SOLID STATE PHYSICS

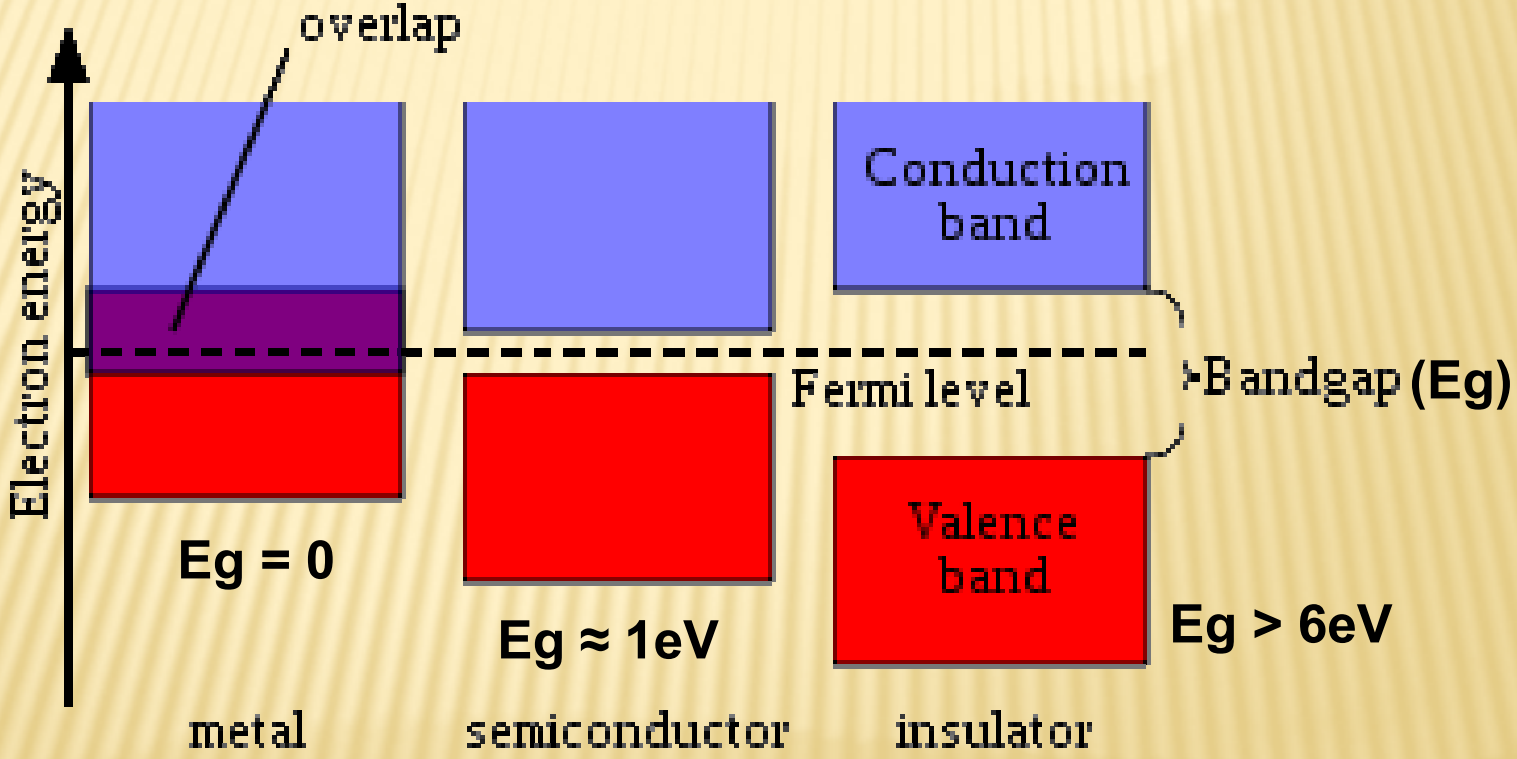
DIGITAL ELECTRONICS

SOFT CONDENSED MATTER

FIRST TRANSISTOR

Tips and warming –up words

1) Band theory of solids



2) Resistivity of :

Metals	10^{-2} to 10^{-8} Ωm
Semiconductors	10^{5} to 10^{0} Ωm
Insulators	10^{8} Ωm

3) There are two types of semiconductors,

Intrinsic semiconductors

Extrinsic semiconductors

4) Intrinsic semiconductors:

1. Pure semiconductors
2. At room temperature current carries are holes and electrons.
3. At any instant no of holes equal to no of electrons
4. At 0 K filled V.B. and empty C.B.
5. At 0 K conductivity is ZERO

5) Extrinsic semiconductors:

1. Doped semiconductors
2. At room temperature majority current carries are either holes or electrons.

6) There are two types of extrinsic semiconductors. P and N type

7) **P-type: obtained by adding trivalent impurity (In, Ga, Al, B) and majority charge carries are holes.**

8) **N-type: obtained by adding pentavalent impurity (As, Sb, P) and majority charge carriers are electrons.**

9) **The extrinsic semiconductors are neutral.**

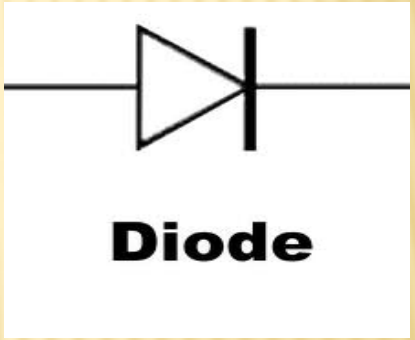
10) **When *N-type or P-type* is heated number of electrons and holes increases equally**

11) **A *0 K* temperature, a *P-type* semiconductor has few holes and no free electrons**

12) Holes can exit only in semiconductors.

13) Diode acts as a RECTIFIER (Converts AC to DC)

14) Works under reverse bias condition, used in switching circuits



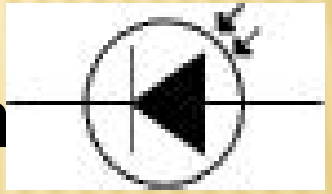
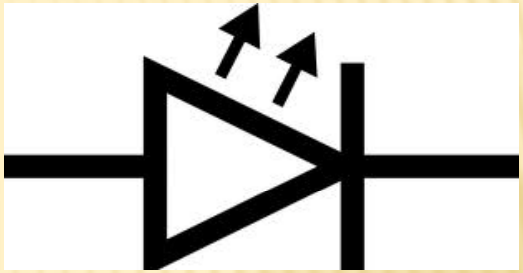


Photo Diode

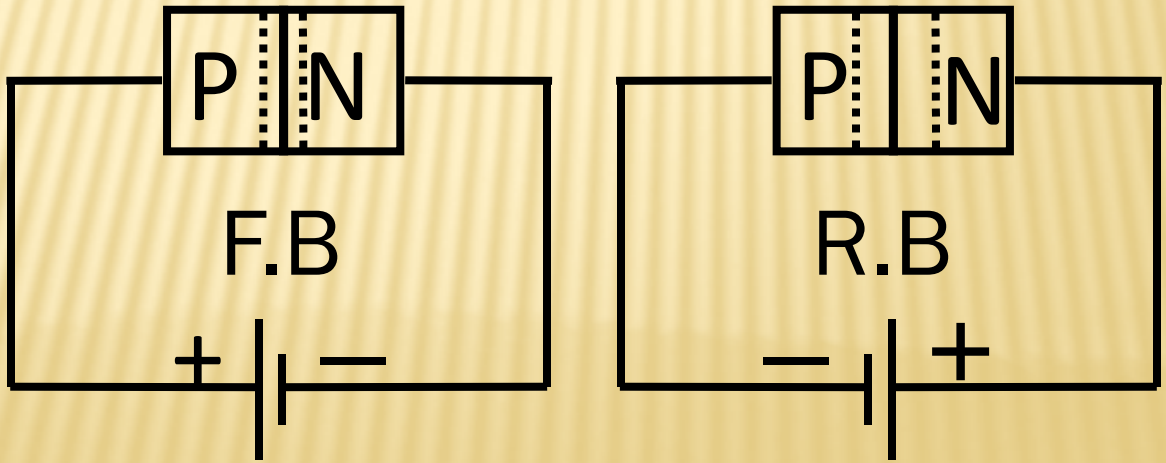
15) LED: light emitting diode, uses the principle of optics and electronics.



LED

Used in seven segment display.

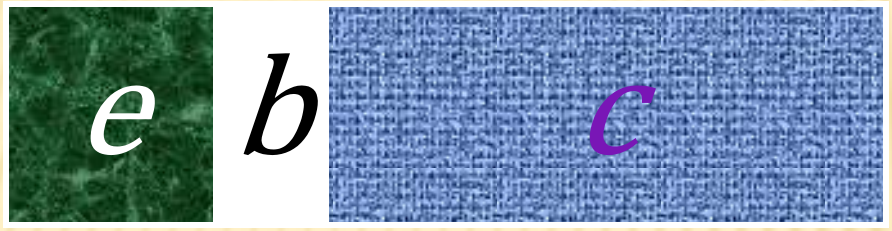
16) Junction diode



17) **The thickness of depletion layer is about 10^{-6} *meter*.**

18) **Knee voltage is the forward voltage at which the current through the junction starts increasing rapidly.**

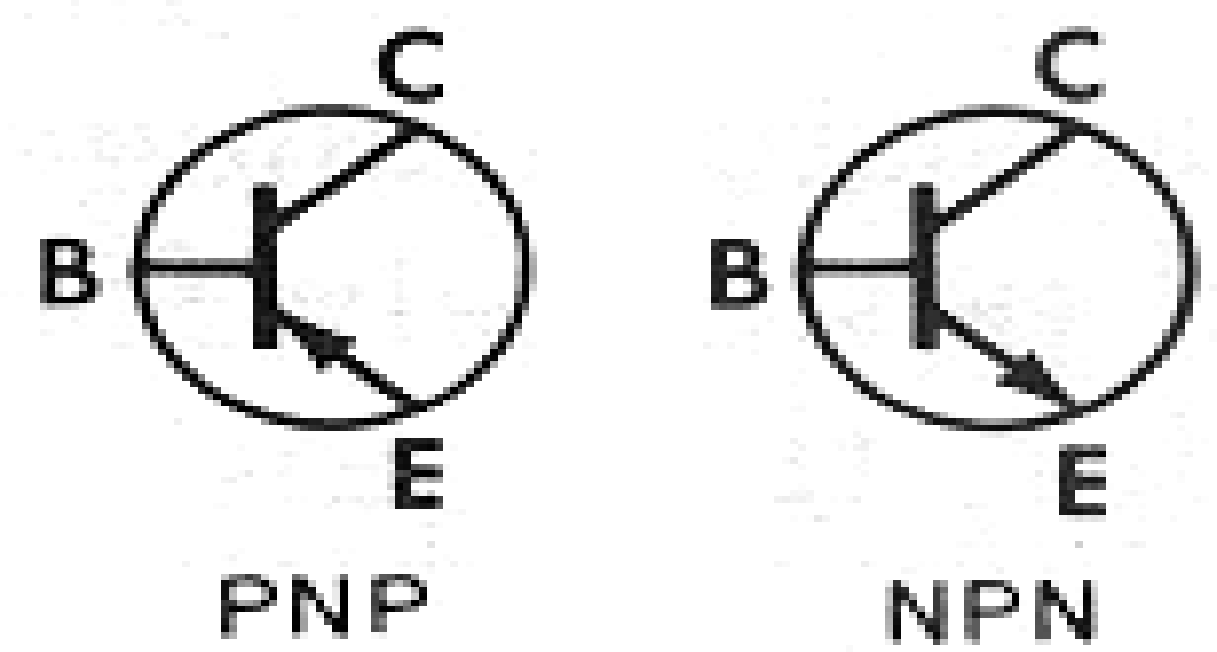
19) **Transistor consists of two PN junctions.**



NPN transistor: electrons are majority charge carriers

PNP transistor: holes are majority charge carriers.

20) Symbol of transistor



21) In normal transistor operation emitter-base junction is forward biased and collector-base junction is reverse biased.

22) Configurations of transistor

CE CB CC

23) Relation between α and β

α and β are current gains

$$\beta = \frac{\alpha}{1 - \alpha}$$

$$\alpha = \frac{\beta}{1 + \beta}$$

QUESTIONS

1. The material such as conductors insulators and semiconductor are distinguished from one another on the basis of,

1. free electron theory of materials
2. band theory of solids
3. kinetic theory of gases
4. special theory of relativity

Solution: 2. band theory of solids

2. The energy bands which are completely filled at absolute zero *(0 K)* are called

1. conduction bands
2. valence bands
3. forbidden bands
4. intrinsic bands

Solution: 2. valence bands

3. When the energy gap *Eg* is zero, the material is

1. a conductor
2. an inductor
3. a semiconductor
4. a dielectric

Solution: 1. a conductor

4. Fermi energy level is

1. the minimum energy of electrons at *0 K*
2. the maximum energy of electrons at *273 K*
3. the maximum energy of electrons at *0 K*
4. the minimum energy of electrons at *272 K*

Solution: 3. the maximum energy of electrons at *0 K*

5. At 0 K temperature P – type semiconductor

1. does not have any charge carriers
2. has few holes and few free electrons
3. has few holes but no free electrons
4. has few electrons but no free holes.

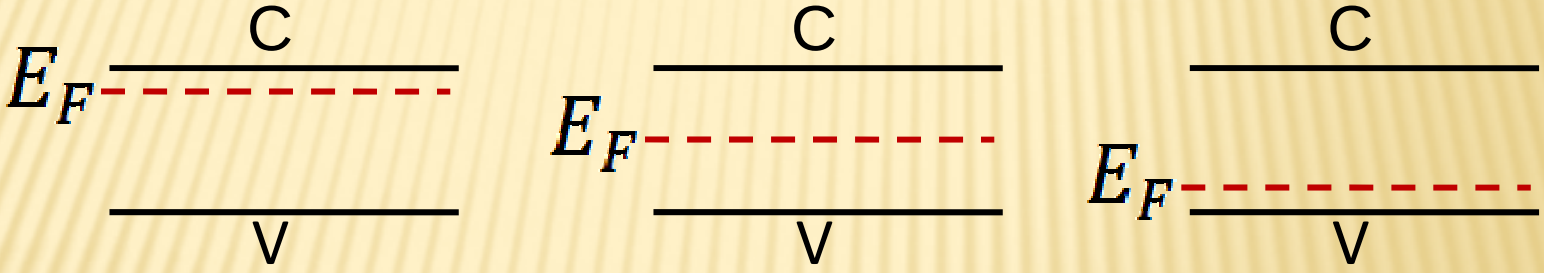
Solution: 3. has few holes but no free electrons

6. The conductivity of an intrinsic semiconductor at absolute zero is

1. infinite
2. zero
3. 10^6 mho
4. 1 mho

Solution: 2. zero

7. The band diagrams of three semi-conductors are given in the following figure. From left to right, they are respectively



1. N – Intrinsic – P

2. P – Intrinsic – N

3. Intrinsic – P – N

4. Intrinsic – N – P

Solution: 1. N – Intrinsic – P

9. In half wave rectifier, the *RMS* value of *A.C.* component of the wave is

1. equal to *D.C.* value

2. more than *D.C.* value

3. less than *D.C.* value.

4. zero

Solution: 2. More than *D.C.* value

10. Transistors are essentially

1. power driven devices
2. current driven devices
3. voltage driven devices
4. resistance driven devices

Solution: 2. current driven devices

11. For a transistor, the value of α = 0.9 . The value of β is

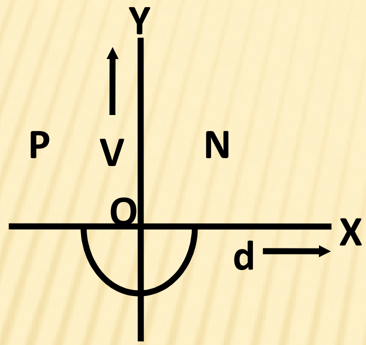
1. 1
2. 0.09
3. 0.9
4. 9

Solution: 4.

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{1-0.9} = \frac{0.9}{0.1} = 9$$

12. The correct curve between potential (V) and distance (d) near P – N junction is

1.



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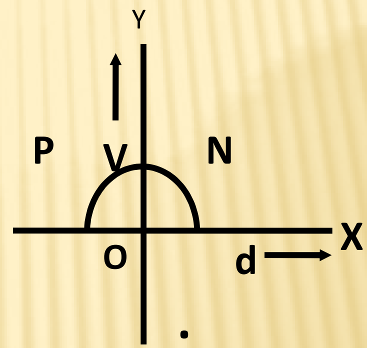

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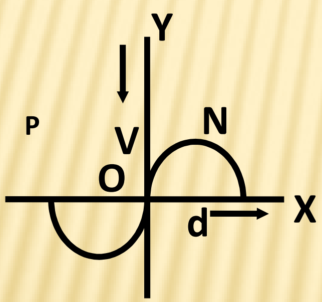
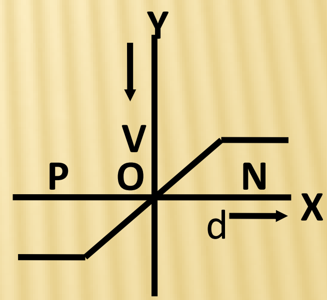


4.



Solution: 4.

13. An frequency oscillator is a device which converts D.C. energy into

1. D.C. of high voltage
2. D.C. of low voltage
3. A.C. energy
4. none of the above

Solution: 3. A.C. energy

14. A seven segment display unit used in calculators, watches is made by using,

1. photo Diode
2. laser Diode
3. photovoltaic cell
4. L.E.D

Solution : 4. L.E.D

15. *The ratio of electron and hole currents in a semiconductor is 5/4 and the ratio of drift velocities of electron and holes is 7/4 , then the ratio of concentrations of electrons and holes will be ….*

1. *5/7*
2. *25/49*
3. *7/5*
4. *49/25*

Solution : 1. *5/7*

We know that

$$i = n \cdot e \cdot A \cdot v \quad \text{OR} \quad i \propto n \cdot v$$

$$\therefore \frac{i_e}{i_h} = \frac{n_e}{n_h} \times \frac{v_e}{v_h} \Rightarrow \frac{5}{4} = \frac{n_e}{n_h} \times \frac{7}{4}$$

$$\Rightarrow \frac{n_e}{n_h} = \frac{5}{4} \times \frac{4}{7} = \mathbf{\frac{5}{7}}$$

16. The energy of a photon of sodium light of $\lambda = 5890$ Å equals the band gap of a semiconducting material. The minimum energy required to create an electron–hole pair is

1. *2.1 eV*
2. *4.2 eV*
3. *1.05 eV*
4. *5.89 eV*

Solution : 1. 2.7 eV

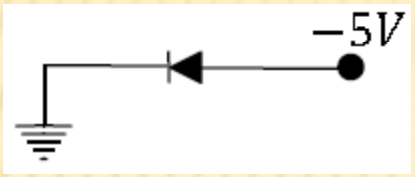
The energy required is given by

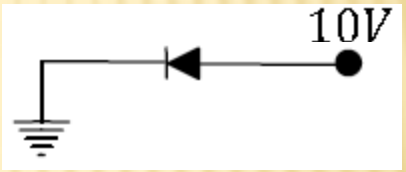
$$E = \frac{h \cdot c}{\lambda}$$

$$= \frac{(6.64 \times 10^{-34}) \times (3 \times 10^{8})}{(5890 \times 10^{-10}) \times (1.6 \times 10^{-19})}$$

$$= 2.1 \text{ eV}$$

17. Which of the following semi-conductor diode is reverse biased?

1. 

2. 

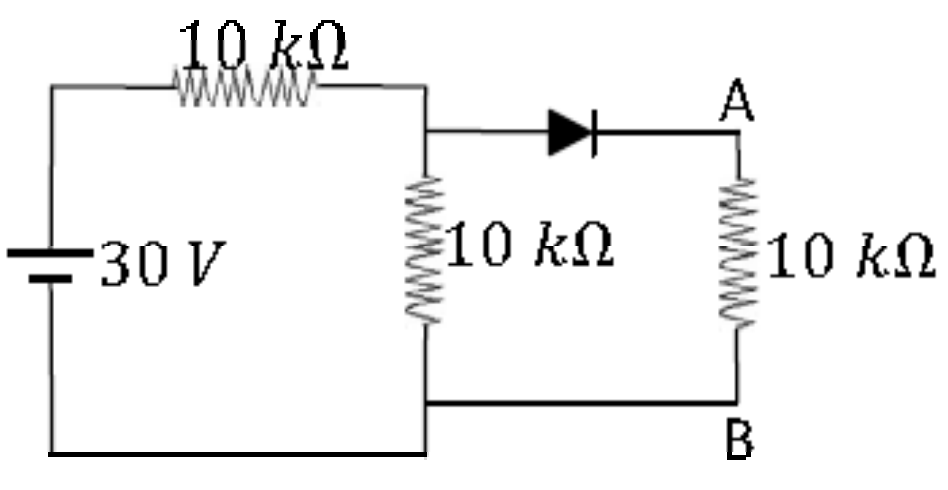
3. 

4. 

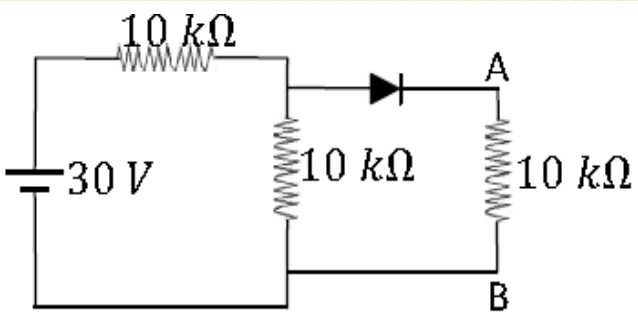
Solution: 1. 

18. In the figure the potential difference between A and B is

1. *0 V*
2. *5 V*
3. *10 V*
4. *15 V*



Solution: 3. *10 V*



Current

$$I = \frac{30}{(10+5)\times 10^3} = 2\times 10^{-3} A = 2\ mA$$

Potential Difference

$$P.D = (5\times 10^3)\ \Omega \times (2\times 10^{-3})\ A = 10\ Volts$$

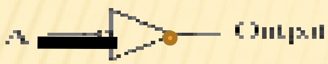
DIGITAL ELECTRONICS

1. A logic gate is an electronic circuit which

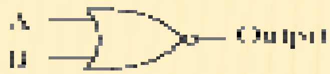
1. makes logic decisions.
2. allows electron flow only in one direction
3. alternates between *0* and *1* values
4. allows hole flow only in one direction

Solution: 1. makes logic decisions.

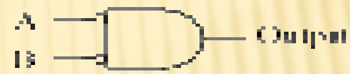
DIGITAL ELECTRONICS



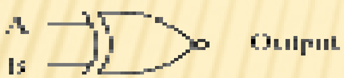
A	Output
0	
1	



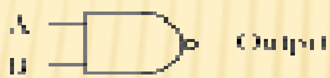
A	B	Output
0	0	
0	1	
1	0	
1	1	



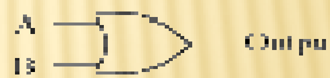
A	B	Output
0	0	
0	1	
1	0	
1	1	



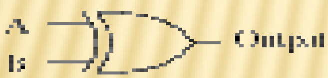
A	B	Output
0	0	
0	1	
1	0	
1	1	



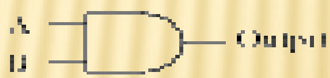
A	B	Output
0	0	
0	1	
1	0	
1	1	



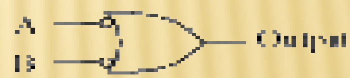
A	B	Output
0	0	
0	1	
1	0	
1	1	



A	B	Output
0	0	
0	1	
1	0	
1	1	



A	B	Output
0	0	
0	1	
1	0	
1	1	



A	B	Output
0	0	
0	1	
1	0	
1	1	

Inputs

Truth Table Outputs for each Gate

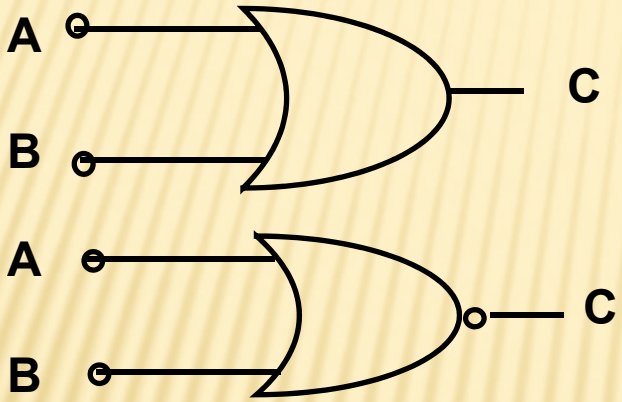
A	B	AND	NAND	OR	NOR	EX-OR	EX-NOR
0	0	0	1	0	1	0	1
0	1	0	1	1	0	1	0
1	0	0	1	1	0	1	0
1	1	1	0	1	0	0	1

DIGITAL ELECTRONICS

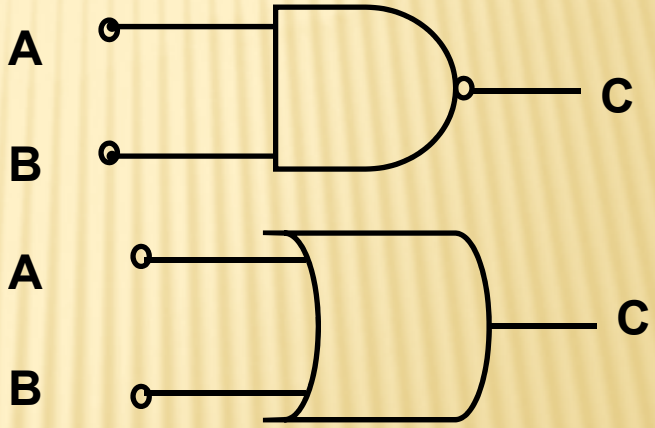
Logic Function	Boolean Notation
AND	$A.B$
OR	$A+B$
NOT	$\overline{A}$
NAND	$\overline{A.B}$
NOR	$\overline{A+B}$
EX-OR	$A \oplus B$
EX-NOR	$\overline{A \oplus B}$

2. Given below are four logic gates symbols those for *OR, NOR* and *NAND* are respectively

1



2



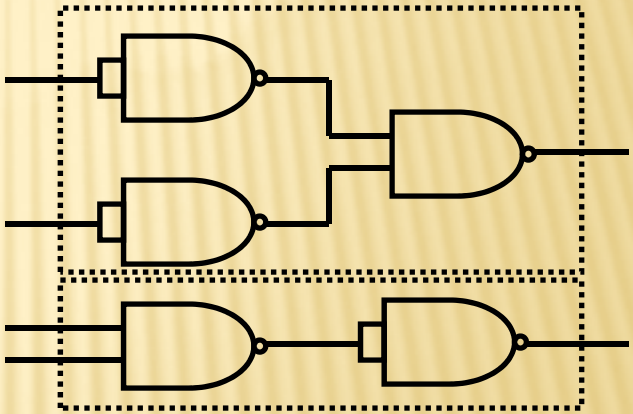
3

4

1. 1, 4, 3
2. 4, 1, 2
3. 1, 3, 2
4. 4, 2, 1

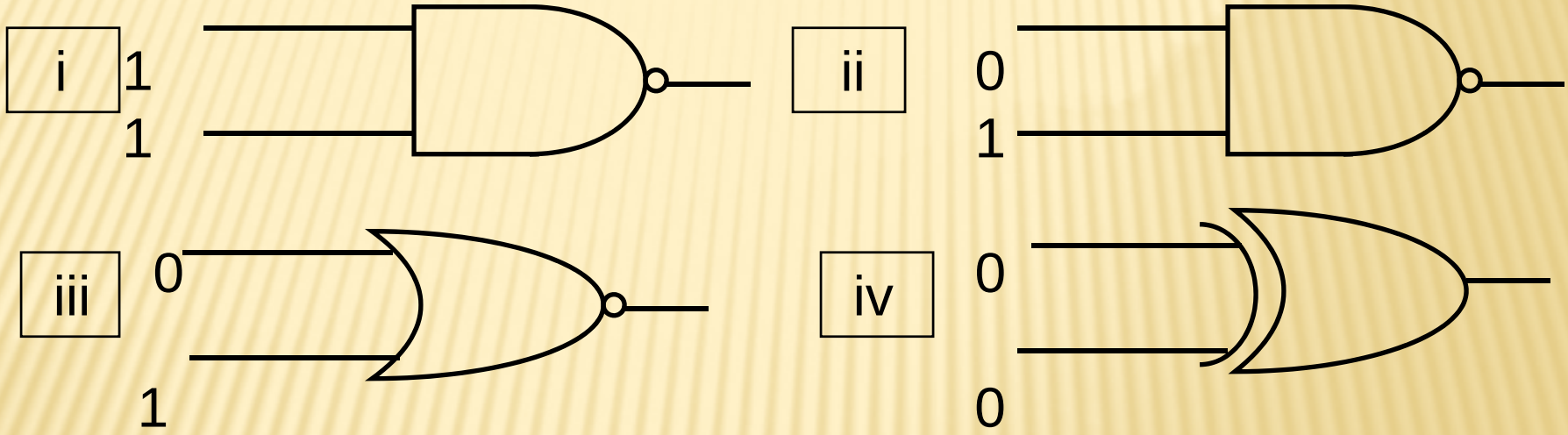
3. The combination of *NAND* gates shown here are equivalent to

1. an *OR* gate and an *AND* gate
2. an *AND* gate and an *NOT* gate
3. an *AND* gate and an *OR* gate
4. an *OR* gate and an *NOT* gate



Key : 1. $C = A \cdot B = \overline{A} + \overline{B} = \overline{A+B}$ 2) $C = \overline{A.B}$

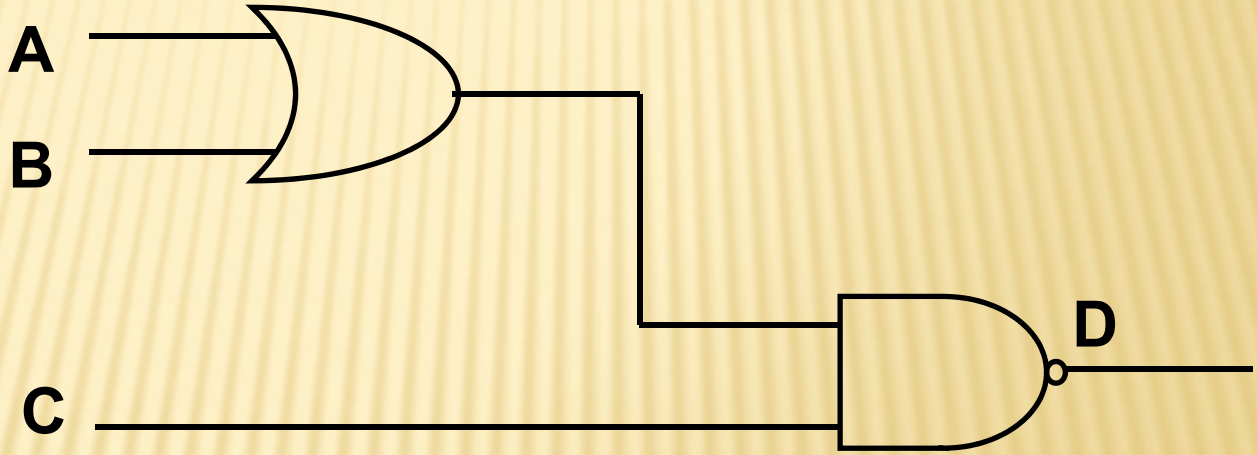
4. Which of the following will have an out put of *1*



1. (ii) 2. (i) 3. (iv) 4. (iii)

Solution: 1. (ii)

5. For the given combination of gates, if the logic states of the in puts *A, B, C* are as follows *A = B = C = 0* and *A = B = 1 & C = 0* then the logic states of the out put *D* are



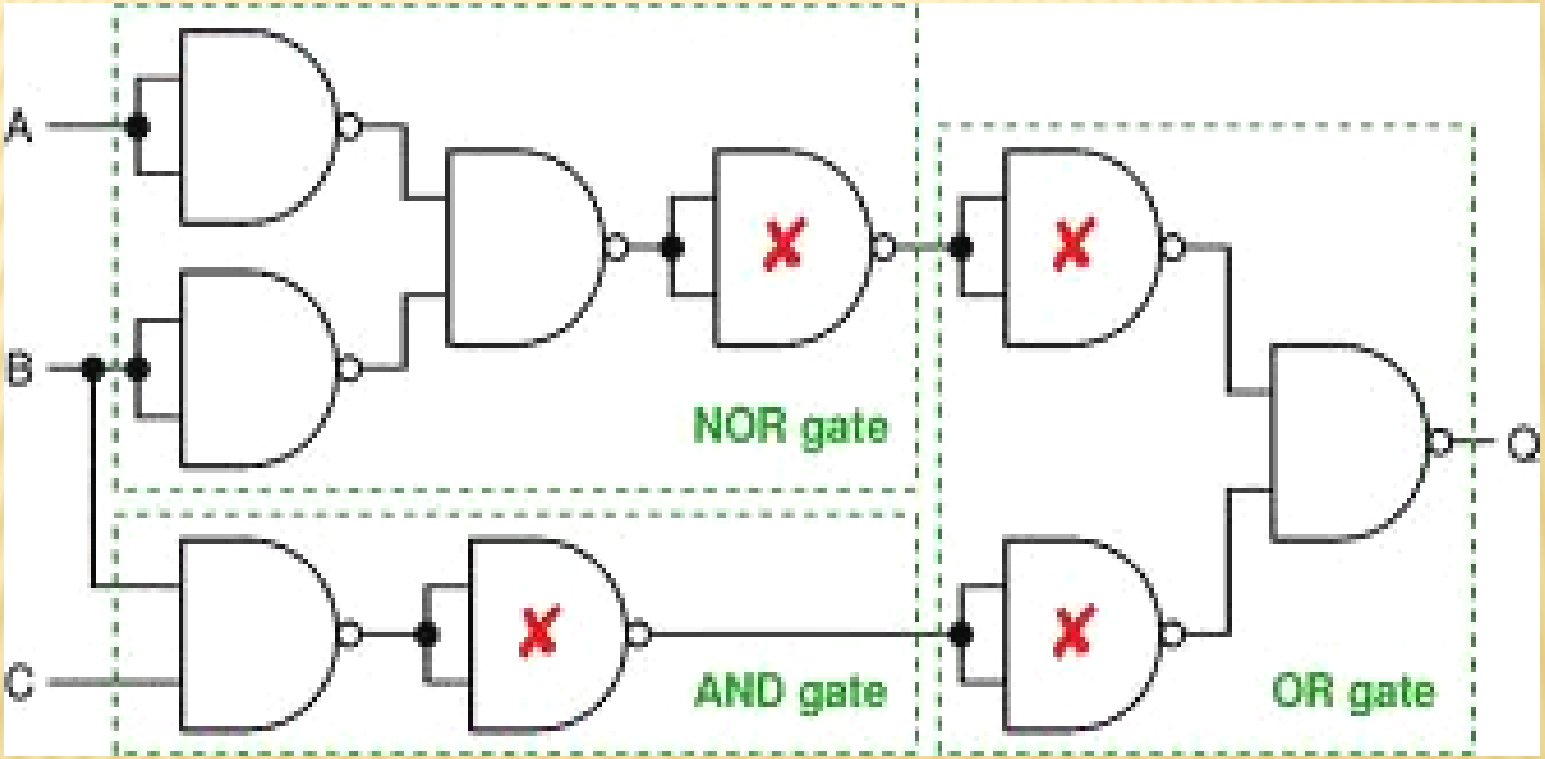
1. 0 , 0
2. 0 , 1
3. *1 , 1*
4. 1 , 1

6. Digital circuits can be made by respective use of

1. *AND* gate
2. *OR* gate
3. *NOT* gate
4. *NAND* gate

Solution: 4. NAND gate

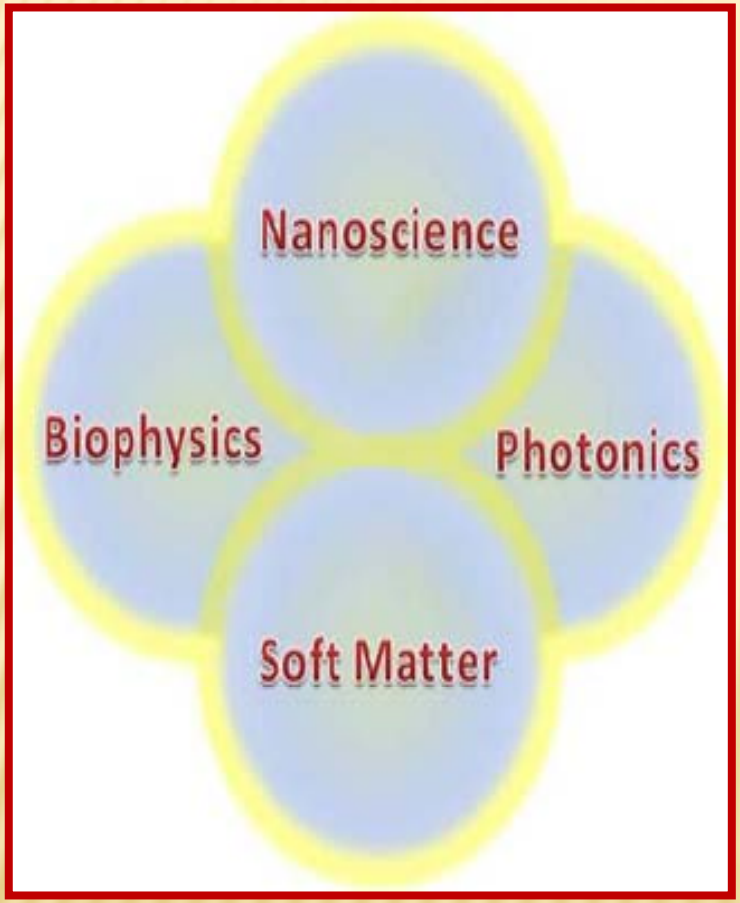
NAND gate as an universal gate



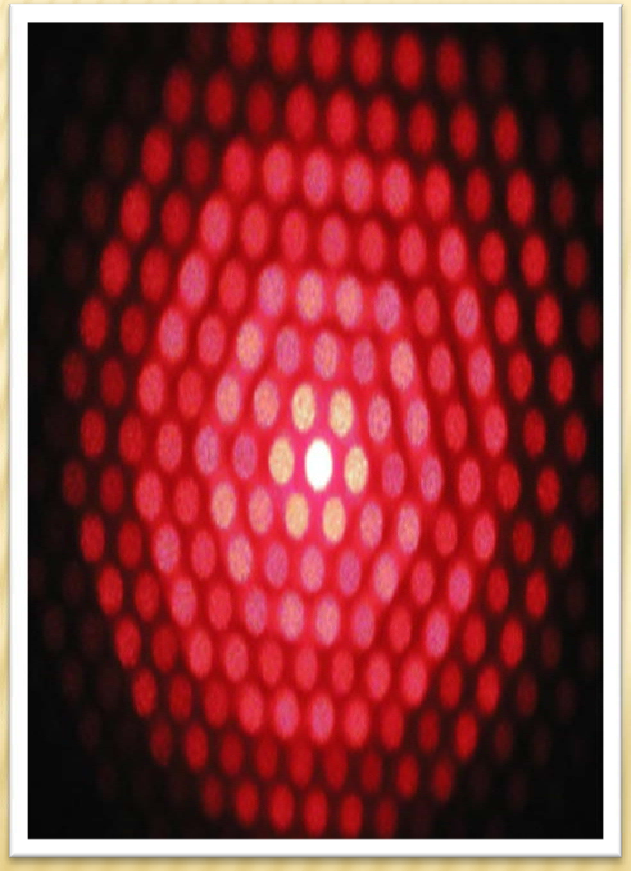
SOFT CONDENSED MATTER

Soft matter is a subfield of condensed matter comprising a variety of physical states that are easily deformed by thermal stresses or thermal fluctuations.
They include liquids, colloids, polymers, foams, gels, granular materials, and a number of biological materials.

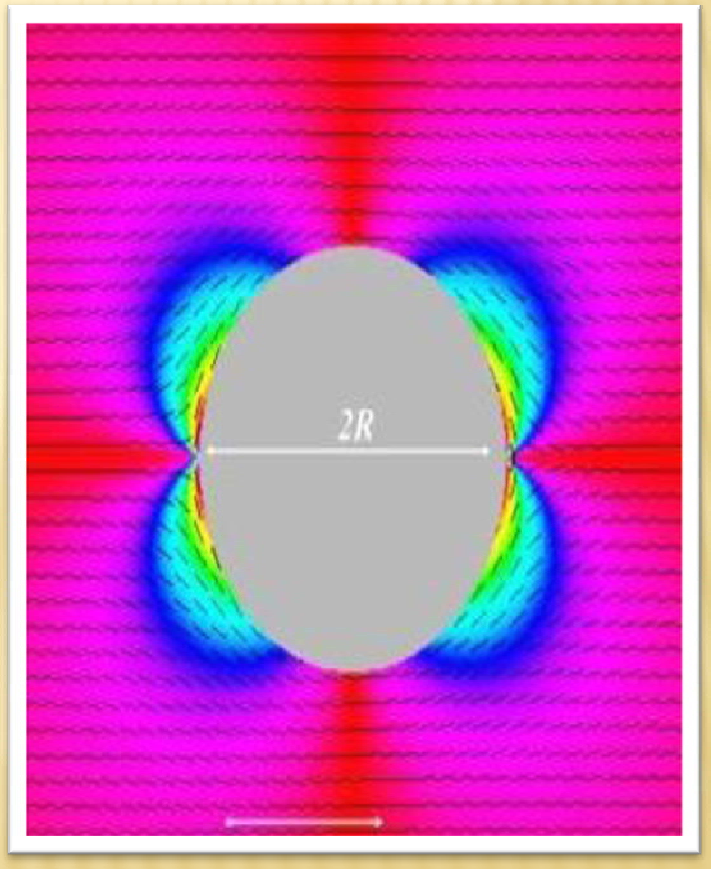
SOFT CONDENSED MATTER



Optics & Photonics Research



Nano science & Nanotechnology Research



Liquid crystals are the materials intermediate between disordered state (liquids) and ordered state (crystal) of matter

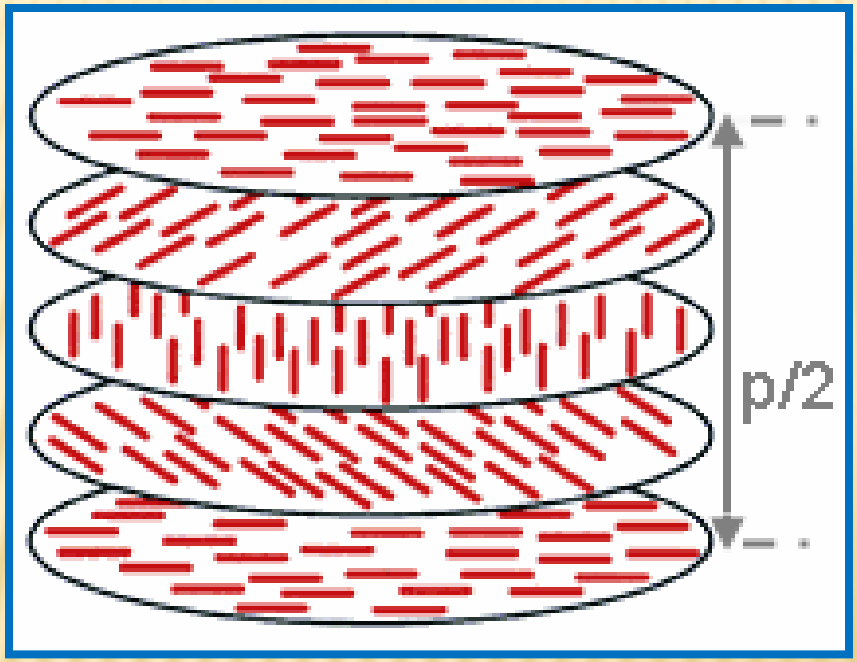
Liquid crystals are of two types

1. thermotropic
2. lyotropic

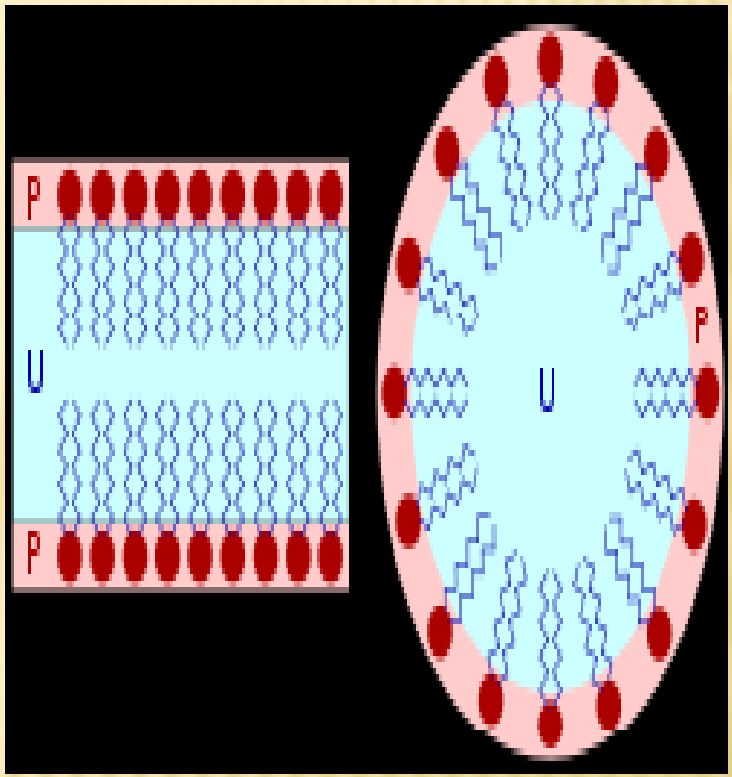
Thermotropic liquid crystals are classified as

1. Nematic (thread like)
2. Smectic (layered)
3. Cholesteric (chirality)

Chiral nematic phase

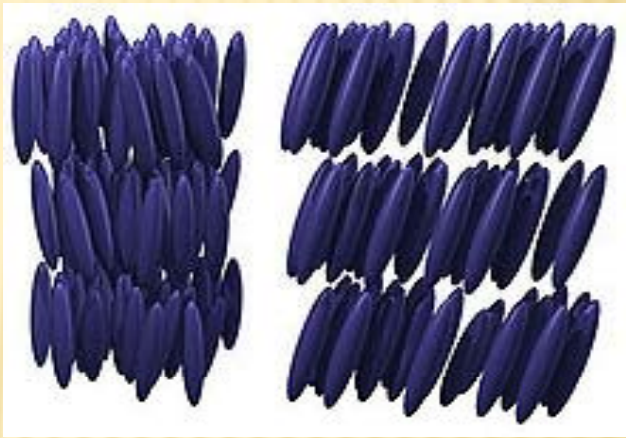


Structure of lyotropic liquid crystal. The red heads of surfactant molecules are in contact with water, whereas the tails are immersed in oil (blue): bilayer (left) and micelle (right).



Alignment in a nematic phase.

Schematic of alignment in the smectic phases.



The chiral nematic phase also called the cholesteric phase

11) The twisted nematic used in *LCD* .

12) The lyotropic phase is sensitive to concentration and temperature.

12) A liquid crystal to be useful in displays should have high dielectric anisotropy

1) **Colloidal solution : Size of dispersion particles in the range *1* to *100nm***

2) **Types:**

Emulsions: Both dispersed phase and dispersion medium are liquids.

E.g. Milk

Applications of emulsions

Food, cleaning action of soap, medicine, emulsion paints, cosmetics

Gels : dispersed phase and dispersion medium are liquid and solid.

Weeping or Syneresis: The shrinking of gel by loosing water

E.g. Elastic gels: gelatin, agar-agar, startch, fibrin

5) **Foams**: dispersed phase and dispersion medium are gas in a liquid or solid.

Stabilizers: Used to prevent coalescence of gas bubbles by lowering interfacial tension.

E.g. *shaving creams, whipped cream, ice cream, egg white, beer form (Air)*

Liquid foam: Fire-extinguisher, during froth floatation

Solid foam: Baker's bread, sponge rubber.

Foamble polymers: Polyurethanes, polystyrene, silicones, PVC, rubber

Applications: **Foam rubbers** are used for making pillows, mattresses, cushions, automotive pads

Polyurethanes are used for leather substitute

Light weight silicone foams for aero-plane and missiles

13) The substance added in a small amount to stabilize on emulsion is called emulsifier.

14) Water in oil is emulsion

15) The cleaning action of soaps and detergents are emulsions.

16) An emulsifying agent of milk is water

18) Flame produced during the combustion of petroleum is effectively controlled by using liquid foam produced by dispersing CO_2 in soap solution

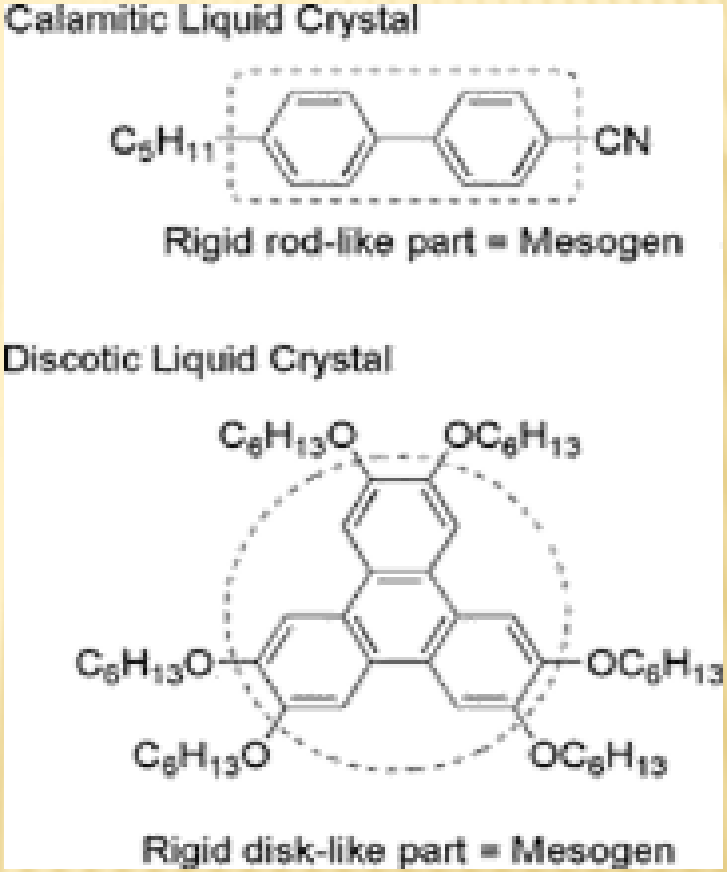
1. A mesogen is a ……..

1. crystalline solid
2. amorphous solid
3. liquid crystal
4. metal

Solution: 3

Liquid crystal

Mesogen is the fundamental unit of a liquid crystal that induces structural order in the crystals.



2. Lehman coined the name

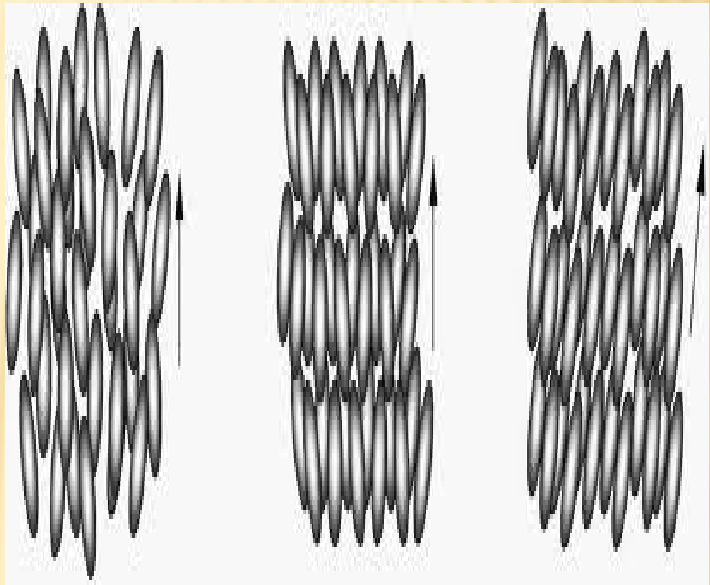
1. liquid crystal
2. crystal
3. amorphous solid
4. lyotropic liquid crystals

Solution: 1 Liquid crystal

Otto Lehmann (January 13, 1855 in Konstanz, Germany – June 17, 1922 in Karlsruhe) was a German physicist and "father" of liquid crystal technology.

3. The liquid crystalline phase of substance is called

1. metaphase
2. mesophase
3. lithophase
4. semi phase



Solution : 2. mesophase

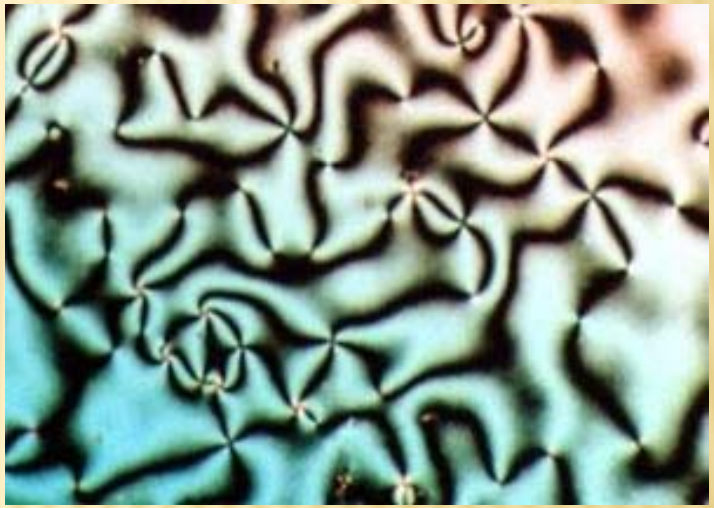
4. A liquid crystal has

1. Ability to flow
2. Low viscosity
3. Optical anisotropy
4. All these

Solution: 4. All these

5. Thread like phase in liquid crystal is known as

1. Nematic phase
2. Cholesteric phase
3. Smectic phase
4. All phases

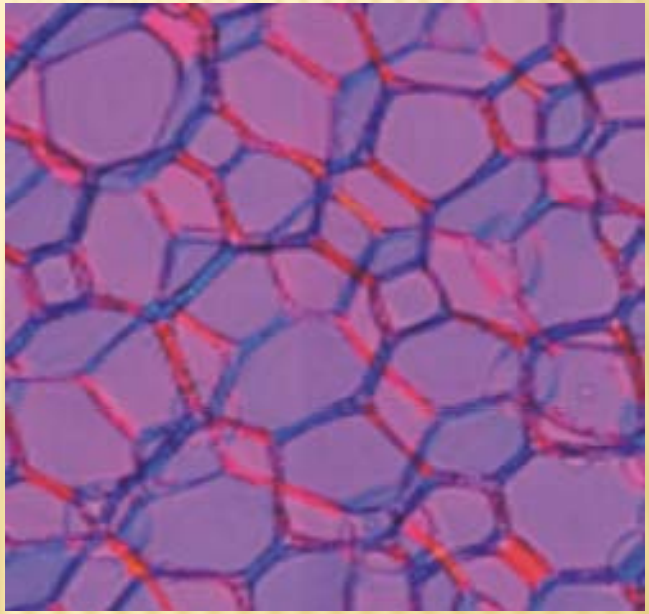


Solution: 1. Nematic phase

In Greek nematic means “threadlike”

6. The liquid crystal found in living systems are…

1. Thermo tropic
2. Lyotropic
3. Both (1) and (2)
4. Neither (1) nor (2)



Solution: 2. Lyotropic

7. Liquid crystals used in a liquid crystal thermometer are……

1. Nematic
2. Smectic
3. Cholesteric
4. lyotropic

Solution: 3. Cholesteric

The colour of reflected light from a sheet of cholesteric material varies appreciably with temperature