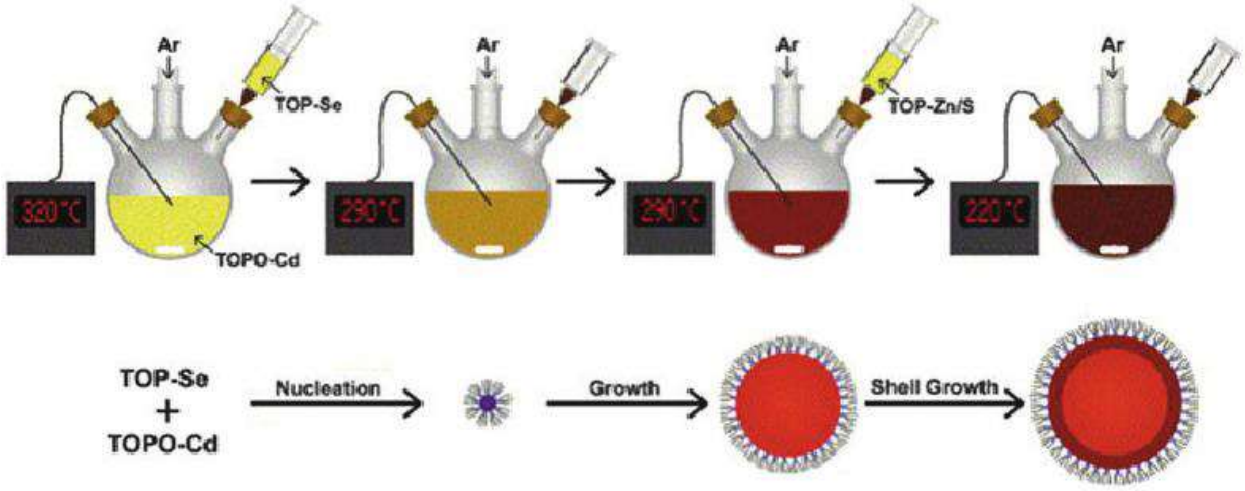
1. Describe the synthesis of CdX (CdSe) quantum dots. Find its applications in electronic gadgets.

Colloidal synthesis of CdSe quantum dots

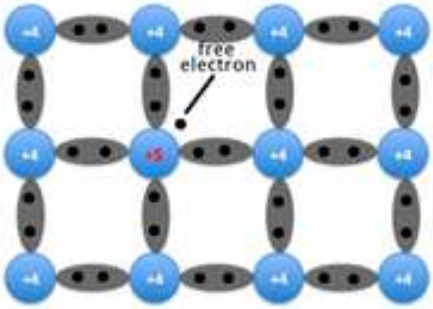
A cadmium compound is heated to 320 ^{o}C and dissolved in an organic solvent. At room temperature selenium compound dissolved in a different organic solvent is injected into the reaction vessel, causing supersaturation of the resultant CdSe solution. As the temperature drops to around 290 ^{o}C, nucleation of new crystals stops and existing crystals grow. After a period of growth, the length of which determines the size of the QDs, the solution is cooled to 220 ^{o}C, stopping growth. A small amount of zinc sulfide is injected into the reaction vessel to coat the QDs and prevent them from reacting with the environment.



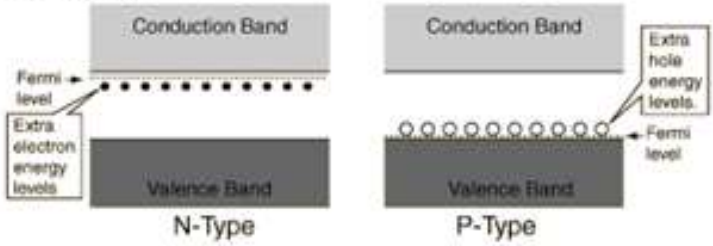
2. Write a note on the nitrogen doped silicon.

N Doped Silicon

• When one of the silicon atom is replaced by an atom with five valence electrons, such as the Group 5 atoms Nitrogen (N).
•In this case, the impurity adds five valence electrons to the lattice where it can only hold four. This means that there is now one excess electron in the lattice (see figure below).
•Because it donates an electron, a Group 5 impurity is called a donor. The material remains electrically neutral.

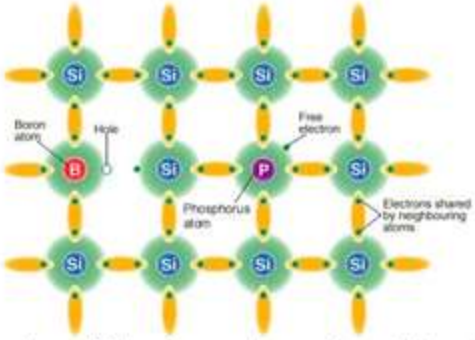


•Donor impurities donate negatively charged electrons to the lattice, so a semiconductor that has been doped with a donor is called an n-type semiconductor.
• Free electrons outnumber holes in an n-type material, so the electrons are the majority carriers and holes are the minority carriers.



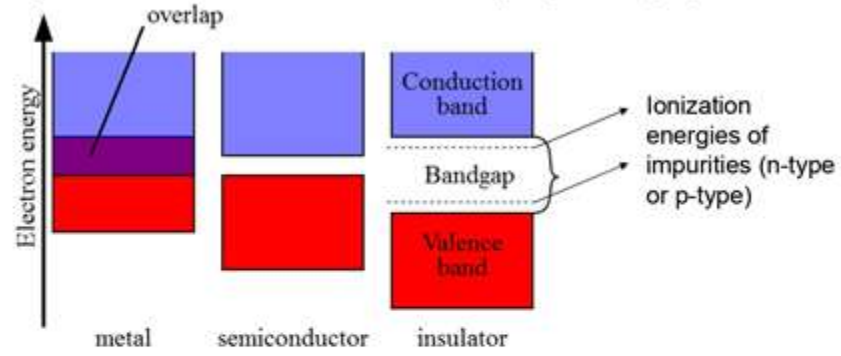
Impurities in semiconductors: Artificial doping to alter properties

- A **dopant**, also called a *doping agent*, is a trace **impurity element** that is artificall inserted into a substance in order to alter the electrical properties or the optical properties of the substance.



- **p-type** : dopant (B) has fewer valence e⁻ than the host element
- **n-type** : dopant (P) has excess valence e⁻ than the host element

Impurities in semiconductors: Artificial doping to alter properties



- E_g (Si) = 1.11 eV at 300 K
- E_g (Ge) = 0.67 eV
- E_g (AlN) = 6.3 eV
- E_g (Diamond) = 5.5 eV
- E_g (PbSe) = 0.37 eV

3. Describe the synthesis, properties and applications of Kevlar.

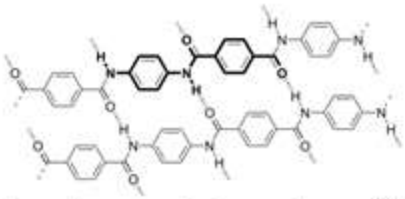
KEVLAR

Synthesis

Kevlar is a polyamide formed from 1,4-diaminobenzene and terphthalic acid

Properties

Strength of Kevlar is mainly due to hydrogen bonding between N-H and C=O groups of two polymeric chains.



Kevlar fiber has a tensile strength of about 3,620 Mpa and relative density of 1.44

Kevlar maintains its strength and resilience down to cryogenic temperatures −196 °C

Kevlar is often used in the field of cryogenics for its low thermal conductivity and high strength relative to other materials for suspension purposes.

Kevlar is a well-known component of personal armor such as combat helmets, ballistic face masks, and ballistic vests.

Kevlar is used to manufacture gloves, sleeves, jackets, chaps and other articles of clothing designed to protect users from cuts, abrasions and heat.

Kevlar is widely used as a protective outer sheath for optical fiber cable, as its strength protects the cable from damage and kinking. When used in this application it is commonly known by the trademarked name Parafil.

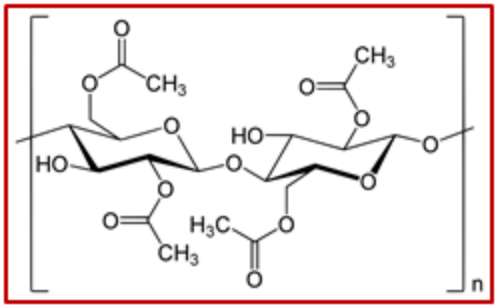
Some cellphones (including the Motorola RAZR Family, the Motorola Droid Maxx, OnePlus 2 and Pocophone F1) have a Kevlar backplate, chosen over other materials such as carbon fiber due to its resilience and lack of interference with signal transmission.

Kevlar 149, the strongest fiber and most crystalline in structure, is an alternative in certain parts of aircraft construction. The wing leading edge is one application, Kevlar being less prone than carbon or glass fiber to break in bird collisions.

4. Describe the synthesis, properties and applications of cellulose acetate.

Cellulose Acetate

- ✓Cellulose acetate is an acetate ester of cellulose, generally cellulose diacetate.
- ✓It is a bioplastic and is used as a film base in photography, as a component in some coatings, and as a frame material for eyeglasses.



- ✓It is also used as a synthetic fiber in the manufacture of cigarette filters and playing cards.
- ✓In photographic film, cellulose acetate film replaced nitrate film because it is less flammable and cheaper.

Preparation:

Acetylating the cellulose: The commercial production of cellulose acetates follows; 1. *acetic acid process* or 2. *methylene chloride process*

1. *Acetic acid processes:* the pre-treated cellulose is reacted in acetic acid (solvent) with an excess of acetic anhydride, and with sulphuric acid as a catalyst.

✓The reaction is highly exothermic and therefore intensive cooling of the reaction vessels is required.

✓The esterification process is quenched by adding of water.

✓This solution must be gel-free and have the desired viscosity.

2. *Methylene chloride process :*

✓Methylene chloride is used in the acetylation mixture as a solvent instead of acetic acid.

✓Since, low-boiling methylene chloride can be easily removed by distillation.

✓Methylene chloride at low temperatures can dissolve cellulose triacetate very well.

✓A small amount of sulfuric acid can used as a catalyst, but most often perchloric acid is used.

✓However, acetic acid is usually also formed as a by-product of the reaction.

✓A very rare heterogeneous process is the fiber acetate process, which is only used for the production of cellulose triacetate as an end product.

✓In this process, the cellulose is suspended in benzene and esterified with acetic anhydride in the presence of perchloric acid as catalyst.

Properties:

Hand: soft, smooth, dry, crisp, resilient

Comfort: breathes, wicks, dries quickly, no static cling

Color: deep brilliant shades with atmospheric dyeing meet colorfastness requirements

Luster: light reflection creates a signature appearance

Performance: colorfast to perspiration staining, colorfast to dry cleaning, air and vapor permeable

Abrasion: poor resistance

Heat retention: poor thermal retention; no allergenic potential (hypoallergenic)

Dyeability: (two methods) cross-dying method where yarns of one fiber and those of another fiber are woven into a fabric in a desired pattern; solution-dying method provides excellent color fastness under the effects of sunlight, perspiration, air contaminants and washing

Applications:

- ✓Cellulose acetate is used as a film base materials in photography.
- ✓It is use as a component in some adhesives.
- ✓It is used as frame material for eyeglasses.
- ✓ it is also used as a synthetic fiber and in the manufacture of cigarette filters, found in screwdriver handles, ink pen reservoirs, x-ray films.

5. Describe the composition, properties and applications of duralumin.

Composition, properties and applications of duralumin

What is Duralumin?

Duralumin is a strong, lightweight alloy of aluminium discovered in 1910 by Alfred Wilm, a German metallurgist.

Chemical Composition

Aluminum, Al	95
Copper, Cu	4
Magnesium, Mg	1

Properties:

- ✓ It is relatively soft, ductile and easily workable under normal temperature.
- ✓ The alloy can be rolled, forged and extruded into various forms and products.
- ✓ The tensile strength of duralumin is higher than aluminum, although its resistance to corrosion is poor.
- ✓ The electrical and heat conductivity of duralumin is less than that of pure aluminum and more than that of steel.

Composition, properties and applications of duralumin

Applications

- ✓ Aircraft frames.
- ✓ Frames of speedboats and automobiles.
- ✓ Lightweight guns like the FAMAS type 97.
- ✓ Surgical and orthopedic work.
- ✓ Manufacturing components of measuring instruments.

6. What is steel? Describe the composition, properties and applications of low-carbon, medium-carbon and high-carbon steel.

Carbon Steel: Composition, Properties and Applications

What Carbon Steel?

- ✓Carbon steel is a common type of steel that is an alloy of iron and carbon.
- ✓It has a higher carbon content, lower melting point and greater durability compared to stainless steel.
- ✓Carbon steel is the most widely used engineering and construction material for industrial applications on a large scale, including marine structures, power plants, transportation, chemical processing and petroleum production and refining.

Carbon Steel: Composition, Properties and Applications

Types of carbon steel and their properties

	Carbon content (wt.%)	*Microstructure*	*Properties*	*Examples*
Low-carbon steel	< 0.25	Ferrite, pearlite	Low hardness and cost. High ductility, toughness, machinability and weldability	AISI 304, ASTM A815, AISI 316L
Medium-carbon steel	0.25 – 0.60	Martensite	Low hardenability, medium strength, ductility and toughness	AISI 409, ASTM A29, SCM435
High-carbon steel	0.60 – 1.25	Pearlite	High hardness, strength, low ductility	AISI 440C, EN 10088-3

Carbon Steel: Composition, Properties and Applications

Applications of Different Carbon Steel.

1. Low-carbon steel

✓Low carbon steels are often used in automobile body components, structural shapes (I-beams, channel and angle iron), pipes, construction and bridge components, and food cans.

2. Medium-carbon steel

✓As a result of their high strength, resistance to wear and toughness, medium-carbon steels are often used for railway tracks, train wheels, crankshafts, and gears and machinery parts requiring this combination of properties.

3. High-carbon steel

✓Due to their high wear-resistance and hardness, high-carbon steels are used in cutting tools, springs high strength wire and dies.

7. Describe the applications of nano incorporated polycarbonate.

Applications of Polycarbonate Nanocomposites.

✓Zinc oxide (ZnO)–polycarbonate (PC) nanocomposite films used for food packaging.

✓Titanium carbide (TiC)- polycarbonate (PC) nanocomposite used for Additive manufacturing.

✓Several polycarbonate (PC) nanocompositse used in several engineering applications, such as automotive, data storage, and construction, among others.

8. What is meant by lacquer? Describe its various constituents and their functions with example.

Lacquer: Content, Functions and Applications

What Does Lacquer Mean?

✓A lacquer is a clear wood coating finish that dries via solvent evaporation. It is used to produce a hard finish that can be polished to exude varying degrees of sheen.

Composition:

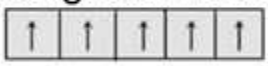
✓lacquer is a solvent-based product made by dissolving nitrocellulose along with plasticizers and pigments in volatile solvents.

✓It also is made with a solution of shellac in alcohol, which creates a synthetic coating and forms a high-gloss surface.

9. What is meant by ferromagnetism? Describe its applications in data storage.

Ferromagnetic

- Permanent magnetism even in the absence of magnetic field, Above a temperature called **Curie** temperature, there is no ferromagnetism.
- Dipoles are aligned in the same direction



- Fe, Ni, Co, CrO_2
- CrO_2 is used in audio and video tapes

10. What is meant by super-paramagnetism?

Magnetic Properties of Nanoparticles

Magnetic properties of nanoparticles

- ✓Magnetic nanoparticles are used for drug delivery, therapeutic treatment, contrast agents for MRI imaging, bioseparation, and in-vitro diagnostics.
- ✓These nanometer-sized particles are superparamagnetic, a property resulting from their tiny size—only a few nanometers.
- ✓Superparamagnetic nanoparticles are not magnetic when located in a zero magnetic field, but they quickly become magnetized when an external magnetic field is applied.
- ✓When returned to a zero magnetic field they quickly revert to a non-magnetized state.
- ✓Superparamagnatism is one of the most important properties of nanoparticles used for biomagnetic separation.

Super-paramagnetism

What is Super-paramagnetism ?

- ✓**Super-paramagnetism** is a form of magnetism which appears in small ferromagnetic or ferrimagnetic nanoparticles.
- ✓In case small nanoparticles, magnetization can randomly flip direction under the influence of temperature.
- ✓The typical time between two flips is called the Néel relaxation time.
- ✓In the absence of an external magnetic field, when the time used to measure the magnetization of the nanoparticles is much longer than the Néel relaxation time, their magnetization appears to be in average zero.
- ✓Then, they are said to be in the super-paramagnetic state.
- ✓In this state, an external magnetic field is able to magnetize the nanoparticles, similarly to a paramagnet.
- ✓However, their magnetic susceptibility is much larger than that of paramagnets.

11. What is meant by optical disk? Give any two examples.

Optical Disc

Optical Disc

- ✓ Optical disc is a form of removable storage.
- ✓ It includes CDs, DVDs and blue ray discs, Optical drives use a leaser to read and write data on optical disc.
- ✓ The leaser stands for *Light Amplification through Stimulated Emission of Radiation*.
- ✓ Laser beam writes on the surface by creating small Pit (hole) in the disc. Optical disc commonly store data in a single track.
- ✓ Optical disc storage capacity is from 700 MB to aseveral GB. The main categories of optical disc are CD and DVD.

CD

- ✓ CD stands for Compact Disc. It is mainly used to store photos, audio and computer software. CDs are available in three types which are read only recordable and rewriteable. Different types of CDs are as follows.

1-CD-ROM

- ✓ CD-ROM stands for compact DISC read-only Memory. The data stored on CD-ROM can only be read. It cannot be deleted or changed. It can store up to 700 MB of data.

USES OF CD-ROM

- ✓ CR-ROM is mostly used to store photos and audios.
- ✓ It is the least expensive way to store data and information.
- ✓ CD-ROM discs are durable and easy to handle.

Disadvantages of CD-ROM

- ✓ The data can't be edited.
- ✓ It retrieves data and information more slowly than magnetic hard disk.

CD

2-CD-R

- ✓ CD-R stands for CD recordable. The user can write data on CD-R only once but can read it many times.
- ✓ The data written on CD-R can't be erased.
- ✓ CD-R drives are known as CD burners. The process of recording data on CD-R is called burning. CD-R is known as WORM (Write Once Read Many).

3-CD-RW

- ✓ CD-RW stands for Compact Disc Rewriteable. It is also known as erasable optical disc.
- ✓ The most common type erasable and rewritable optical disc is magneto-optical disc.

DVD

DVD

- ✓ DVD stands for Digital Video Disc. The storage capacity of DVD is much greater than CD. It can store up to 17 GB of data. DVD are available in three types which are read-only, recordable and rewritable.
- ✓ Types:
- ✓ *1-DVD-ROM*
- ✓ DVD-ROM stands for Digital Video Disc Read Only Memory.
- ✓ It is high capacity optical disc that the users can only read but not write or erase.
- ✓ *2-DVD-R*
- ✓ DVD-R stands for Digital Video Disc Recordable. It is similar to CD-R disc. The written data cannot be erased.

DVD

3-DVD-RW

- ✓ DVD-RW stands for Digital Video Disc Rewritable. The user can write data on CD-RW many times by erasing the existing contents.

BLU-RAY-DISC

- ✓ Blu-Ray Disc is a new and more expensive DVD format. It provides higher capacity and better quality than standards DVDs especially for high-definition video. It can store up to 100 GB of data.

12. What is meant by flash memory storage? Give any two examples.

Flash Memory Storage

Disadvantages

- ✓ Flash Memory is a solid-state chip that maintains stored data without any external power source.
- ✓ It is commonly used in portable electronics and removable storage devices, and to replace computer hard drive.
- ✓ Flash memory is widely used in Smartphone, digital camera, portable media player.

Types of flash Memory.

Solid State Drives

- ✓ The newest flash memory application.
- ✓ SSDs can be replace a computer's hard drive.
- ✓ The have no moving parts, so mechanical failure is near zero.
- ✓ Solid-state drives are quieter and smaller than hard drives, and they provide faster response, access and boot-up times but consume much less power and run cooler.