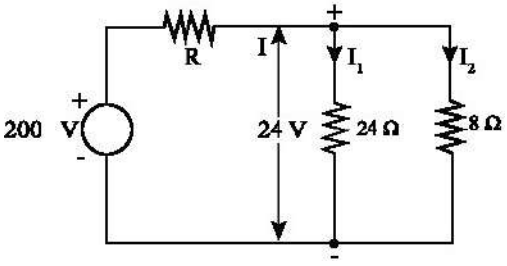
True.

KCL is derived from the principle of conversation of electric charge, so charge cannot accumulate at a node in a circuit.

Hence, Both A and R are true and R is the correct explanation of A

25. Explanation: (a) Both A and R are true and R is the correct explanation of A

26. Explanation: (c)



$I_1 = \frac{24}{24} = 1$ A

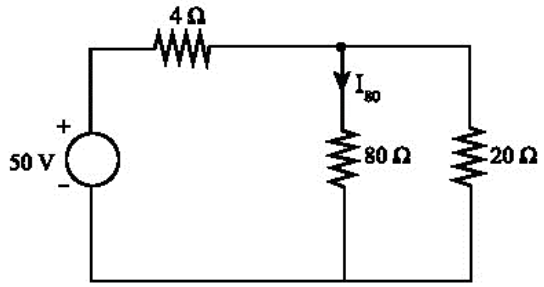
$I_2 = \frac{24}{8} = 3$ A

$I = I_1 + I_2 = 1 + 3 = 4$ A

Now $I = \frac{200-24}{R} = 4$

$R = \frac{176}{4} = 44\ \Omega$

27. Explanation: (a)



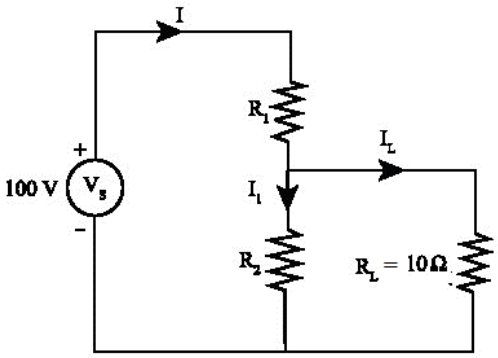
By KCL at node 1

$\frac{V_1 - 50}{4} + \frac{V_1}{80} + \frac{V_1}{20} = 0$

$V_1 = 40$ V

$I_{80\,\Omega} = \frac{V_1}{80} = \frac{40}{80} = 0.5\ A$

28. Explanation: (b)



Given, $R_1 = R_2 = R_L = 10\ \Omega$

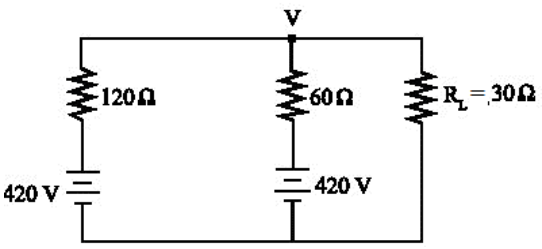
$I = \frac{100}{R_1 + \frac{R_2 \times R_L}{R_2 + R_L}} = \frac{100}{10+5} = \frac{100}{15}$

$I_L = I_1 = \frac{I}{2} = \frac{100}{30}$ A

So, voltage across R_L is

$V_L = I_L R_L = \frac{100}{30} \times 10 = 33.333$ V

29. Explanation: (a)



By KCL at node V

$$\frac{V-420}{120}+\frac{V-420}{60}+\frac{V}{30}=0$$

$$\frac{V}{120}+\frac{V}{60}+\frac{V}{30}=\frac{420}{120}+\frac{420}{60}$$

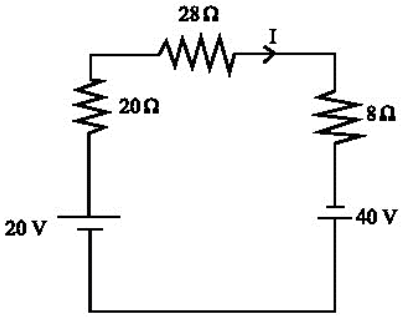
$V = 180$ volt

Current through R_L is

$$I_L=\frac{V}{R_L}=\frac{180}{30}=6\text{ A}$$

30. Explanation: (b)

By applying source transformation, circuit can be redrawn as

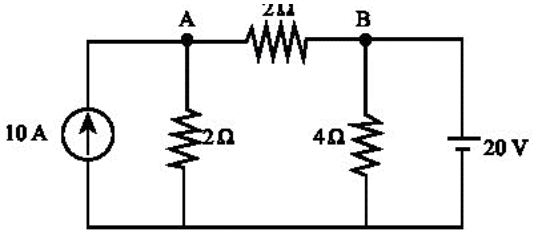


$$I=\frac{20+40}{4+28+8}=1.5\text{ A}$$

31. Explanation: (b)

Thevenin's equivalent circuit

32. Explanation: (c)



By applying KCL at node A

$$\frac{V_A}{2}+\frac{V_A-V_B}{2}=10$$

$$2V_A-V_B=20$$

$V_B = 20$ V

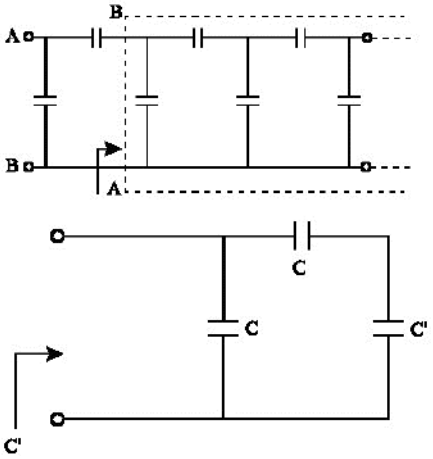
$V_A = 20$ V

Hence current through branch AB

$$I_{AB}=\frac{V_A-V_B}{2}=\frac{20-20}{2}=0\text{ A}$$

33. Explanation: (b) Ideal voltage source delivers constant voltage irrespective of the value of current through it.

34. Explanation: (d)



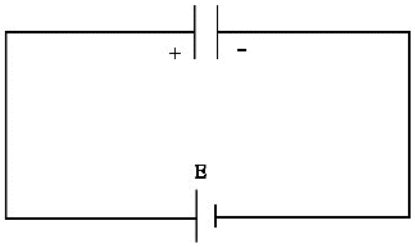
$$C'=C+\frac{C'C}{C+C'}$$

$$CC'+C'^2=C^2+CC'+CC'$$

$$C'^2-CC'-C^2=0$$

$$C'=\left(\frac{1+\sqrt{5}}{2}\right)C$$

35. Explanation: (c)



Initially, charge on capacitance is

$Q = CE$

Finally initial voltage on capacitor is E

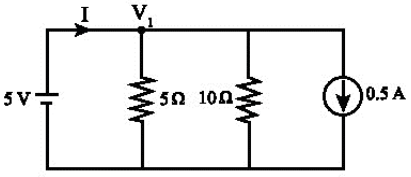
New charge on capacitor is

$Q' = C \cdot (2E) = 2CE$

Heat developed is

$$H=\frac{1}{2}\frac{Q^2}{C}=\frac{1}{2}\times\frac{4C^2E^2}{C}=2CE^2$$

36. Explanation: (c)



By applying KCL at node V_1

$$\frac{V_1}{5}+\frac{V_1}{10}+0.5=I$$

$$V_1 = 5\text{ V}$$

$$\frac{5}{5}+\frac{5}{10}+0.5=I$$

$$I = 2\text{ Amp}$$

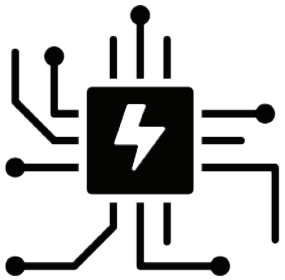
So resistance $=\frac{V_1}{I}=\frac{5}{2}=2.5\ \Omega$

ANALOG & DIGITAL CIRCUITS

SECTION 6

SYLLABUS

SMALL SIGNAL EQUIVALENT CIRCUITS OF DIODES, BJTS AND FETS; DIODE CIRCUITS FOR DIFFERENT USES; BIASING & STABILITY OF BJT & JFET AMPLIFIER CIRCUITS; ANALYSIS/DESIGN OF AMPLIFIER- SINGLE/MULTI-STAGE; FEEDBACK& USES; ACTIVE FILTERS, TIMERS, MULTIPLIERS, WAVE SHAPING, A/D-D/A CONVERTERS; BOOLEAN ALGEBRA& USES; LOGIC GATES, DIGITAL IC FAMILIES, COMBINATORIAL /SEQUENTIAL CIRCUITS; BASICS OF MULTIPLEXERS, COUNTERS /REGISTERS/MEMORIES /MICROPROCESSORS, DESIGN& APPLICATIONS.



NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS - ESE ELECTRONICS

ANALOG AND DIGITAL CIRCUITS		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
6.1.1	Diode Circuits	3	1	2	2	4	1	1	7	2	5	3	2	3
6.1.2	BJT and FET Circuits	3	2	7	6	6	10	4	5	13	2	6	8	8
6.1.3	Frequency Response and Filters	3	6	6	6	6	3	8	6	4	1	6	4	7
6.1.4	Oscillators and Operational Amplifiers	7	11	5	7	4	6	3	2	4	1	5	1	6
6.1.5	Power Amplifiers and Multivibrators	2	2	2	5	2	2	2	4	6	1	4	4	3
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
6.1.1	Diode Circuits	4	5	4	1	1	3	1	2	-	-	1	-	
6.1.2	BJT and FET Circuits	9	12	8	3	3	1	5	2	1	3	6	10	
6.1.3	Frequency Response and Filters	2	4	3	1	2	-	-	1	-	1	4	3	
6.1.4	Oscillators and Operational Amplifiers	4	7	9	2	5	4	4	5	2	2	4	2	
6.1.5	Power Amplifiers and Multivibrators	3	2	2	2	-	3	1	1	1	2	1	-	

ANALOG AND DIGITAL CIRCUITS		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
6.2.1	Number Systems and Boolean Algebra	5	8	2	2	7	6	6	5	2	4	3	5	10
6.2.2	Logic Gates and Combinational Circuits	4	2	8	9	4	5	6	3	5	8	6	3	3
6.2.3	Sequential Circuits	5	3	7	4	3	3	3	4	9	6	5	7	3
6.2.4	Memories and Programmable Logic Devices	1	1	-	2	2	1	1	1	-	3	1	1	1
6.2.5	Logic Famalies and Data Converters	6	8	3	2	1	9	6	6	7	8	10	11	7
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
6.2.1	Number Systems and Boolean Algebra	2	10	7	3	2	6	2	2	4	1	2	3	
6.2.2	Logic Gates and Combinational Circuits	3	4	7	4	-	-	1	-	3	3	5	-	
6.2.3	Sequential Circuits	6	5	6	1	4	2	2	1	3	2	6	1	
6.2.4	Memories and Programmable Logic Devices	1	-	-	2	1	-	-	-	-	2	4	2	
6.2.5	Logic Famalies and Data Converters	6	5	8	2	2	4	4	-	1	4	-	1	

CHAPTER-6 ANALOG AND DIGITAL CIRCUITS

Unit 6.1: Analog Circuits

Unit 6.1.1 Diode Circuits

Previous Year Exam Questions

[ESE-2001]

1. Consider the following statements:
The function of bleeder resistance in filter circuit is to
1. maintain minimum current necessary for optimum inductor filter operation.
2. work as voltage divider in order to provide variable output from the supply.
3. provide discharge to capacitors so that output becomes zero when the circuit has been de-energised.

Which of these statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

[ESE-2001]

2. Consider the following rectifier circuits:
1. Half-wave rectifier without filter.
2. Full-wave rectifier without filter.
3. Full-wave rectifier with series inductance filter.
4. Full-wave rectifier with capacitance filter.

The sequence of these rectifier circuits in decreasing order of their ripple factor is
(a) $1, 2, 3, 4$ (b) $3, 4, 1, 2$
(c) $1, 4, 3, 2$ (d) $3, 2, 1, 4$

[ESE-2001]

3. The use of a rectifier filter in a capacitor circuit gives satisfactory performance only when the load
(a) current is high (b) current is low
(c) voltage is high (d) voltage is low

[ESE-2002]

4. The PIV rating of the diodes used in power supply circuits are chosen by which one of the following criteria? (V_m is the peak input supply voltage to the rectifier circuit used in the power supply)
(a) The diodes that are to be used in a full wave rectifier should be rated $2V_m$ and in bridge rectifier equal to V_m
(b) The diodes that are to be used in a full wave rectifier should be rated V_m and in bridge rectifier equal to $2V_m$
(c) All diodes should be rated for V_m only
(d) All diodes should be rated for $2V_m$

[ESE-2003]

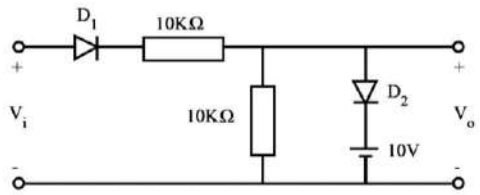
5. For a full-wave rectifier with shunt capacitor filter, the peak to peak ripple voltage is
(a) $\frac{2I_{DC}}{fC}$ (b) $\frac{I_{DC}}{fC}$
(c) $\frac{I_{DC}}{2fC}$ (d) $\frac{I_{DC}}{4fC}$
(where f = fundamental power line frequency, I_{DC} = DC current)

[ESE-2003]

6. The average value of the full-wave rectified sine wave with period π, and a peak value of V_m is
(a) $0.707\ V_m$ (b) $0.500\ \mathrm{V_m}$
(c) $0.637\ V_m$ (d) $0.318\ V_m$

[ESE-2004]

7. Consider the following circuit:



For the circuit shown above, which one of the following is a correct statement?
(a) D_2 does not conduct for any value of V_i
(b) $V_o = 10$ V for all values of $V_i > 10$ V
(c) $V_o = 0$ V for all values of $V_i < 0$ V
(d) $V_o = 10$ V for all values of $V_i > 0$ V

[ESE-2004]

8. Which one of the following statements is correct? Under small signal operation of a diode,
(a) its bulk resistance increases
(b) its junction resistance predominates
(c) it acts like a closed switch
(d) it behaves as a clipper

[ESE-2005]

9. Consider the following statements:
A clamper circuit
1. adds or subtracts a dc voltage to or from a waveform.
2. does not change the shape of the waveform.
3. amplifies the waveform.

Which of the statements given above are correct?

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

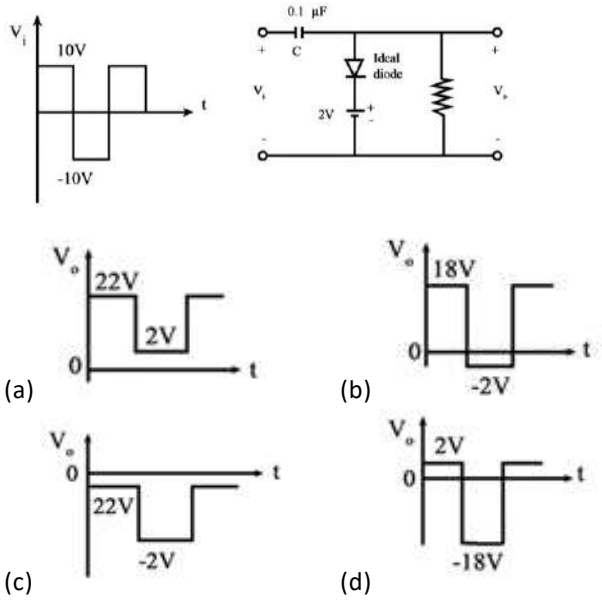
[ESE-2005]

10. In a half-wave rectifier, if an a.c. supply is 60 Hz, then what is the a.c. ripple at output?

(a) 30 Hz (b) 60 Hz
(c) 120 Hz (d) 15 Hz

[ESE-2005]

11. Select the correct output (V_0) wave-shape for a given input (V_i) in the clamping network given below:



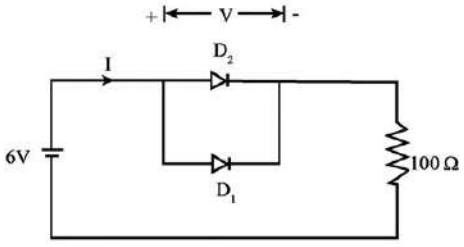
[ESE-2005]

12. A half-wave rectifier having a resistance load of $1\ \text{k}\Omega$ rectifies an a.c. voltage of 325 V peak value and the diode has a forward resistance of $100\ \Omega$. What is the RMS value of the current?

(a) 295.4 mA (b) 94.0 mA
(c) 147.7 mA (d) 208.0 mA

[ESE-2006]

13. In the given circuit, D_1 is an ideal germanium diode and D_2 is a silicon diode having its cut-in voltage as 0.7 V, forward resistance as $20\ \Omega$ and reverse saturation current (I_s) as 10 nA. What are the values of I and V for this circuit, respectively?



(a) 60 mA and 0 V (b) 50 mA and 0 V
(c) 53 mA and 0.7 V (d) 44 mA and 1.58 V

[ESE-2007]

14. A power supply has a full-load voltage of 24 V. What is its no-load voltage for 5% regulation (rounded to the nearest integer)?

(a) 12 V (b) 23 V
(c) 25 V (d) 6 V

[ESE-2008]

15. Which of the following components are chosen to construct a d.c. power supply to supply 6 V DC voltage from 230 V a.c. to operate a tape recorder?

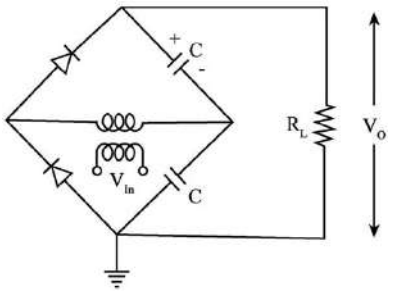
1. Step down transformer
2. Diodes
3. Resistors and capacitors
4. Three-pin voltage stabilizer

Select the correct answer using the code given below:

(a) 1, 2 and 3 only (b) 1 and 4 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

[ESE-2008]

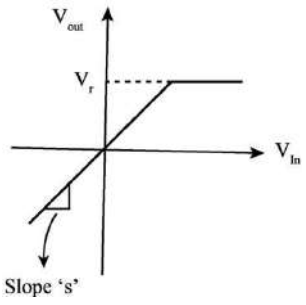
16. The figure shown below is a circuit of which one of the following?



(a) Bridge rectifier (b) Voltage doubler
(c) Rectifier with filter (d) Comparator

[ESE-2008]

17. The figure given below shows the transfer characteristics of which one of the following



(a) Peak clipper (b) Bottom clipper
(c) Clamper (d) Two level clipper

[ESE-2008]

18. When a junction diode is used as a half-wave rectifier with purely resistive load and sinusoidal input voltage, what is the value of diode conduction angle (where ϕ_i is the ignition angle corresponding to the cut-in voltage)?

(a) π
(b) $\pi - \phi_i$
(c) $\pi - 2\phi_i$
(d) Slightly greater than π

[ESE-2008]

19. Assertion (A): A high value of resistor is connected across the diode in a clamper circuit for better performance.
Reason (R): If this resistor is not present, the circuit will respond to sudden decrease in the magnitude of the input pulse train, but the response to sudden increase in the amplitude will cause improper response.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2008]

20. Silicon diodes are less suited for low voltage rectifier operation because
(a) it cannot withstand high temperatures
(b) its reverse saturation current is low
(c) its cut-in voltage is high
(d) its breakdown voltage is high

[ESE-2008]

21. The 'voltage stability with time' of reference diodes incorporating Zener diodes is comparable to that of which of the following?
(a) Dry cells
(b) Nickel -cadmium cells
(c) Lead-acid accumulator batteries
(d) Conventional standard cells

[ESE-2009]

22. Consider the following statements about a good power supply:
1. The a.c. ripple should be high.
2. S_v, (Voltage stability factor) should be low.
3. S_T, (Temperature stability factor) should be low.
Which of the above statements are correct?
(a) 1, 2 and 3 (b) 2 only
(c) 3 only (d) 2 and 3 only

[ESE-2009]

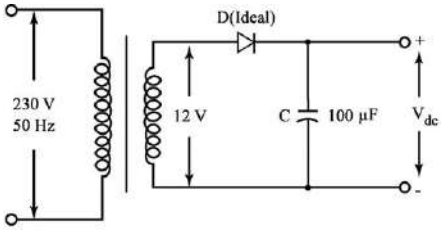
23. Assertion (A): A rectifier with inductor filter is more efficient for high load current.
Reason (R): In rectifier with inductor filter we can use a larger choke to reduce ripple, larger choke will have higher dc resistance which will result in lower dc output voltage for higher load current.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2010]

24. Consider the following statements:
When compared with a bridge rectifier, a centre-tapped full wave rectifier:
1. Has larger transformer utilization factor.
2. Can be used for floating output terminals i.e. no input terminal is grounded.
3. Needs two diodes instead of four.
4. Needs diodes of a lower PIV rating.
Which of these statements is/are correct?
(a) 1 and 2 only (b) 1, 2 and 3
(c) 3 only (d) 3 and 4 only

[ESE-2010]

25. The output V_{dc} from the below circuit is



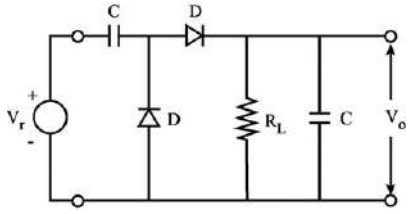
(a) $12\sqrt{2}$ (b) $\frac{12}{\pi}$
(c) $\frac{24}{\pi}$ (d) $\frac{12}{\sqrt{2}}$

[ESE-2010]

26. A rectifier (without filter) with fundamental ripple frequency equal to twice the mains frequency, has ripple factor of 0.482 and power conversion efficiency equal to 81.2%. The rectifier is
1. Bridge rectifier
2. Full-wave (non-bridge) rectifier
3. Half-wave rectifier
Which of these are correct?
(a) 2 and 3 only (b) 2 only
(c) 1 and 2 only (d) 1, 2 and 3

[ESE-2010]

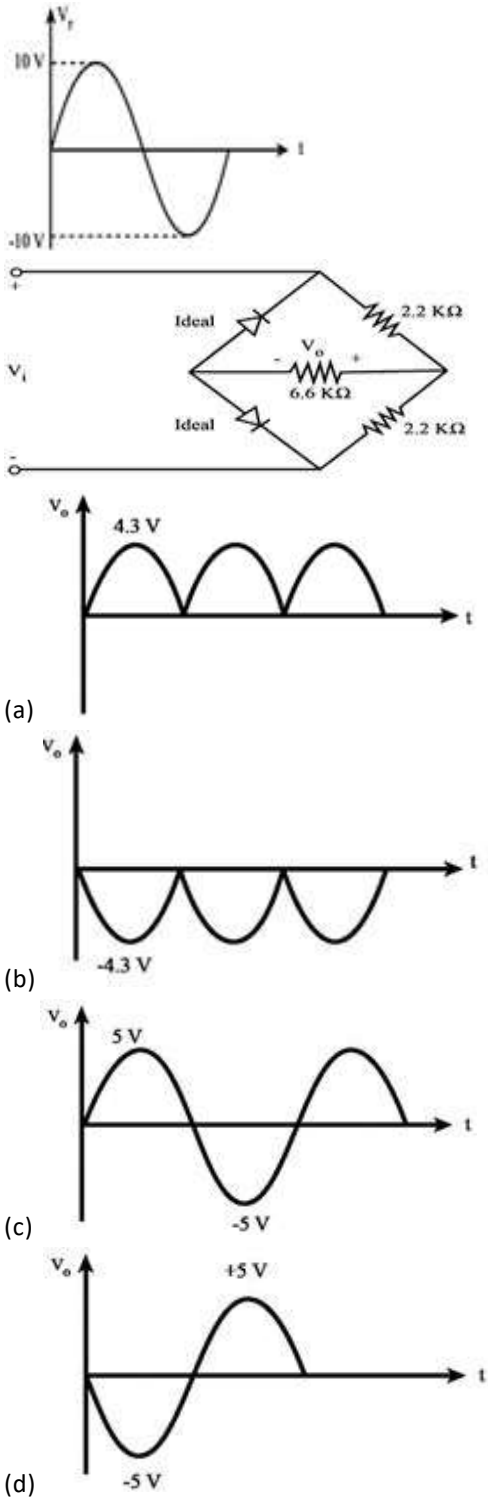
27. Consider the below circuit, for $V_i = V_m \sin \omega t$, the output voltage V_o for $R_L \to \infty$ will be



(a) Zero (b) V_m
(c) $2V_m$ (d) $-V_m$

[ESE-2010]

28. The correct waveform for output (V_0) for below network is



[ESE-2011]

29. A half-wave rectifier has an input voltage of 240 V rms. If the step-down transformer has turns ratio of $8:1$, what is the peak load voltage? Ignore diode drop.

(a) 27.5 V (b) 86.5 V
(c) 30.0 V (d) 42.5 V

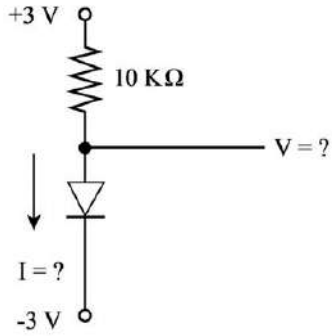
[ESE-2011]

30. A 700 mW maximum power dissipation diode at $25^{\circ}C$ has $5\ mW/^{\circ}C$ de-rating factor. If the forward voltage drop remains constant at 0.7 V, the maximum forward current at $65^{\circ}C$ is

(a) 700 mA (b) 714 mA
(c) 1 A (d) 1 mA

[ESE-2011]

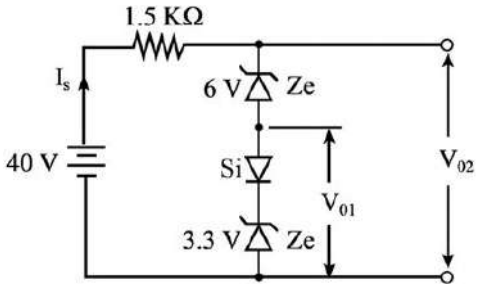
31. For the circuit shown below, using ideal diode, the values of voltage and current are



(a) -3 V and 0.6 mA (b) 3 V and 0.0 mA
(c) 3 V and 0.6 mA (d) -3 V and 0.0 mA

[ESE-2012]

32. A 40 V dc supply is connected across the network comprising of Zener and Silicon diodes as shown. The regulated voltages V_{01}, V_{02} and source current I_s are



(a) 2.4 V, 5.1 V and 21.7 mA
(b) 3 V, 6 V and 22.7 mA
(c) 3.3 V, 9.3 V and 20.5 mA
(d) 4 V, 10 V and 20 mA

[ESE-2012]

33. For a full wave rectifier, with sinusoidal input and inductor as filter, ripple factor for maximum load current and minimum load current conditions are respectively

(a) 0.1 and 1 (b) 0.1 and 0.47
(c) 0 and 0.47 (d) 0 and 0.22

[ESE-2013]

34. The ripple factor in case of a full-wave rectifier is

(a) 1.21 (b) 0.50
(c) 0.48 (d) 1.0

[ESE-2013]

35. The maximum efficiency of half-wave rectifier is
(a) 33.33% (b) 40.60%
(c) 50.00% (d) 68.00%

[ESE-2013]

36. Statement (I): Centre tap transformer is essential for a centre-tapped rectifier.
Statement (II): In half wave rectification minimum two diodes are required.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2014]

37. The maximum depletion layer width in Silicon is
(a) 0.143 μm (b) 0.57μm
(c) 1 μm (d) 1.143 μm

[ESE-2014]

38. A full wave rectifier with a centre tapped transformer supplies dc current of 100 mA to a load resistance of $20\,\Omega$. The secondary resistance of transformer is $1\,\Omega$. Each diode has a forward resistance of $0.5\,\Omega$. What are rms value of signal voltage across each half of the secondary as well as dc power supplied to the load?
(a) 2.39 V and 0.2 Watt (b) 23.9 V and 2 Watt
(c) 0.239 V and 20 Watt (d) 2.39 V and 2 Watt

[ESE-2014]

39. A bridge rectifier uses a 9 V ac input voltage. The diodes are ideal what is the dc output voltage?
(a) 12.726 V (b) -12.726 V
(c) 9 V (d) 8.1 V

[ESE-2014]

40. A half-wave rectifier is used to supply 50 V DC to a resistive load of $800\,\Omega$. The diode has resistance of $25\,\Omega$. What is the required ac voltage.
(a) 50π (b) 51.5π
(c) 25.7π (d) 25π

[ESE-2015]

41. A power supply uses bridge rectifier with capacitor input filter. If one of the diodes is defective, then
1. The dc load voltage will be lower than its expected value.
2. Ripple frequency will be lower than its expected value.
3. The surge current will increase manifold.

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2015]

42. In an L-section filter, a bleeder resistance is connected across the load to
(a) Provide good regulation for all values of load
(b) Ensure lower PIV of the diodes
(c) Ensure lower values of capacitance in the filter
(d) Reduce ripple content

[ESE-2015]

43. A full wave rectifier uses two diodes. The internal resistance of each diode is $20\,\Omega$. The transformer RMS secondary voltage from centre tap of each end of secondary is 50 V and the load resistance is $980\,\Omega$. Mean load current will be
(a) 45 A (b) 4.5 A
(c) 45 mA (d) 45 μA

[ESE-2015]

44. In a voltage regulator, zener diode is
1. Connected in series with filter output.
2. Forward biased.
3. Connected in parallel with filter output.
4. Reverse biased.

Which of the above are correct?
(a) 1 and 2 (b) 3 and 4
(c) 1 and 4 (d) 2 and 3

[ESE-2015]

45. Small recovery time of a diode is most significant for
(a) Line-frequency rectification
(b) Switching operations
(c) High-frequency rectification and switching operations
(d) Low-frequency rectification and switching operations

[ESE-2016]

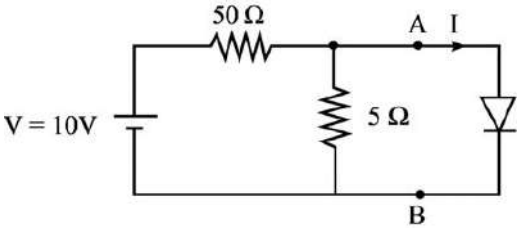
46. The capacitance of a full wave rectifier, with 60 Hz input signal, peak output voltage $V_p = 10$ V, load resistance $R = 10$ kΩ and input ripple voltage $V_r = 0.2$ V, is
(a) 22.7 μF (b) 33.3 μF
(c) 41.7 μF (d) 83.4 μF

[ESE-2016]

47. A full wave rectifier connected to the output terminals of the mains transformer produces an RMS voltage of 18 V across the secondary. The no-load voltage across the secondary of the transformer is
(a) 1.62 V (b) 16.2 V
(c) 61.2 V (d) 6.12 V

[ESE-2016]

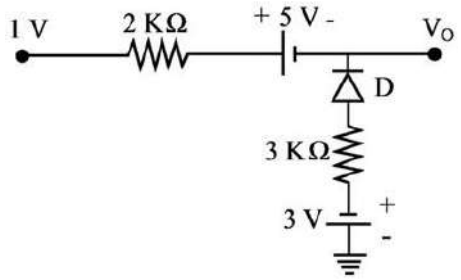
48. What is the value of current I through the ideal diode in the circuit?



(a) 100 mA (b) 150 mA
(c) 200 mA (d) 250 mA

[ESE-2016]

49. What is the output voltage V_0 for the circuit shown below assuming an ideal diode?



(a) $-\frac{18}{5}$ V (b) $\frac{18}{5}$ V
(c) $-\frac{13}{5}$ V (d) $\frac{13}{5}$ V

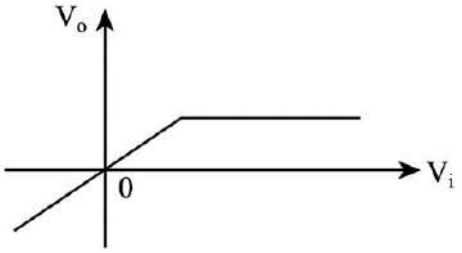
[ESE-2017]

50. A low resistance LDR of $20\ \Omega$, operated at a certain intensity of light, is to be protected through a series resistance in such a way that up to 12 mA of current is to flow at a supply voltage of 10 V. What is the nearest value of the protective resistance?

(a) 873 Ω (b) 813 Ω
(c) 273 Ω (d) 81 Ω

[ESE-2018]

51. The voltage transfer characteristic as shown in the figure will relate to a



1. voltage regulator
2. half-wave rectifier
3. full-wave rectifier

Which of the above is/are correct?

(a) 1 only (b) 2 only
(c) 1 and 2 (d) 1 and 3

[ESE-2019]

52. The input to a bridge rectifier is $230\ \text{V}\ (\text{r.m.s.}), 50\ \text{Hz}$. The DC output voltage and the ripple factor with R_L of $100\ \Omega$ and capacitor filter of $1000\ \mu\text{F}$ are

(a) 207 V and 0.028 (b) 325 V and 0.028
(c) 207 V and 0.020 (d) 325 V and 0.020

[ESE-2019]

53. The peak-to-peak ripple voltage for a half-wave rectifier and filter circuit operating at 60 Hz, which has a 680 μF reservoir capacitor, an average output of 28 V and 200 Ω load resistance, will be nearly

(a) 2.5 V (b) 3.4 V
(c) 4.3 V (d) 5.2 V

[ESE-2019]

54. The components of full-wave voltage doubler circuit are

(a) 2 diodes and 1 capacitor
(b) 4 diodes and 1 capacitor
(c) 2 diodes and 2 capacitors
(d) 4 diodes and 2 capacitors

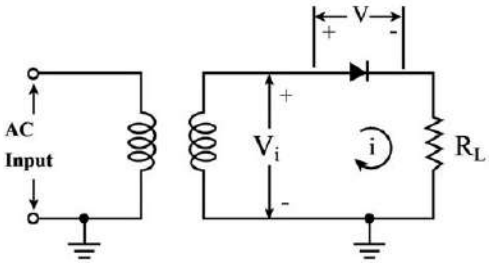
[ESE-2020]

55. A single-phase full wave rectifier uses semiconductor diodes. The transformer voltage is 35 V rms to center tap. The load consists of a $40\ \mu\text{F}$ capacitor in parallel with a $250\ \Omega$ resistor. The diode and transformer resistances and leakage reactance are neglected. If the power line frequency is 50 Hz, the dc current in the circuit will be

(a) 132 mA (b) 144 mA
(c) 156 mA (d) 168 mA

[ESE-2021]

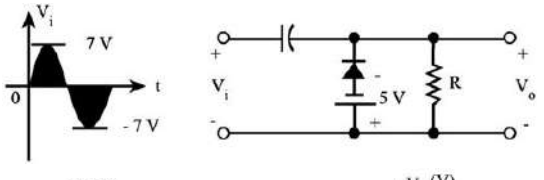
56. The circuit given below is a half wave rectifier. The internal resistance of a diode R_f is $20\ \Omega$ and load resistance R_L is $1\ \text{k}\Omega$. The input AC source with rms voltage is 110 V What is the DC voltage across the diode?

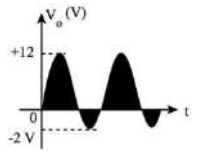


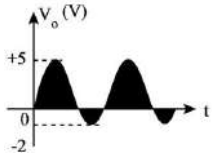
(a) -28.54 V (b) -38.54 V
(c) -48.54 V (d) -58.54 V

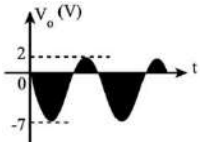
[ESE-2021]

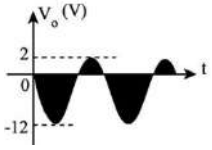
57. A sinusoidal input is given to the network shown below. The output waveform is



(a) 

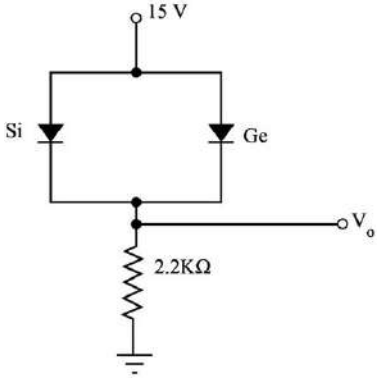
(b) 

(c) 

(d) 

[ESE-2024]

58. What is the output voltage V_0 for the network given below?



(a) 13.3 V (b) 14.7 V
(c) 15 V (d) 16 V

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(c)	(a)	(b)	(a)	(c)	(c)	(c)	(b)	(a)	(b)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(d)	(c)	(a)	(c)	(d)	(b)	(a)	(c)	(c)	(c)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(c)	(d)	(c)	(c)	(a)	(c)	(c)	(a)	(d)	(b)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(a)	(d)	(c)	(c)	(b)	(c)	(*)	(a)	(d)	(b)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(d)	(a)	(c)	(b)	(c)	(c)	(b)	(c)	(a)	(b)
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**		
(a)	(b)	(b)	(c)	(a)	(c)	(*)	(b)		

EXPLANATIONS

1. Explanation: (c)

The bleeder resistor in a filter circuit has the following functions:

1. Maintain minimum current necessary for optimum inductor filter operation

True

Bleeder resistance ensures a small, continuous current even when the load is disconnected, which helps maintain proper functioning of components like chokes that require a minimum current for filtering.

2. Work as a voltage divider to provide variable output from the supply

False

This is not the purpose of a bleeder resistor. Voltage dividers use two or more resistors arranged in series to divide voltage, which is a different application.

3. Provide discharge path to capacitors when the circuit is de-energised

True

The bleeder resistor safely discharges the filter capacitors after the power is turned off, which is essential for safety to avoid electric shock or damage.

Hence, correct statements are 1 and 3

2. Explanation: (a)

Ripple factor is

$$r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

For HWR

$$r = \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1} = 1.21$$

For FWR

$$r = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1} = 0.48$$

Series inductance or shunt capacitance both are used to reduce the ripple factor of FWR.

3. Explanation: (b)

Capacitor filter is used for high load resistance to minimize ripple.

$$r \propto \frac{1}{R_L C}$$

4. Explanation: (a)

For HWR

PIV $= V_m$

For Center-tapped FWR

PIV $= 2V_m$

For Bridge rectifier

PIV $= V_m$

5. Explanation: (c)

The peak to peak ripple voltage is

$$V_r = \frac{I_{DC}}{2fC}$$

6. Explanation: (c)

Average value of FWR is

$$V_{avg} = \frac{1}{T}\int_0^T v(t)dt = \frac{1}{\pi}\int_0^\pi V_m \sin\theta d\theta$$

$$V_{avg} = \frac{V_m}{\pi}(-\cos\theta)_0^\pi = \frac{2V_m}{\pi}$$

$$V_{avg} = 0.637\, V_m$$

7. Explanation: (c)

In the given circuit, for $V_i < 0$ V both the diodes D_1 and D_2 will be in reverse bias region.

Hence, $V_o = 0$ V for all values of $V_i < 0$ V.

8. Explanation: (b)

Under small signal operation, a diode is biased at a certain operating point, and very small AC signals are superimposed on this DC bias.

In this condition:

- The diode is not switching fully ON or OFF, but operates in a linearized region around the bias point.
- The diode can be modelled by a small-signal resistance, called the dynamic or junction resistance $r_d = \frac{\eta V_T}{I_D}$, where I_D is the DC bias current.

Under small-signal analysis, the diode's behaviour is dominated by its **junction resistance**, which is inversely proportional to the DC current.

9. Explanation: (a)

(i) A clamper clamps a signal to a different dc level.

(ii) The total swing of the output signal is equal to the total swing of input signal.

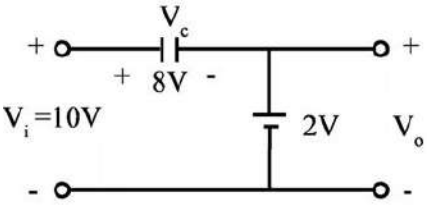
(iii) The shape of the signal does not change. Only dc level shifts.

10. Explanation: (b)

In case of HWR, frequency of a.c. ripple is same as input signal frequency.

11. Explanation: (d)

When $V_i = 10$ V, diode is forward biased

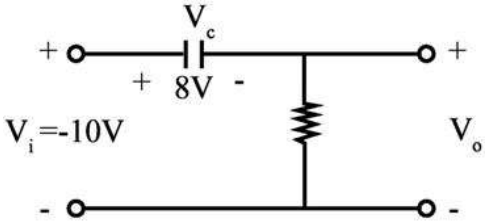


V_0 = 2 Volts

$$-10 + V_C + 2 = 0$$

$$V_c = +8\, V$$

When $V_i = -10$ V, diode is reverse biased



$$-V_i + V_C + V_0 = 0$$

$$10\text{ V} + 8\text{ V} + V_0 = 0$$

$$V_0 = -18\text{ V}$$

12. Explanation: (c)

Peak value of current is

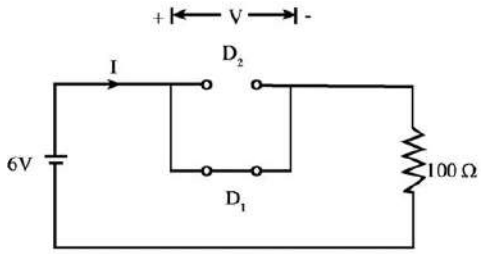
$$I_m = \frac{V_m}{R_f + R_L} = \frac{325}{100+1000} = 295.45\text{ mA}$$

$$I_{rms} = \frac{I_m}{2} \text{ for HWR} = \frac{295.45}{2} = 147.7\text{ mA}$$

13. Explanation: (a)

In the given circuit, only the ideal germanium diode (D_1) will be in ON state and D_2 will be in OFF state.

So, the equivalent circuit can be drawn as



From the equivalent circuit

$V = 0$ V

and $I = \frac{6}{100}\text{ A} = 60\text{ mA}$

14. Explanation: (c)

$$\%\text{ Regulation} = \frac{V_{\text{no load}} - V_{\text{full load}}}{V_{\text{full load}}} \times 100$$

$$5 = \frac{V_{\text{no load}} - 24}{24} \times 100$$

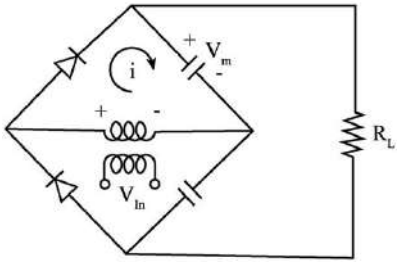
$$120 = 100\, V_{\text{no load}} - 2400$$

$$100\, V_{\text{no load}} = 2520$$

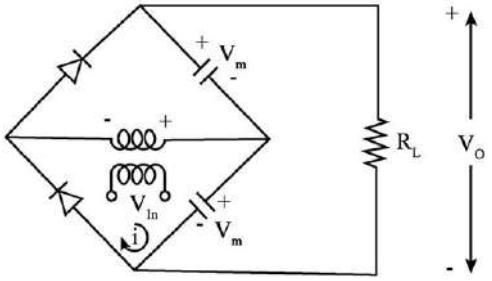
$$V_{\text{no load}} = 25.2\text{ V} = 25\text{ V}$$

15. Explanation: (d)
Components required to construct a 6 V DC from 230 V AC are given below
(i) Step down transformer for high AC to low AC.
(ii) Diode as rectifiers to convert AC to DC.
(iii) Resistors and capacitors to filter the output.
(iv) 3-pin voltage stabilizer to stabilize the signal.

16. Explanation: (b) The given circuit is a voltage doubler which is operated by alternately charging each of the two capacitors to the transformer peak voltage V_m, current being continually drained from the capacitors through the load.
Let $V_{\text{in}} = V_m \sin\omega t$
For first half cycle



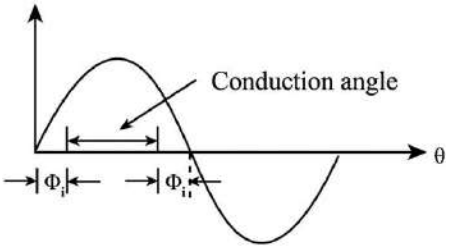
For next half cycle



$V_o = V_m + V_m = 2V_m$

17. Explanation: (a)
Peak clipper

18. Explanation: (c)



Conduction angle $= \pi - 2\phi_i$

19. Explanation: (c) If the resistor is not present, then the capacitor does not have discharge path and will not respond to sudden decrease in the magnitude of input pulse train.

20. Explanation: (c) The higher cut-in voltage of silicon diodes makes them **less ideal for low-voltage rectification,** where a lower voltage drop is preferred.

21. Explanation: (c) Lead-acid accumulator batteries

22. Explanation: (d) In a good power supply, the AC ripple should be as low as possible.

23. Explanation: (c)
- A rectifier with an inductor filter is more efficient for high load current.
- Inductor offers zero resistance for DC signal.

24. Explanation: (c)
1. Has larger transformer utilization factor
Incorrect
- A **bridge rectifier** actually has a **higher TUF** (~0.812) compared to a **centre - tapped full-wave rectifier** (~0.693), because the entire secondary winding is used in both half cycles.
- In the centre - tapped type, only **half of the secondary** conducts current in each half-cycle.

2. Can be used for floating output terminals
Incorrect
- This is **true for bridge rectifiers**, which do **not require a centre tap** and can have floating outputs.
- **Centre - tapped rectifiers** have a grounded centre tap, so the **output is not floating**.

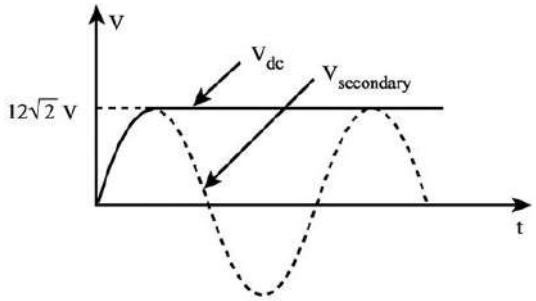
3. Needs two diodes instead of four
Correct
- **Centre - tapped rectifier** uses **2 diodes** (one for each half cycle).
- **Bridge rectifier** uses **4 diodes** (two conduct during each half cycle).

4. Needs diodes of a lower PIV (Peak Inverse Voltage) rating
Incorrect
- **Centre - tapped rectifier** requires diodes rated for **2**V_{max}.
- **Bridge rectifier** diodes need to withstand only V_{max}, so **bridge requires lower PIV - rated diodes**.

Hence, statement 3 is correct

25. Explanation: (a)
$V_m = 12\sqrt{2}$ V
Since there is no discharge path available, once the capacitor gets charged it remain at the same voltage i.e. output remain constant.

$V_0 = V_m = 12\sqrt{2}\ \text{V}$



26. Explanation: (c)

Ripple Frequency

- **Half - wave rectifier:** Ripple frequency is **same as mains frequency**
- **Full - wave rectifier (bridge or centre - tapped):** Ripple frequency = **2 × mains frequency**

So, **Half - wave rectifier is eliminated**.

Ripple Factor

- **Half - wave:** ~ 1.21
- **Full - wave (centre - tapped or bridge):** ~ 0.482

So the given **ripple factor matches that of a full-wave rectifier**.

Efficiency

- **Half-wave:** ~ 40.6%
- **Full-wave (bridge or centre - tapped):** ~ 81.2%

Again, the efficiency matches full-wave rectifier.

Valid Rectifiers:

1. **Bridge rectifier** → Full-wave
2. **Full-wave (non-bridge, center-tapped)** → Full-wave
3. **Half-wave** → (fails frequency, ripple factor, and efficiency tests)

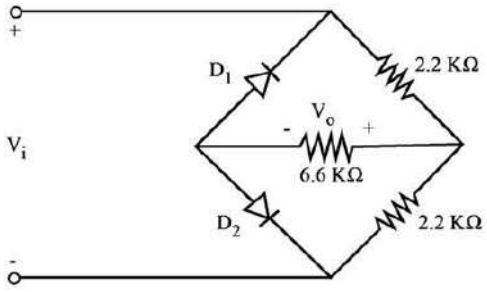
Final Answer: **(c) 1 and 2 only**

27. Explanation: (c)

Since, the given circuit is a voltage doubler. Hence,

$V_o = 2\,V_m$

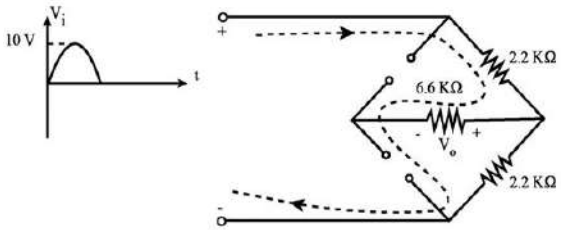
28. Explanation: (a)



For positive half cycle of input voltage

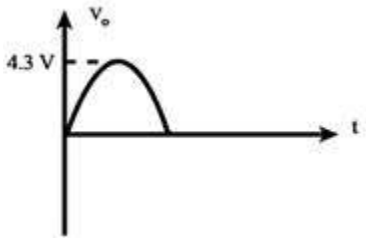
$D_1 \rightarrow \text{OFF}$

$D_2 \rightarrow \text{ON}$

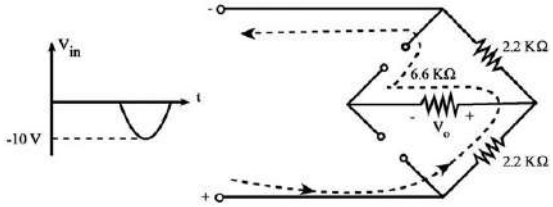


$$V_{o_{\max}} = \frac{[6.6\text{k}\Omega \| 2.2\text{k}\Omega]}{2.2\text{k}\Omega + [6.6\text{k}\Omega \| 2.2\text{k}\Omega]} V_{i_{\max}}$$

$$= \frac{0.75}{1+0.75} \times 10\ \text{V} = 4.3\ \text{V}$$

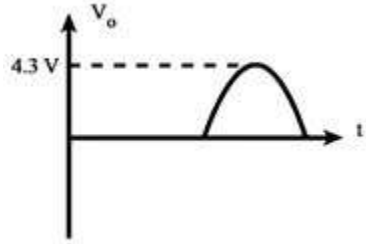


For negative half cycle of input voltage

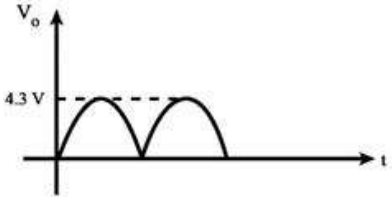


$$V_{o_{max}} = \frac{[6.6\ \text{k}\Omega \| 2.2\ \text{k}\Omega]}{2.2\ \text{k}\Omega + [6.6\ \text{k}\Omega \| 2.2\ \text{k}\Omega]} V_{i\max}$$

$$V_{o_{max}} = \frac{0.75}{1+0.75} \times 10\ \text{V} = 4.3\ \text{V}$$



Still the polarity of output voltage is in the same direction. So, net output of the circuit will be a full rectified wave.



29. Explanation: (d)

Output of stepdown transformer is

$$V_{\text{rms}} = \frac{240}{8} = 30\ \text{V}$$

So peak value of load voltage is

$$\frac{V_m}{\sqrt{2}} = V_{rms}$$

$$V_m = 30\sqrt{2} = 42.5\ \text{V}$$