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Chapter no. 1.

Questions / Answers :-

Q no. 1 List six different property classification of materials that determine their applicability.

Virtually all important properties of solid materials may be grouped into six different categories; (i) mechanical, (ii) thermal, (iii) electrical, (iv) thermal, (v) magnetic (vi) optical (and deteriorative) properties.
+ **Examples (ahead).**

Q no. 2 Cite the four components involved in the design, production and utilization of materials; briefly describe the interrelationships between these components.

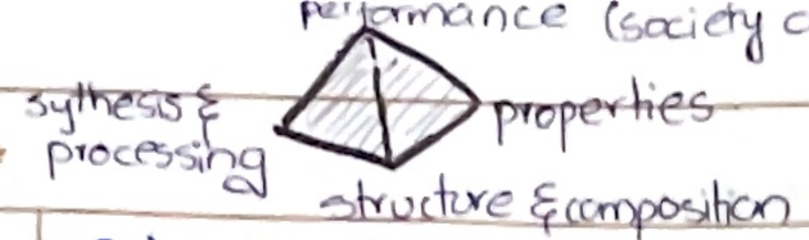
The four components involved are as follows:-

(i) Structure (the arrangement of particles at sub-atomic levels of a substance.) *(b)

(ii) properties (6x ; ↑ that describe applicability of materials) *(c)

(iii) processing (the structure of a material depends on how it was processed) *(a)

(iv) performance (performance of a material is a function of its properties) *(d)



COMPONENT △ OF MATERIAL SCIENCES & ENGIN

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Qno.3 **Cite three Criteria that are important in the material selection process.**

The more familiar an engineer or a scientist is with the various (i) characteristics and
(ii) structure
(iii) property (relationships) as well as;
(iv) processing techniques.

The more proficient and confident he or she will be in making judicious materials choises.

Qno.4

(a) **List three primary classifications of solid materials and then cite the distinctive chemical feature for each.**

The solid materials have been convienently grouped into three basic categories:

(i) metals:-
composed of one or more metallic & non-metallic (same) elements. The are composed of metallic bondings and consist of many localized (non) electrons (free electrons); this accounts for their unique properties like heat & electric conduction.

* composites are two or more individual materials that come from metals, ceramics, and polymers.

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(ii) Ceramics:- (they are oxidies, nitrides & carbides) Compounds between metallic and non-metallic elements. Example:- Al_2O_3, SiO_2, SiC, Si_3N_4.

Traditional ceramics are composed of clay minerals e.g: porcelain, cement, glass.

* The have ionic or covalent bonding (& often both).

(iii) Polymers:-
They include familar plastics, rubber, organic compound (containing C-H bonds) and other non-metallics as (O, N & Si)
Example:- PE, PVC, PC, PS

* They have a backbone of Carbon chain thus organic covalent bondings.

Qno.b **Note all four advanced materials, and for each; its distinctive feature(s).**

Materials utilized in high-technology or (high-tech) applications are sometimes termed as advanced materials, device/product that functions on intricate and sophisticated principles, including CD's, camcorder or DVD players etc. They include:

(i) Semi-conductors:

a. Electrical properties intermediate between electrical conductors and insulators

b. The are highly sensitive in electrical properties even at the presence of a little impurity conc.

c. They are essentially used in ICs that has revolutionized the tech industry.

(ii) BIO-MATERIAL:- (e.g. metals, creamics, polymers, semi-conductors.)

a. Materials implanted into the human body to replace diseased / damaged body parts.

b. The should be non-toxic & bio compatible.

[Qno.5(a)] same answer ↓

(iii) SMART MATERIALS:-
(new-state of the art)

smart →

a. They have the ability to change in their environment & respond to changes (for input)

b. They are in sophisticated (components include sensor & actuators (respond)) systems having both smart + traditional materials

- → shape memory alloys (revert to org. shape at certain temp)
- → piezoelectric ceramics (expand/contract with $\Delta \vec{E}$ and produce ↓)
- ← → magnetostrictive materials. (same as piezo but with $\Delta \vec{B}$)
- → electrorheological / magnetorheological fluids (Δ in viscosity with Δ in $\vec{B}$ or $\vec{E}$)

(iv) NANO-MATERIALS

a. Any material with any dimension at a nano-scale is called as a nanomaterial.

b. There properties depend upon; size of particles, quantum mechanical effect, surface phenomena.

c. Examples:- Catalytic convertes, Nanocarbons, Nanocomposites etc.

Qno.5 (b) Briefly explain the concept of nanotechnology as it applies to materials.

The general procedure to understand the chemistry and physics of materials was to begin by studying complex / large structures; making our way down to the fundamental block i.e top-down approach. However, with scanning probe microscopes the individual atomic level observation now allows "the ability to arrange atoms carefully to develop mechanical, magnetic and electrical properties that were otherwise not possible. this is called as the bottom up approach and study of these material is termed "nano-technology".

EXERCISE QUESTIONS:-

1.2 List 3 items made from materials (metals) or their alloys : one characteristic that led to this choice.

(i) Stainless-steell :- (alloy of Fe, Ni, Cr etc) chosen for cutlery because it is corrosion-resistant durable and easy to clean.

(ii) Aircraft Frame :- (7075-T6)/Al-alloy (five) chosen due to high strength, lightweight body.

(iii) Copper Wiring :- excellent conductor, mealiable, ductile.

1.3 List 3 items for materials (ceramics)
" " ....

(i) Ceramic tiles :- (Silica, clay etc). flooring; due to hardness, resistance to wear

(ii) Insulating Ceramic Fiber Blanket :- (Alumina-silica Ceramic Fiber) used for insulation in higher temp, applications.

(iii) Porcelain Tableware :- smooth, durable etc.

1.4 List 3 items for materials (polymeric materials).....

(i) PVC pipes :- (Polyvinyl Chlorides) chemical resistance, durability, low cost.

(ii) PE plastic water bottles :- (Polyethylene) lightweight, durable, resistance to cleaning

(iii) Nylon Backpack :- (Polyamide) used due to strength, abrasion resistance & lightweight.

SLIDE QUESTIONS:-

Q no.1 (Examples) Biological properties: self replicating; Radioactivity; etc.

A property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus.

(i) Mechanical properties; relate to deformation by applied force e.g stifness, strength & toughness.

(ii) Electric properties (stimulus: $\vec{E}$) e.g:- Electrical conductivity and diaelectric constant,

(iii) Thermal properties e.g: thermal conductivity and heat capacity, insulator, refractory.

(iv) Magnetic properties e.g:- response to $\vec{B}$ applications, dia & paramagnetic.

(v) LCD & cameras. Optical properties e.g:- reflectivity and index of refraction (stimulus is electromagnetic & light radiation).

(vi) Deteriorative e.g:- (related to chemical reactivity of material) composition, structure, bonding, corrosive, toxic, pollutant, inert, bio degradable.

Q. What is material Science or engineering.

From a functional perspective, the role of a material scientist is to develop/synthesize new materials, whereas a material engineer is called upon to create new product/system from the exisiting material. However, almost all material program train a graduate to do both.

* Therefore it requires the knowledge of science, (phys, maths, chemistry), mechanic and english with experience and imagination.

Bone, Bronze, Plant Fibres.

Q. Historical perspective of Material Sciences.

Q. List of material available for ancient people.

In historical perspective, the developement of the societies is measured through their advancements in material science; categorizing as (i) stone age → (ii) Bronze age → (iii) Iron age. Early humans had access to only stone, wood/clay etc, skin however it was noted with time that heat treatement alters the properties of materials; with time more knowledge or material properties gathered as it made revolutionary design for different product much easier.

Example:-

(i) Creation of vehical through steel as a relatively cheap alternate.

(ii) Advancement in technology through semi-conducting material.

* now nanotechology is emerging.

Q. What is Nanotechnology.

Nanotechnology is refered as the branch of science of and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at a nanoscale.

↓

(have one of more dimension of 100 nm or 100×10^{9} of a 10^{-3} m)

* low carbon steel contains (99.75 wt%. Fe + 0.25 wt%. C).

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* only 99% Fe pure can be acquired. due to carbon impurities.

Q. Enlist some useful properties of Iron (use comparison to explain).

(i) Iron is available abundantly on the Earth crust. (7%.)

(ii) Iron deforms easily as compared to glass or stone; therefore much more easier to work with.

(iii) Iron is more ductile (than glass, stone etc) therefore can be shaped.
(However brittle with addition of certain C%.)

(iv) Iron is tougher than stone, glass and china ware. Therefore it more malleable.

(v) Iron is more machinable due to having properties like ductility & toughess in comparison to glass, stone etc that is brittle.

(vi) Iron as steel is more/good weldable in contrast to glass/stone etc due to properties like → ductility
→ toughness
→ thermal conductivity etc.
↓
i.e resistance against thermal Cracking

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Q. Undesirable properties of Iron:-

Corrossion → structural degradation
→ costly excessive preventive measure maintaince challenges

Q. DEFINE; machinability and weldability.

machinability: The measure of how a material can be cut, shaped or removed by tools during processes like
(i) mining
(ii) turning
(iii) drilling
(helps in manufacturing.)

weldability: Measure of a materials to be welded or joined together by various welding processes.
(helps in developing structural integrity of various materials).

Q. Which properties of materials are useful for improving our lifestyle?

(i) Availability
(ii) Economic feasibility.
(iii) Sustainability
(iv) Durability. / Lifetime (e.g mechanical strength, non-corrossive)
(v) Environmental friendly.

(bend, mould, shape)
ability to deform plastic before it rupture.

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Q. Define brittleness, ductility and toughness.

brittleness ↙ : tendancy to fracture without significant plastic deformation.

ductility ↓ : energy absorption capacity (toughness) before its fracture point.

Q. How can material sciences provide options to consumers?

Q. With example describe the evolution of materials!

Soda water packaging.

Glass (heavy, costly transport, brittle)
↓
Tin (less product packaging)
↓
plastic. (Final solution
↙ ↘
(recyclable few biodegrable)
etc

* we design products as per our needs & wishes.

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Q. How do materials respond when subjected to;

(i) Mechanical force.
(ii) electrical force.
(iii) magnetic fields.
(iv) optical fields.
(v) temperature gradients.
(vi) corrosive/chemical environments.

Q. Describe the optical performance of Al_2O_3 as a result of processing.

The three thin disks show different optical performance due to the difference in structures obtained from the different methods of processing.

a. Right most disk:- (Poly Crystalline & porous)
It is composed of numerous small, interconnected crystals with a large no. of small pores / void spaces. These pores effectively scatter light and render the material opaque.

b. Centre disk:- (Polycrystalline)
It is composed of numerous small crystals that are all connected; the boundaries between the small crystals scatter a portion of light which makes the material translucent.

c. Left most disk:- It is the single crystal with high degree of perfection that gives it transperancy.

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Graph?

Q. Order of Fracture toughness of diff types of materials / energy absorption ability.

(i) Metals (most resistant to fracture).
(ii) Composites
(iii) Ceramics ?
(iv) Polymers. ?

?
Graph!

Q. Electrical Conductivity of different materials

(i) Metals (Most conductive)
(ii) Semi-Conductors
(iii) Polymers
(iv) Ceramics.

Image description:-

(1) Crystalline structure (Diamond)
(2) layered structure (graphite)
(3) Bucky ball
(4) Carbon nanotube (0.14nm interatomic distances).
142 pm → 341 pm

* a single crystal is a homogenous structure with a certain grain boundary, when many crystal & their boundary(s) combine = poly crystalline.

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Q. Can the earlier described structure be electrically conductive.

Diamond :- excellect insulator.
Graphite : good conductor. (delocalized electrons)
Bucky ball : poor conductors
Carbon nanotube : excellent conductors (variable ↑ & structure)
↳ (one dimensional structure.

Q. Describe the tyndall Effect.

The refeletion of light, variating color spectrum can be described by the tyndall Effect that describes as.

Dispersion of light spectrum on a particle ∝ the size of the particle.

Q. Why is there a need of modern materials?

(i) Replace energy used in transportation/enhance it.
(ii) New economical energy source developement.
(iii) Reduce pollution.

↓
OR

(i) Discovery of additional Resources.
(ii) developement of new material with comparably less hazardous environmental effects.
(iii) Increase recycling efforts / new recycling technologies.

Q Describe.

Structure of an atom.	structure of a molecule.
Subatomic particles protons, neutrons, ēs	Many atomic particles and atoms combine to form it.
Nucleus	Bonding has type
(electrostatic forces of attraction / repulsion)	↙ ↘
	covalent ionic.

Q. Describe structures:

Diamond	Graphite	Graphene	B.B
- tetrahedral carbon structure - 3x dimensional crystal lattice. - Covalent bonds	- layer of C in hexagonal lattice - planar layered structures - Vander wall forces.	1x layer of Carbon atom - hexagonal lattice - Covalent bonds.	O cage C-60 atoms - Covalent bonding.

Q. How can we enhance 'fuel efficiency' in transportation?

(i) Reducing weight of the transportation vehicals
(ii) improving engine operating temperature.
(iii) developing new, high strength low density material

Q. Can Nuclear energy be used as modern solution to our problems?

Nuclear energy holds some promise, but the solution to many problems that remain necessarily involve materials such as fuels, containment structures, and facilities for the disposal of radioactive waste.

Q. Describe the surface phenomena in nano-materials.

When the size of the material/particle decreases, the no of particles on the surface of the materials (component) increases this is known as the surface phenomena.

Q. Describe /enlist some practical uses of nano-materials.

- Catalytic converters for automobiles.
- Nano carbons (B B, carbon nanotubes)
- Nano composites.
- Magnetic nanograins (HHD).
- Magnetic particles (in magnetic tapes) to store data

Q. Give example of smart system.

One type of smart system is used in helicopters to reduce aerodynamic cokpit noise created by rotating rotar blade. Piezoelectric sensors inserted into the ~~set~~ blades stresses and deformations. feedback signals ~~from these signals from~~ these sensors are fed into a computer-controlled adaptive device that generates noise-cancelling antinoise.

Galaxy

natural composites :- wood & Bone.
synthetic " :- fiberglass (stiff, strong flexible).
:- CFRP

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Q. Why do we study material sciences?

Due to;

(i) Application in engineering and design.
(ii) Deterioration Considerations.
e.g effect of exposure of light/heat etc.
(iii) Economic factors.
(iv) Compromises and decision making
(v) knowledge & proficiency.

Q. Describe the cycle that can enhance the performance of a material. (as per the society demands)