CHAPTER 28

Semiconductor Electronics : Materials, Devices and Simple Circuits

1. At absolute zero, Si acts as **[2002]**
(a) non-metal (b) metal
(c) insulator (d) none of these

2. By increasing the temperature, the specific resistance of a conductor and a semiconductor **[2002]**
(a) increases for both
(b) decreases for both
(c) increases, decreases
(d) decreases, increases

3. The energy band gap is maximum in **[2002]**
(a) metals (b) superconductors
(c) insulators (d) semiconductors.

4. The part of a transistor which is most heavily doped to produce large number of majority carriers is **[2002]**
(a) emitter
(b) base
(c) collector
(d) can be any of the above three.

5. A strip of copper and another of germanium are cooled from room temperature to 80K. The resistance of **[2003]**
(a) each of these decreases
(b) copper strip increases and that of germanium decreases
(c) copper strip decreases and that of germanium increases
(d) each of these increases

6. The difference in the variation of resistance with temeperature in a metal and a semiconductor arises essentially due to the difference in the **[2003]**
(a) crystal sturcture
(b) variation of the number of charge carriers with temperature
(c) type of bonding
(d) variation of scattering mechanism with temperature

7. In the middle of the depletion layer of a reverse-biased *p-n* junction, the **[2003]**
(a) electric field is zero
(b) potential is maximum
(c) electric field is maximum
(d) potential is zero

8. When npn transistor is used as an amplifier **[2004]**
(a) electrons move from collector to base
(b) holes move from emitter to base
(c) electrons move from base to collector
(d) holes move from base to emitter

9. For a transistor amplifier in common emitter configuration for load impedance of 1kΩ $(h_{fe} = 50$ and $h_{oe} = 25)$ the current gain is **[2004]**
(a) -24.8 (b) -15.7
(c) -5.2 (d) -48.78

10. A piece of copper and another of germanium are cooled from room temperature to 77K, the resistance of **[2004]**
(a) copper increases and germanium decreases
(b) each of them decreases
(c) each of them increases
(d) copper decreases and germanium increases

11. When p-n junction diode is forward biased then **[2004]**

(a) both the depletion region and barrier height are reduced
(b) the depletion region is widened and barrier height is reduced
(c) the depletion region is reduced and barrier height is increased
(d) Both the depletion region and barrier height are increased

12. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is **[2005]**

(a) 2.5 eV (b) 1.1 eV
(c) 0.7 eV (d) 0.5 eV

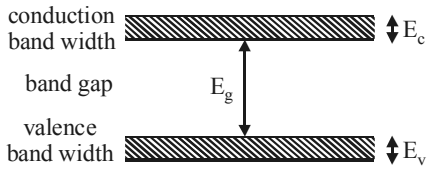
13. In a common base amplifier, the phase difference between the input signal voltage and output voltage is **[2005]**

(a) π (b) $\frac{\pi}{4}$
(c) $\frac{\pi}{2}$ (d) 0

14. In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be **[2005]**

(a) 25 Hz (b) 50 Hz
(c) 70.7 Hz (d) 100 Hz

15. If the lattice constant of this semiconductor is decreased, then which of the following is correct? **[2006]**



(a) All E_c, E_g, E_v increase
(b) E_c and E_v increase, but E_g decreases
(c) E_c and E_v decrease, but E_g increases
(d) All E_c, E_g, E_v decrease

16. In a common base mode of a transistor, the collector current is 5.488 mA for an emitter current of 5.60 mA. The value of the base current amplification factor (β) will be **[2006]**

(a) 49 (b) 50
(c) 51 (d) 48

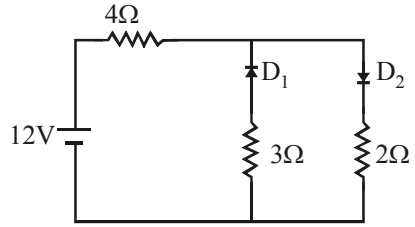
17. A solid which is not transparent to visible light and whose conductivity increases with temperature is formed by **[2006]**

(a) Ionic bonding
(b) Covalent bonding
(c) Vander Waals bonding
(d) Metallic bonding

18. If the ratio of the concentration of electrons to that of holes in a semiconductor is $\frac{7}{5}$ and the ratio of currents is $\frac{7}{4}$, then what is the ratio of their drift velocities? **[2006]**

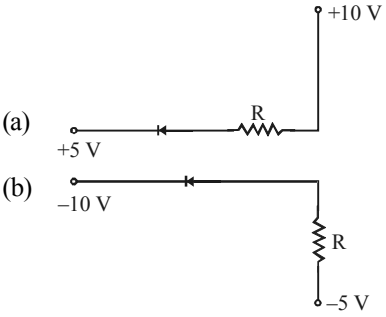
(a) $\frac{5}{8}$ (b) $\frac{4}{5}$
(c) $\frac{5}{4}$ (d) $\frac{4}{7}$

19. The circuit has two oppositively connected ideal diodes in parallel. What is the current flowing in the circuit? **[2006]**

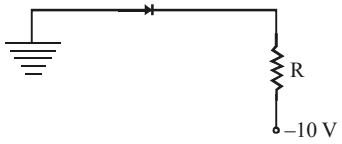


(a) 1.71 A (b) 2.00 A
(c) 2.31 A (d) 1.33 A

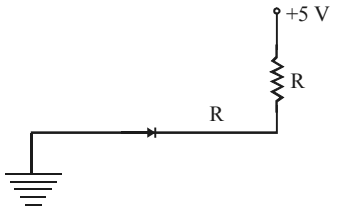
20. In the following, which one of the diodes reverse biased? **[2006]**



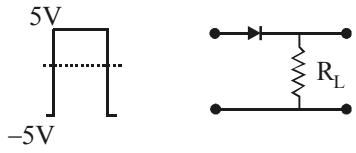
(c)



(d)

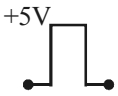


21. If in a *p-n* junction diode, a square input signal of 10 V is applied as shown **[2007]**

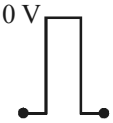


Then the output signal across R_L will be

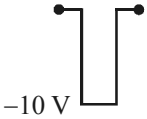
(a)



(b)



(c)



(d)

22. Carbon, silicon and germanium have four valence electrons each. At room temperature which one of the following statements is most appropriate ? **[2007]**

(a) The number of free electrons for conduction is significant only in Si and Ge but small in C.

(b) The number of free conduction electrons is significant in C but small in Si and Ge.

(c) The number of free conduction electrons is negligibly small in all the three.

(d) The number of free electrons for conduction is significant in all the three.

23. A working transistor with its three legs marked *P*, *Q* and *R* is tested using a multimeter. No conduction is found between *P* and *Q*. By connecting the common (negative) terminal of the multimeter to *R* and the other (positive) terminal to *P* or *Q*, some resistance is seen on the multimeter. Which of the following is true for the transistor? **[2008]**

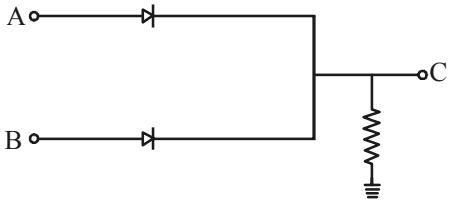
(a) It is an npn transistor with *R* as base

(b) It is a pnp transistor with *R* as base

(c) It is a pnp transistor with *R* as emitter

(d) It is an npn transistor with *R* as collector

24. In the circuit below, *A* and *B* represent two inputs and *C* represents the output. **[2008]**

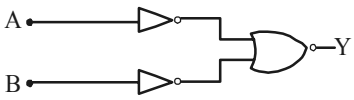


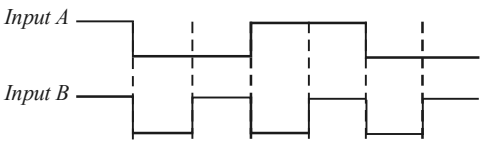
The circuit represents

(a) NOR gate (b) AND gate

(c) NAND gate (d) OR gate

25. The logic circuit shown below has the input waveforms '*A*' and '*B*' as shown. Pick out the correct output waveform. **[2009]**

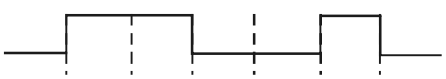




Output is

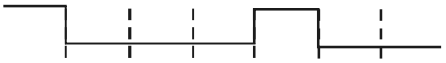
(a)

(b)

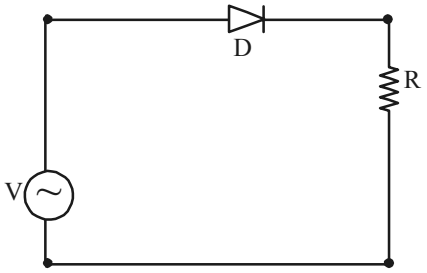


(c)

(d)

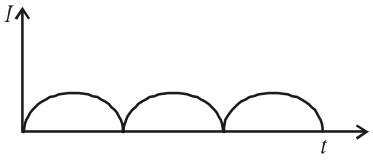


26. A *p-n* junction (*D*) shown in the figure can act as a rectifier. An alternating current source (*V*) is connected in the circuit. **[2009]**

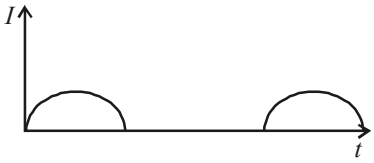


The current (*I*) in the resistor (*R*) can be shown by :

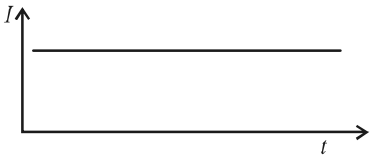
(a)



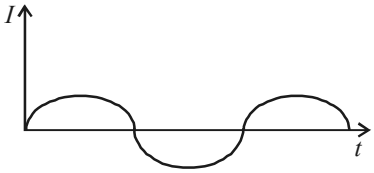
(b)



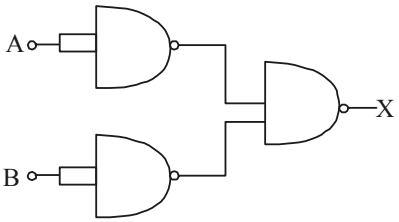
(c)



(d)



27. The combination of gates shown below yields **[2010]**



(a) OR gate (b) NOT gate

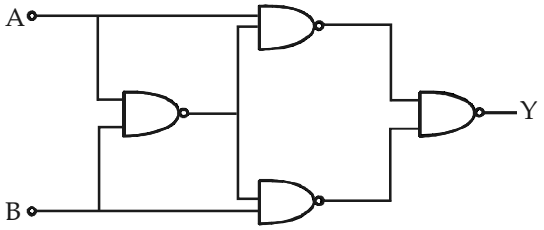
(c) XOR gate (d) NAND gate

28. The output of an OR gate is connected to both the inputs of a NAND gate. The combination will serve as a: **[2011 RS]**

(a) NOT gate (b) NOR gate

(c) AND gate (d) OR gate

29. Truth table for system of four NAND gates as shown in figure is : **[2012]**



(a)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

(b)

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

(c)

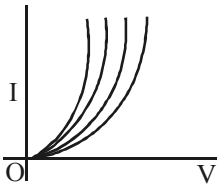
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	0

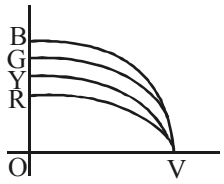
(d)

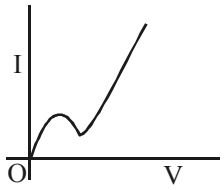
A	B	Y
0	0	1
0	1	0
1	0	1
1	1	1

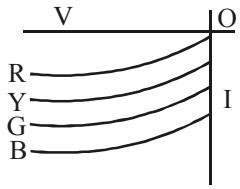
30. The I-V characteristic of an LED is **[2013]**

(a)

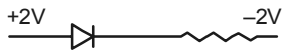


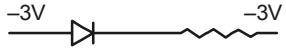
(b)


(c)


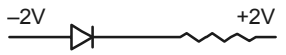
(d)


31. The forward biased diode connection is: **[2014]**

(a)


(b)


(c)


(d)


32. A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is : **[2015]**

(a) 5.48 V/m (b) 7.75 V/m

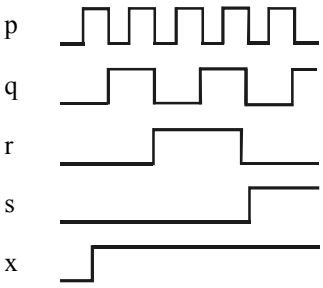
(c) 1.73 V/m (d) 2.45 V/m

33. For a common emitter configuration, if α and β have their usual meanings, the incorrect relationship between α and β is : **[2016]**

(a) $\alpha = \frac{\beta}{1+\beta}$ (b) $\alpha = \frac{\beta^2}{1+\beta^2}$

(c) $\frac{1}{\alpha} = \frac{1}{\beta} + 1$ (d) $\alpha = \frac{\beta}{1-\beta}$

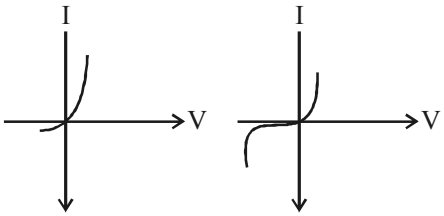
34. If p, q, r, s are inputs to a gate and x is its output, then, as per the following time graph, the gate is : **[2016]**



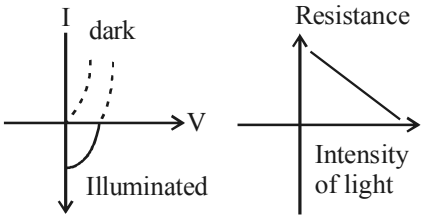
(a) OR (b) NAND

(c) NOT (d) AND

35. Identify the semiconductor devices whose characteristics are given below, in the order (p), (q), (r), (s) : **[2016]**



(p) (q)



(r) (s)

(a) Solar cell, Light dependent resistance, Zener diode, simple diode

(b) Zener diode, Solar cell, simple diode, Light dependent resistance

(c) Simple diode, Zener diode, Solar cell, Light dependent resistance

(d) Zener diode, Simple diode, Light dependent resistance, Solar cell

36. In a common emitter amplifier circuit using an n-p-n transistor, the phase difference between the input and the output voltages will be : **[2017]**

(a) 135° (b) 180°

(c) 45° (d) 90°

Answer Key														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(c)	(c)	(c)	(a)	(c)	(b)	(c)	(d)	(d)	(d)	(a)	(d)	(d)	(d)	(c)
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
(a)	(b)	(c)	(b)	(d)	(a)	(a)	(b)	(d)	(d)	(b)	(a)	(b)	(a)	(a)
31	32	33	34	35	36									
(a)	(d)	(b)	(a)	(c)	(b)									

SOLUTIONS

1. **(c)** Pure silicon, at absolute zero, will contain all the electrons in bounded state. The conduction band will be empty. So there will be no free electrons (in conduction band) and holes (in valence band) due to thermal agitation. Pure silicon will act as insulator.

2. **(c)** Specific resistance is resistivity which is given by

$$\rho = \frac{m}{ne^2\tau}$$

where n = no. of free electrons per unit volume

and τ = average relaxation time

For a conductor with rise in temperature n increases and τ decreases. But the decrease in τ is more dominant than increase in n resulting an increase in the value of ρ .

For a semiconductor with rise in temperature, n increases and τ decreases. But the increase in n is more dominant than decrease in τ resulting in a decrease in the value of ρ.

ALTERNATE SOLUTION

$\rho_2 = \rho_1(1+\alpha\Delta T)$

For conductor α is positive

$\therefore \rho_2 > \rho_1$ for ΔT positive i.e., increase in temperature.

For semi conductor α is negative

$\therefore \rho_2 < \rho_1$ for ΔT positive.

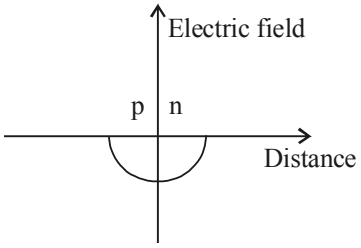
3. **(c)** The energy band gap is maximum in insulators. Because of this the conduction band of insulators is empty.

4. **(a)** Emitter sends the majority charge carrriers towards the collector. Therefore emitter is most heavily doped.

5. **(c)** The resistance of metal (like Cu) decreases with decrease in temperature whereas the resistance of a semi-conductor (like Ge) increases with decrease in temperature.

6. **(b)** When the temperature increases, certain bounded electrons become free which tend to promote conductivity. Simultaneously number of collisions between electrons and positive kernels increases

7. **(c)** It can be seen from the following graph -



8. **(d)** Holes move from base to emmitter.

9. **(d)** In common emitter configuration current gain

$$A_i = \frac{-hf_e}{1+b_{oe}R_L}$$

$$= \frac{-50}{1+25\times10^{-6}\times1\times10^{3}}$$

$$= -48.78$$

10. **(d)** Copper is a conductor, so its resistance decreases on decreasing temperature as thermal agitation decreases,; whereas germanium is semiconductor therefore on decreasing temperature resistance increases.

11. **(a)** Both the depletion region and barrier height is reduced.

12. **(d)** Band gap = energy of photon of wavelength 2480 nm. So,

$$\Delta E = \frac{hc}{\lambda}$$

$$= \left(\frac{6.63\times10^{-34}\times3\times10^{8}}{2480\times10^{-9}}\right)\times\frac{1}{1.6\times10^{-19}}\text{eV}$$

$$= 0.5\text{ eV}$$

13. **(d)** Zero; In common base amplifier circuit, input and output voltage are in the same phase.

14. **(d)** Input frequency, $f = 50$ Hz $\Rightarrow T = \frac{1}{50}$

For full wave rectifier, $T_1 = \frac{T}{2} = \frac{1}{100}$

$\Rightarrow f_1 = 100$ Hz.

15. **(c)** A crystal structure is composed of a unit cell, a set of atoms arranged in a particular way; which is periodically repeated in three dimensions on a lattice. The spacing between unit cells in various directions is called its lattice parameters or constants. Increasing these lattice constants will increase or widen the band-gap (E_g), which means more energy would be required by electrons to reach the conduction band from the valence band. Automatically E_c and E_v decreases.

16. **(a)** $I_C = 5.488$ mA, $I_e = 5.6$ mA

$$\alpha = \frac{5.488}{5.6},\ \beta = \frac{\alpha}{1-\alpha} = 49$$

17. **(b)** Van der Waal's bonding is attributed to the attractive forces between molecules of a liquid. The conductivity of semiconductors (covalent bonding) and insulators (ionic bonding) increases with increase in temperature while that of metals (metallic bonding) decreases.

18. **(c)** $\frac{I_e}{I_h} = \frac{n_e eAv_e}{n_h eAv_h} \Rightarrow \frac{7}{4} = \frac{7}{5}\times\frac{v_e}{v_h} \Rightarrow \frac{v_e}{v_h} = \frac{5}{4}$

19. **(b)** D_2 is forward biased whereas D_1 is reversed biased.

So effective resistance of the circuit

$R = 4 + 2 = 6\Omega$

$\therefore i = \frac{12}{6} = 2$ A

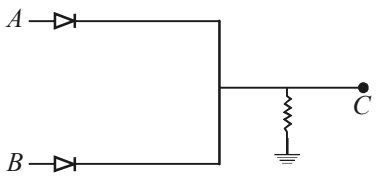
20. **(d)** p-side connected to low potential and n-side is connected to high potential.

21. **(a)** The current will flow through R_L when the diode is forward biased.

22. **(a)** Si and Ge are semiconductors but C is an insulator. Also, the conductivity of Si and Ge is more than C because the valence electrons of Si, Ge and C lie in third, fourth and second orbit respectively.

23. **(b)** It is a p-n-p transistor with R as base. None of the option is correct.

24. **(d)**



The truth table for the above logic gate is :

A	B	C
1	1	1
1	0	1
0	1	1
0	0	0

This truth table follows the boolean algebra $C = A + B$ which is for OR gate

25. **(d)** Here $Y = (\overline{\bar{A} + \bar{B}}) = \bar{\bar{A}}.\bar{\bar{B}} = A \cdot B$. Thus, it is an AND gate for which truth table is

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

26. (b) We know that a single *p-n* junction diode connected to an *a-c* source acts as a half wave rectifier [Forward biased in one half cycle and reverse biased in the other half cycle].

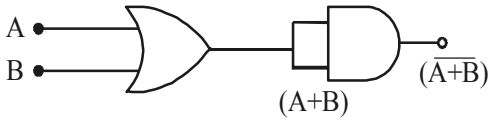
27. (a) The final boolean expression is,

$$X = \overline{(\bar{A}.\bar{B})} = \bar{\bar{A}} + \bar{\bar{B}} = A + B \Rightarrow \text{OR gate}$$

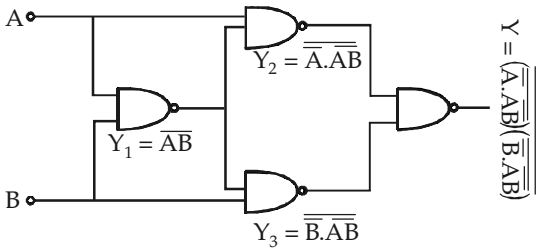
28. (b) $\overline{(A+B)}$ = NOR gate

When both inputs of NAND gate are connected, it behaves as NOT gate

OR + NOT = NOR.



29. (a)

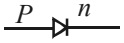


By expanding this Boolen expression

$$Y = A.\bar{B} + B.\bar{A}$$

Thus the truth table for this expression should be (a).

30. (a) For same value of current higher value of voltage is required for higher frequency hence (1) is correct answer.

31. (a) 

For forward bias, p-side must be at higher potential than *n*-side. $\Delta V = (+)Ve$

32. (d) Using $U_{av} = \frac{1}{2}\varepsilon_0 E^2$

But $U_{av} = \frac{P}{4\pi r^2 \times c}$

$\therefore \quad \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E^2 \times c$

$$E_0^2 = \frac{2P}{4\pi r^2 \varepsilon_0 c} = \frac{2\times 0.1\times 9\times 10^9}{1\times 3\times 10^8}$$

$\therefore \quad E_0 = \sqrt{6} = 2.45 V/m$

33. (b) We know that $\alpha = \frac{I_c}{I_e}$ and $\beta = \frac{I_c}{I_b}$

Also $I_e = I_b + I_c$

$$\therefore \ \alpha = \frac{Ic}{I_b + I_c} = \frac{\frac{I_c}{I_b}}{1+\frac{I_c}{I_b}} = \frac{\beta}{1+\beta}$$

Option (b) and (d) are therefore correct.

34. (a) In case of an 'OR' gate the input is zero when all inputs are zero. If any one input is ' 1', then the output is '1'.

35. (c) Graph (p) is for a simple diode.
Graph (q) is showing the V Break down used for zener diode.
Graph (r) is for solar cell which shows cut-off voltage and open circuit current.
Graph (s) shows the variation of resistance h and hence current with intensity of light.

36. (b) In common emitter configuration for *n-p-n* transistor input and output signals are 180° out of phase *i.e.,* phase difference between output and input voltage is 180°.