Semiconductor Electronics JEE Main PYQ - 3

Total Time: 1 Hour **Total Marks:** 100

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Semiconductor Electronics

1. In an experiment, the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (= 0.5), then the least count of the instrument is **(+4, -1)**

a. (A) One degree

b. (B) Half degree

c. (C) One minute

d. (D) Half minute

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2. A wall has two layers A and B, each made of different materials. Both layers have the same thickness. The thermal conductivity of the material of A is twice that of B. Under thermal equilibrium, the temperature difference across the wall is 36 C. The temperature difference across the layer A is: **(+4, -1)**

a. (A) 21 C

b. (B) 35 C

c. (C) 12 C

d. (D) 57 C

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3. One mole of a diatomic ideal gas (= 1.4) is taken through a cyclic process starting from point . The process is an adiabatic compression, is an isobaric expansion is an adiabatic expansion and is an isochoric process. The volume ratios are / = 16 and / = 2 and the temperature at is = 300 . Calculate the temperature of the gas at the points and . **(+4, -1)**

a. (A) 609.43 K, 791 K

b. (B) 909.43 K, 991 K

c. (C) 909.43 K, 791 K

d. (D) 800.43 K, 791 K

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4. The angle of polarization of glass is 58° and that for water is 53° .The angle of polarization for glass in water is **(+4, -1)**

a. (A) 55.5°

b. (B) $\tan^{-1}\left[\frac{\tan(53^\circ)}{\tan(58^\circ)}\right]$

c. (C) $\tan^{-1}\left[\frac{\tan(58^\circ)}{\tan(53^\circ)}\right]$

d. (D) $^{-1}(55.5^\circ)$

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5. The energy band gap of semiconducting material to produce violet (wavelength $= 4000\mathring{A}$) LED is _____eV (Round off to the nearest integer) **(+4, -1)**

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6. Which of the following is metal compound semiconductor? **(+4, -1)**

a. Copper

b. Silver

c. Aluminium

d. Germanium

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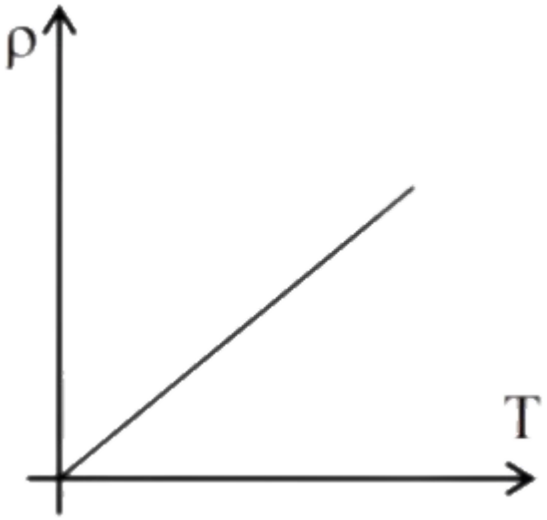
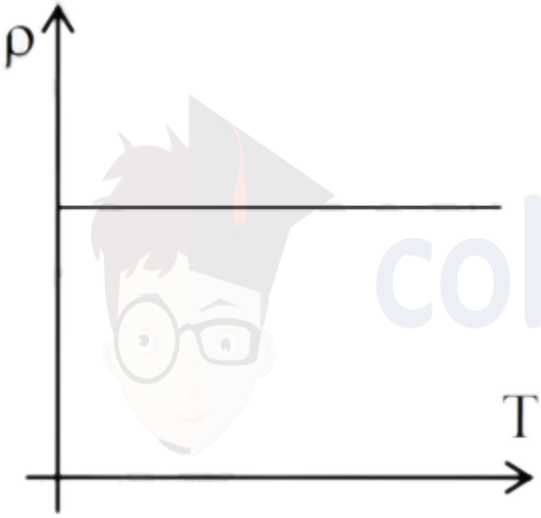
7. Choose correct graph of resistivity and temperature for semi-conductor material. **(+4, -1)**

a.



b.



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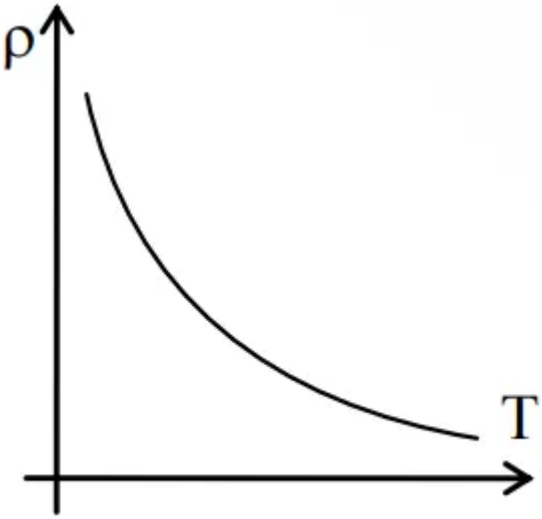

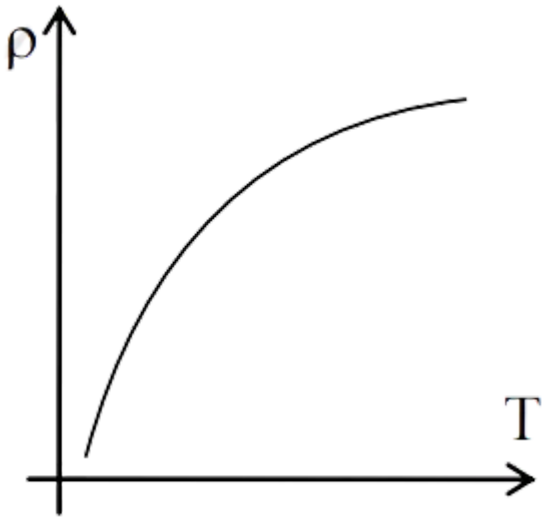

d.

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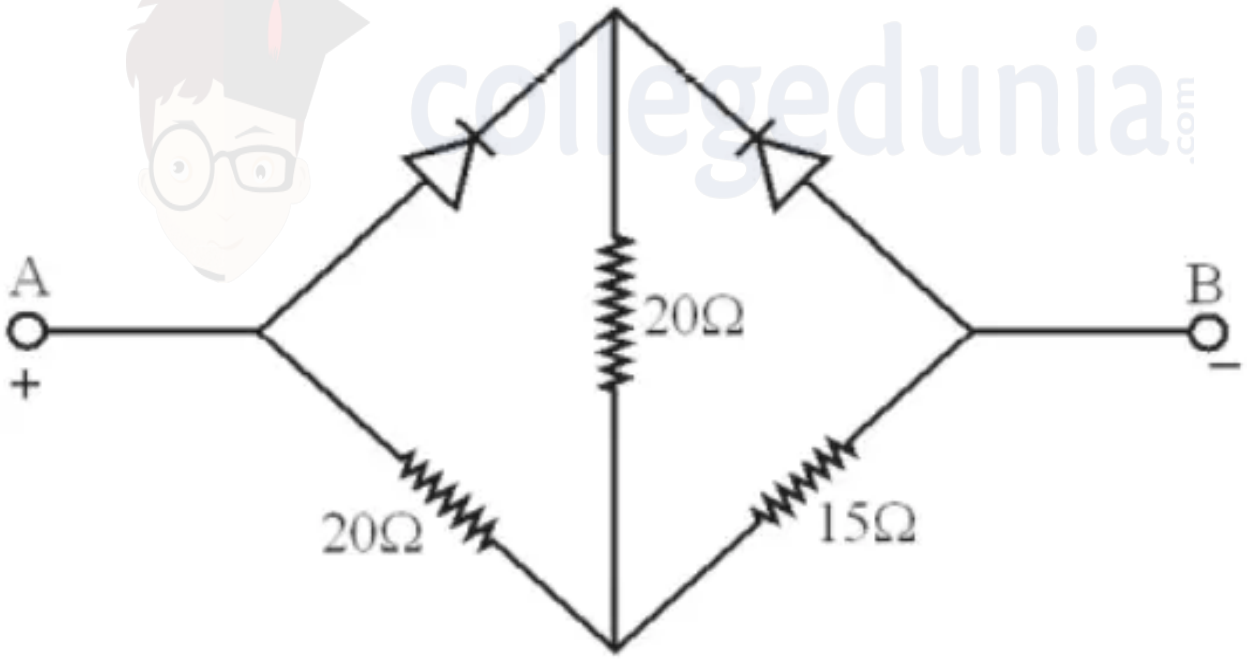
8. Two ideal diodes are connected in the network as shown in figure The equivalent resistance between A and B is _____Ω **(+4, -1)**



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9. Statement I: When a Si sample is doped with Boron, it becomes P type and when doped by Arsenic it becomes N-type semi conductor such that P-type has excess holes and N-type has excess electrons. **(+4, -1)**

Statement II: When such P-type and N-type semi-conductors, are fused to make a junction, a current will automatically flow which can be detected with an externally connected ammeter.

In the light of above statements, choose the most appropriate answer from the options given below

a. Statenent I is correct but statement II is incorrect

b. Both Statement I and Statement II are incorrect

c. Statenent I is incorrect but statement II is correct

d. Both Statenent I and statement II are correct

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10. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R **(+4, -1)**

Assertion A: Photodiodes are preferably operated in reverse bias condition for light intensity measurement

Reason R: The current in the forward bias is more than the current in the reverse bias for a $p-n$ junction diode

In the light of the above statements, choose the correct answer from the options given below:

a. A is true but R is false

b. Both A and R are true and R is the correct explanation of A

c. A is false but R is true

d. Both A and R are true but R is NOT the correct explanation of A

---

11. The effect of increase in temperature on the number of electrons in conduction band (n_e) and resistance of a semiconductor will be as: **(+4, -1)**

a. n_e decreases, resistance increases

b. Both n_e and resistance increase

c. n_e increases, resistance decreases

d. Both n_e and resistance decrease

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12. Choose the correct statement about Zener diode : **(+4, -1)**

a. It works as a voltage regulator in reverse bias and behaves like simple pn junction diode in forward bias.

b. It works as a voltage regulator in both forward and reverse bias.

c. It works as a voltage regulator only in forward bias.

d. It works as a voltage regulator in forward bias and behaves like simple pn junction diode in reverse bias.

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13. A particle moves in a straight line according to the relation $= {}^{3} - 4 {}^{2} + 3$. Find the acceleration of the particle at displacement equal to zero: **(+4, -1)**

a. (A) $10\ m/s^2$

b. (B) $12\ m/s^2$

c. (C) $15\ m/s^2$

d. (D) None of these

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14. When $^{235}_{92}$ undergoes fission, 0.2% of its original mass is changed into energy. How much energy is released if 1 of $^{235}_{92}$ undergoes fission? **(+4, -1)**

a. (A) 9×10^{13}

b. (B) 1.8×10^{14}

c. (C) 3.6×10^{14}

d. (D) 5.4×10^{14}

---

15. A circular hole of radius 1 m is cut off from a disc of radius 6 cm. The centre of the hole is 3 cm from the centre 0 of the disc. The centre of mass of the remaining disc is: **(+4, -1)**

a. (A) $\frac{3}{35}$ cm

b. (B) $\frac{1}{35}$ cm

c. (C) $\frac{3}{10}$ cm

d. (D) None of these

---

16. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$. Which of the following statements is true? **(+4, -1)**

a. (A) $(E_g)_C < (E_g)_{Si} < (E_g)_{Ge}$

b. (B) $(E_g)_C < (E_g)_{Si} > (E_g)_{Ge}$

c. (C) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

d. (D) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

---

17. What is the conductivity of a semiconductor sample having electron concentration of $5 \times 10^{18}\, m^{-3}$, hole concentration of $5 \times 10^{19}\, m^{-3}$, electron mobility of $2.0\, m^2\, V^{-1}\, s^{-1}$ and hole mobility of $0.01\, m^2\, V^{-1}\, s^{-1}$? (Take charge of electron as $1.6 \times 10^{-19} C$) **(+4, -1)**

a. $1.68(\Omega - m)^{-1}$

b. $1.83(\Omega - m)^{-1}$

c. $0.59(\Omega - m)^{-1}$

d. $1.20(\Omega - m)^{-1}$

---

18. In the given circuit, the current through zener diode is : **(+4, -1)**

a. $5.5\, mA$

b. $6.7\, mA$

c. $2.5\,mA$

d. $3.3\,mA$

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19. Identify the semiconductor devices whose characteristics are given below, in the order $(a), (b), (c), (d)$: **(+4, -1)**

a. Simple diode, Zener diode, Solar cell, Light dependent resistance

b. Zener diode, Simple diode, Light dependent resistance, Solar cell

c. Solar cell, Light dependent resistance, Zener diode, Simple diode

d. Zener diode, Solar cell, Simple diode, Light dependent resistance

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20. Ge and Si diodes start conducting at $0.3\,V$ and $0.7\,V$ respectively. In the following figure if Ge diode connection are reversed, the value of V_o changes by : (assume that the Ge diode has large breakdown voltage) **(+4, -1)**

a. $0.6\,V$

b. $0.8\,V$

c. $0.4\,V$

d. $0.2\,V$

---

21. For the circuit shown below, the current through the Zener diode is : **(+4, -1)**

a. $5\,mA$

b. Zero

c. $14\,mA$

d. $9\,mA$

---

22. Figure shows a circuit in which three identical diodes are used. Each diode has forward resistance of $20\,\Omega$ and infinite backward resistance. Resistors **(+4, -1)**

$R_1 = R_2 = R_3 = 50\,\Omega$. Battery voltage is $6\,V$. The current through R_3 is:

a. $50\,mA$

b. $100\,mA$

c. $60\,mA$

d. $25\,mA$

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23. Figure shown a DC voltage regulator circuit, with a Zener diode of breakdown voltage = $6V$. If the unregulated input voltage varies between $10\,V$ to $16\,V$, then what is the maximum Zener current ? **(+4, -1)**

a. 2.5 mA

b. 3.5 mA

c. 7.5 mA

d. 1.5 mA

---

24. A Zener diode is connected to a battery and a load as shown below : The currents I, I_z and I_L are respectively **(+4, -1)**

a. $15\,mA, 5\,mA, 10\,mA$

b. $15\,mA, 7.5\,mA, 7.5\,mA$

c. $12.5\,mA, 5\,mA, 7.5\,mA$

d. $12.5\,mA, 7.5\,mA, 5\,mA$

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25. A common emitter amplifier circuit, built using an npn transistor, is shown in the figure. Its dc current gain is 250, $R_C = 1k\Omega$ and $V_{CC} = 10V$. What is the minimum base current for V_{CE} to reach saturation ? **(+4, -1)**

a. $100\,\mu A$

b. $7\,\mu A$

c. $40\,\mu A$

d. $10\,\mu A$

Answers

1. Answer: c

Explanation:

Explanation:
30 divisions of the vernier scale coincide with 29 divisions of the main scale.Therefore, $1V.S.D = (\frac{29}{30})$ M.S.DLeast Count $= 1MSD - 1VSD = 1MSD - (\frac{29}{30})MSD = (\frac{1}{30})MSD = (\frac{1}{30})(0.5\ ) = (\frac{1}{30}) \times 30$ min $= 1$ minHence, the correct option is (C).

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2. Answer: c

Explanation:

Explanation:
Consider two walls 'A' and 'B' of thickness 't' each, and thermal conductivity of ' 2 K ' and 'K' respectively.The temperatures at the left of A = T_a.The temperatures at the right of B = T_b.The temperature at the junction = T. Heat flow is a constant in steady state:$Q = KA\frac{dT}{dx}$ = constantEquating heat flow for both walls we get:$2KA\frac{T - T_a}{t - 0} = KA\frac{T_b - T}{2t - t}$ Which simplifies to: $3T = T_b + 2T_a$ .....(i)Also given that the temperature difference between the walls is 36 C.$T_b - T_a = 36$ C .....(ii)Combining the two equation in T, T_a, T_b and eliminating T_b.We get, – = 12 C.Hence, the correct option is (C).

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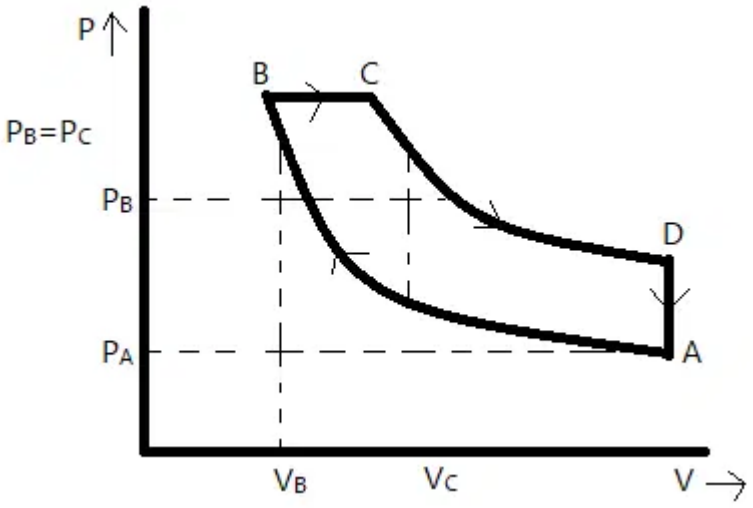
3. Answer: c

Explanation:

Explanation:
: Adiabatic Compression : Isobatic Expansion : Adiabatic Expansion : Isochoric process = $(—)^{-1} = 300(16)^{0.4} = 909$ = $(—)^{-1}$ = $(\frac{2}{—})^{-1}$ = $(\frac{2}{—})^{-1}$ $(2 \times \frac{1}{16})^{0.4}$ = $(\frac{1}{8})^{0.4}$ where = $(—) \times$ = $2 \times 909 = 1818$ K = $1818(\frac{1}{8})^{0.4}$ = 795



Hence, the correct option is (C).

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4. Answer: c

Explanation:

Explanation:
Given:The angle of polarization for glass, ig = 58°The angle of polarization for water, iw = 53°According to Brewster's law, the angle of polarization is related to the refractive index of the transparent medium:tan( ) = ...(i)and when the medium is water:tan( ) = ...(ii)Now, when the glass is in water, the relative refractive index of the system is— = $\frac{\tan(\ \ )}{\tan(\ \ )}$ — = = $\frac{\tan(58\ )}{\tan(53\ )}$Let the angle of polarization be ip when a glass is in water. Then we gettan( ) = = $\frac{\tan(58\ )}{\tan(53\ )}$or, = $\tan^{-1}$ [$\frac{\tan(58\ )}{\tan(53\ )}$]Hence, the correct option is (C).

---

5. Answer: 3 - 3

Explanation:

The correct answer is 3.

Concepts:

1. Semiconductors:

Semiconductors are a crystalline solid materials, whose electrical conductivity lies between a conductor and an insulator. Semiconductors are mainly used in the manufacturing of electronic devices like capacitors, transistors, diodes, Integrated circuits, etc.

Properties of Semiconductor:

1. Semiconductor acts like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
2. Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches, and amplifiers.
3. Lesser power losses.

Uses of Semiconductor:

1. Semiconductors are widely used in manufacturing electronics devices like transistors, diodes, sensors, integrated circuits.
2. Semiconductors are widely used in all electronic devices, like mobile phones, digital cameras, communication devices, trains, ATMs, etc.

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6. **Answer: d**

Explanation:

Germanium (Ge) is a metalloid that can behave as a semiconductor when used in electronic devices. It has properties that allow it to conduct electricity under certain conditions, making it suitable for use in semiconductor applications. Copper (A), silver (B), and aluminium (C) are not typically used as semiconductors.

So, the correct answer is option (D): Germanium.

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7. **Answer: c**

Explanation:

$\rho = \frac{m}{ne^2\tau}$
As the T increases the τ decreases but n increases, but the n is dominant over τ. so the ρ decreases as the temperature increases.

So, the correct graph is option (C)

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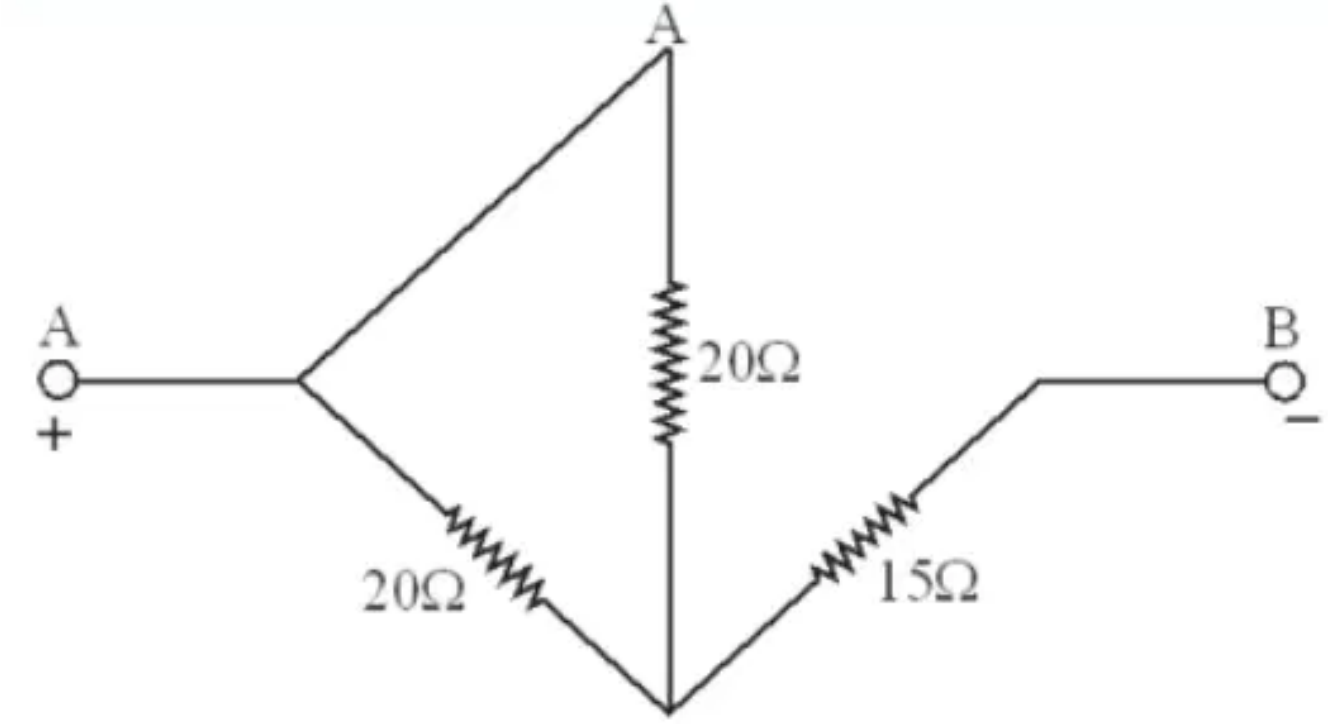
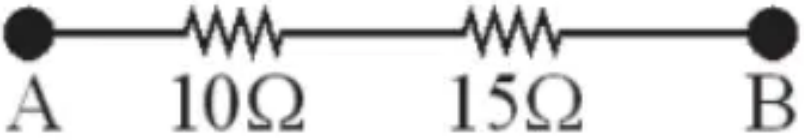
8. **Answer: 25 - 25**

Explanation:

The correct answer is 25



The forward biased diode will conduct while the reverse biased will not



$\therefore$ Equivalent resistance $= 10 + 15 = 25\Omega$

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9. **Answer: a**

Explanation:

The correct option is(A): Statenent I is correct but statement II is incorrect.
When P-N junction is formed an electric field is generated form N-side to P-side due

to which barrier potential arises & majority charge carrier can not flow through the junction due to barrier potential so current is zero unless we apply forward bias voltage.

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10. Answer: b

Explanation:

Photodiodes are operated in reverse bias because the fractional change in current due to light is easier to detect in reverse bias. While it is true that the forward bias current is greater than the reverse bias current, this is not the reason photodiodes

are used in reverse bias.
Thus, A is true, and R is also true, but R is not the correct explanation for A.

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11. Answer: c

Explanation:

As temperature increases, more electrons gain enough thermal energy to excite to the conduction band, thereby increasing the number of free charge carriers available for conduction. This leads to an increase in the material's conductivity, as more electrons can move freely through the material. Consequently, the resistance of the material decreases.

This phenomenon is observed in semiconductors, where the conductivity significantly improves with temperature. In conductors, however, the increase in temperature typically causes the atoms to vibrate more, which leads to an increase in scattering of the free electrons, thereby increasing the resistance.

The relationship between conductivity and temperature is especially important in devices like thermistors, where the resistance changes significantly with temperature. Positive temperature coefficient (PTC) thermistors show an increase in resistance with temperature, while negative temperature coefficient (NTC) thermistors exhibit the opposite behavior, which makes them useful for temperature sensing and circuit protection applications.

In summary, for most semiconductors, as temperature rises, the number of charge carriers increases, which lowers the resistance, making these materials more conductive. However, in metals and conductors, increased temperature leads to higher resistance due to increased atomic vibrations.

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12. **Answer: a**

Explanation:

A Zener diode is designed to operate in the reverse breakdown region. In this region, the voltage across the diode remains relatively constant even with variations in current. This characteristic allows it to be used as a voltage regulator in reverse bias. In forward bias, a Zener diode behaves like a regular pn junction diode.

Conclusion: The correct statement about a Zener diode is that it works as a voltage regulator in reverse bias and as a simple pn junction diode in forward bias (**Option 1**).

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13. Answer: a

Explanation:

Explanation:
Given that,A particle moves in a straight line according to the relation : $= {}^{3} - 4{}^{2} + 3$ The acceleration of the particle at displacement equal to zero.When displacement is equal to 0 , $^{3} - 4{}^{2} + 3 = 0{}^{2} - 4 + 3 = 0 = 1$ and $= 3$ Acceleration is given by : $= \frac{2}{2} = \frac{(^{3} - 4{}^{2} + 3)}{} = 3{}^{2} - 8 + 3 = — = \frac{(3{}^{2} - 8 + 3)}{} = 6 - 8$At $= 1$ $= 6(1) - 8 = -2\ m/s^{2}$ At $= 3$ $= 6(3) - 8 = 10\ m/s^{2}$ Hence, the correct option is (A).

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14. Answer: b

Explanation:

Explanation:
Given that:Mass of Uranium changed into energy $= 0.2\%$ of 1 $= 0.002$ The energy released if 1 of $^{235}_{92}$ undergoes fission is: $= \Delta{}^{2} = 0.002 \times (3 \times 10^{8})^{2}$ $= 0.018 \times 10^{16} = 1.8 \times 10^{14}$ Hence, the correct option is (D).

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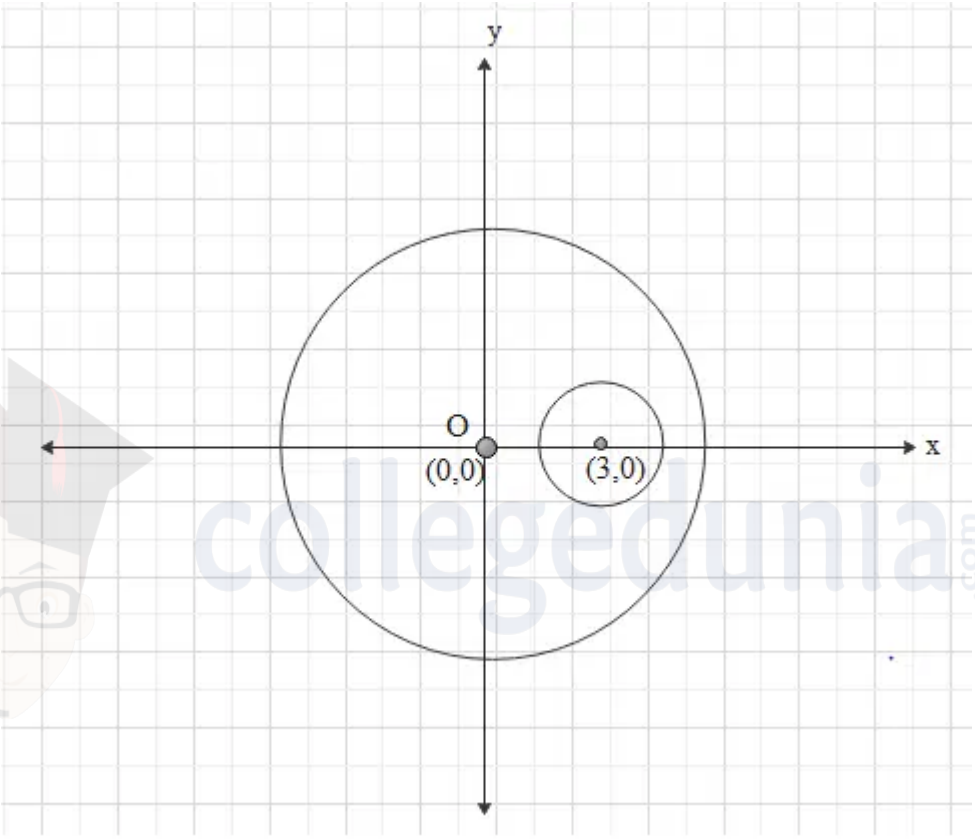
15. Answer: a

Explanation:

Explanation:
The disc has a radius, $= 6$ It is given that a circular hole is cut off from this disc.The radius of the circular hole, $= 1$ The centre of the hole is at a distance 3 m from the centre of mass O of the disc.We need to calculate the centre of mass of the remaining disc.Assume that the thickness is .Then the volume is area multiplied by thickness. $=$ Area of base is, $= {}^{2} = {}^{2}$ Let the density be , then we have $= - = = {}^{2}$ On substituting the value of radius, we get $= 36$ ... (1)Similarly, the mass of the removed part, can be written as $= {}^{2}$ On

substituting the value of the radius of cut out the part, we get = ...(2)On dividing equation (1) and (2) we get = $\frac{}{36}$Now let us use the negative mass concept. That is, we can consider that the disc is whole and a part of $-\frac{}{36}$ mass is placed at a distance 3 away from its centre. So, we get the same total mass as we would get if there is a hole of the same portion.The centre of mass of the inner disc will be at its centre. That is 3 away from the centre of the larger disc.Let us take the coordinate of the centre of mass of the larger disc as (0,0). That is the origin.



The centre of mass of inner disc will be at (3,0).Now we can calculate the centre of mass of the system as a whole.The centre of mass of two body is given as = $\frac{1\ 1\ +\ 2\ 2}{1\ +\ 2}$ = $\frac{1\ 1\ +\ 2\ 2}{1\ +\ 2}$Now let us substitute the values, = $\frac{\times 0\ -\ \frac{}{36}\times 3}{-\frac{}{36}}$Since the coordinate of the larger disc is zero and the coordinate of the smaller disc is 3. = $\frac{\frac{-3}{36}}{\frac{35}{36}}$ = $\frac{-3}{35}$If we substitute the values in = $\frac{1\ 1\ +\ 2\ 2}{1\ +\ 2}$We get, = $\frac{\times 0\ -\ \frac{}{36}\times 0}{-\frac{}{36}}$ = 0Since the y coordinate of the centre of mass of the outer and inner disc is zero.So, we get the centre of mass at ($-\frac{3}{35}$, 0).That is the new centre of mass will be at a distance $\frac{3}{35}$ to the left of the centre o of the given disc.Hence, the correct option is (A).

---

16. Answer: c

Explanation:

Explanation:
Carbon, silicon and germanium are semiconductors.( ) = 5.2 ( ) = 1.21 ( ) = 0.75 Above these three given elements, the energy band gap of carbon is the maximum and that of germanium is the least.The energy band gap of these elements are related as: ( ) > ( ) > ( ) .Hence, the correct option is (C).

---

17. **Answer: a**

Explanation:

$$s = e\left(n_e\mu_e + n_n\mu_n\right)$$
$$= 1.6?10^{-19}\left(5?10^{18}?2 + 5?10^{19}?0.01\right)$$
$$= 1.6?10^{-19}\left(10^{19} + 0.05?10^{19}\right)$$
$$= 1.6?1.05$$
$$= 1.68$$

Concepts:

1. Semiconductors:

Semiconductors are a crystalline solid materials, whose electrical conductivity lies between a conductor and an insulator. Semiconductors are mainly used in the manufacturing of electronic devices like capacitors, transistors, diodes, Integrated circuits, etc.

Properties of Semiconductor:

1. Semiconductor acts like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
2. Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches, and amplifiers.
3. Lesser power losses.

Uses of Semiconductor:

1. Semiconductors are widely used in manufacturing electronics devices like transistors, diodes, sensors, integrated circuits.
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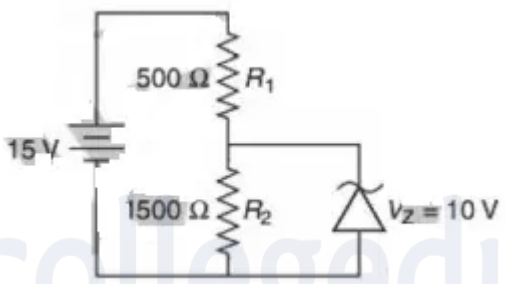
18. Answer: d

Explanation:

Voltage across R_1 is given by
$V_{R_1} = V - V_z = 15 - 10 = 5V$. Resistance $R_1 = 500\,\Omega$



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19. **Answer: a**

Explanation:

Answer (a) Simple diode, Zener diode, Solar cell, Light dependent resistance

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20. **Answer: c**

Explanation:

Initially Ge & Si are both forward biased so current will effectivily pass through Ge diode with a drop of $0.3\,V$
if $"Ge"$ is revesed then current will flow through $"Si"$ diode hence an effective drop of $(0.7-0.3)=0.4\,V$ is observed.

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---

21. **Answer: d**

Explanation:

Assuming zener diode doesnot undergo breakdown, current in circuit = $\frac{120}{15000} = 8mA$
$\therefore$ Voltage drop across diode = $80V > 50V$.
The diode undergo breakdown.
Current is $R_1 = \frac{70}{5000} = 14\,mA$
Current is $R_2 = \frac{50}{10000} = 5\,mA$
$\therefore$ Current through diode = $9\,mA$

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---

22. Answer: a

Explanation:

Here, diodes D_1 and D_2 are forward biased and D_3 is reverse biased.
Therefore current through R_3
$i = \frac{V}{R'} = \frac{6}{120} = \frac{1}{20}A = 50\,mA$

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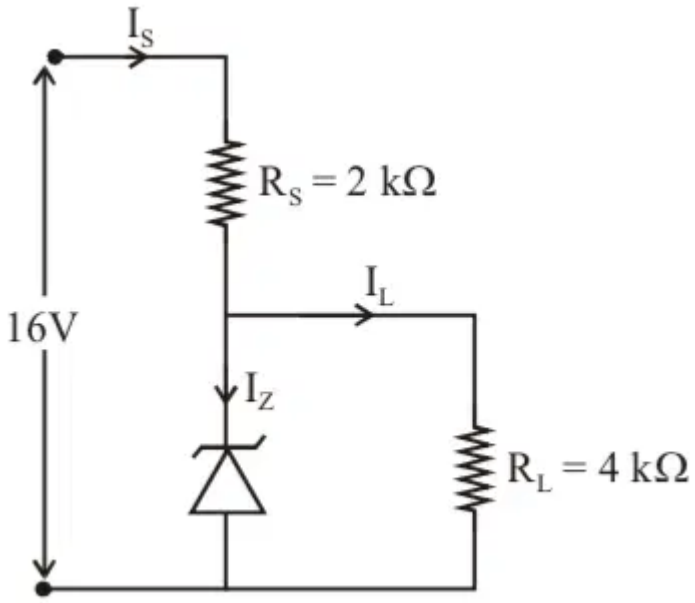
23. Answer: b

Explanation:

Maximum current will flow from zener if input voltage is maximum.



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24. Answer: d

Explanation:

$I_L = \frac{10V}{2k\Omega} = 5mA$
$I = \frac{(60-10)v}{4k\Omega} = \frac{50}{4k\Omega} = 12.5\,mA$
$I_Z = I - I_L = (12.5 - 5)\ mA = 7.5\,mA$

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25. Answer: c

Explanation:

At saturation state, V_{CE} becomes zero

$\Rightarrow i_C = \frac{10V}{1000\Omega} = 10mA$

now current gain factor $\beta = \frac{i_C}{i_B}$

$\Rightarrow i_B = \frac{10mA}{250} = 40\mu A$

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