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Internal Assessment Test 3 – November, 2017

Sub:	Engineering Physics					Sub Code:	17PHY12	Branch:	ECE/EEE/ME
Date:	18/11/2017	Duration:	90 mins	Max Marks:	50	Sem / Sec:	I / I,J,K,L,M,N,O		OBE

<u>Answer any **FIVE FULL** Questions</u>

Note: Value of Constants: $h = 6.625\times10^{-34}$ Js $k = 1.38\times10^{-23}$ J/K $m = 9.11\times10^{-31}$ kg. $e = 1.6 \times 10^{-19}$ C, $c = 3\times10^{8}$ m/s

		MARKS	CO	RBT
1 (a)	Define atomic packing factor. Calculate the packing factor for sc, bcc and fcc structures.	[07]	CO102.4	L3
(b)	Nickel has fcc structure and the lattice constant is 0.35 nm. Calculate the atomic radius.	[03]	CO102.4	L2
2 (a)	Describe the crystal structure of diamond with the help of a neat diagram.	[06]	CO102.4	L2
(b)	Draw the following planes in a cubic unit cell: (100), (101), $(1\bar{2}1)$ and (123)	[04]	CO102.4	L3
3 (a)	Explain the construction and working of Bragg's X-ray spectrometer.	[06]	CO102.4	L3
(b)	A monochromatic X-ray beam of wavelength 1.5 Å undergoes first order Bragg reflection from the plane (202) of a cubic crystal at a glancing angle of 30^{o}. Calculate the lattice constant.	[04]	CO102.4	L2
4 (a)	What are shock waves? Mention the applications of shock waves.	[05]	CO102.5	L2
(b)	Define the following: Mach number, Subsonic waves, Supersonic waves, Hypersonic waves and Ultrasonic waves	[05]	CO102.5	L1
5 (a)	Describe the construction and working of Reddy shock tube.	[07]	CO102.5	L3
(b)	The time taken by a shock wave to travel a distance of 80 mm is 100 µs. Calculate the Mach number of the shock wave if the velocity of sound wave in the same medium is 340 ms^{-1}.	[03]	CO102.5	L2
6 (a)	Explain density of states for various quantum structures.	[07]	CO102.5	L2
(b)	Mention the advantages of sol- gel method of synthesizing nanomaterials.	[03]	CO102.5	L2
7 (a)	Explain the construction and working of scanning electron microscope (SEM).	[07]	CO102.5	L3
(b)	Write a short note on Carbon Nanotubes.	[03]	CO102.5	L2

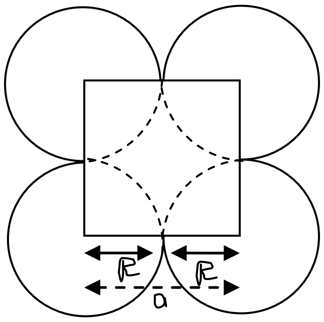
Scheme of evaluation-TEST 3 NOV 2017

1.a.

Packing factor:

It is the ratio of total volume occupied by the atoms in the unit cell to the total volume of the unit cell.

For simple cubic structure:



Number of atoms per unit cell = 1

Volume of one atom = $\frac{4}{3}\Pi R^3$

Volume of the unit cell = a^3

Here a = 2R,

∴ Volume of the unit cell = $8R^3$

Packing factor = $\frac{4\Pi R^3}{3a^3} = 0.52$

For BCC structure:

BCC:

Number of atoms per unit cell = 2

∴ Volume of two atoms = $2.\ \frac{4}{3}\Pi R^3$

Volume of the unit cell = a^3

For BCC, a = $\frac{4R}{\sqrt{3}}$

∴ Volume of the unit cell = $\frac{64R^3}{3\sqrt{3}}$

Packing factor = 0.68

For FCC structure:

Number of atoms per unit cell = 4

Volume occupied by four atoms = 4 X $\frac{4}{3}\Pi R^3$

For FCC, a = $R.2\sqrt{2}$

Volume of the unit cell = a^3 = $16\sqrt{2}\ R^3$

Packing factor = (16/3) Π R^3 / $16\sqrt{2}\ R^3$ = 0.74

1.b. For FCC, a = $R.2\sqrt{2}$

R = 0.123nm

2.a. Structure of Diamond:

Diamond structure consists of two inter penetrating face centered cubic lattices. The two lattices are separated by (1/4) of the body diagonal. The coordination number is 4 as each carbon atom is surrounded by 4 other carbon atoms situated at the corners of a regular tetrahedron.

The unit cell for this structure is an FCC with a basis made up of two carbon atoms associated with each lattice site .Number of atoms per unit cell is 8.The positions of two basis atoms are (0 0 0)and $(\frac{1}{4}\frac{1}{4}\frac{1}{4})$.

Packing factor = Volume occupied by atoms/ volume of unit cell

$$=8\left(\frac{4}{3}\right)\frac{\pi R^3}{a^3}$$

From the diagram $2r = \frac{2\left(\frac{a}{4}\right)^2 + \left(\frac{a}{4}\right)^2}{}$

Simplify $a = 4r/\sqrt{3}$

So, APF = 0.34

2.b.

(123)

$(1\,\bar{2}\,1)$

(101)

(101)

3.a.

X-ray diffraction spectrometer:

Apparatus: A source of X-ray, slits, crystal mounted on a circular turn table spectrometer with vernier scale.

Construction: X –ray beam after reflection from the crystal enters the ionization chamber mounted on a mechanical arm which can turn co axially with the turn table .This ionization chamber is coupled with the turn table so that if the turn table rotates through an angle ‘θ’, the ionization chamber rotates through ‘2θ’.The ionization current produced by X-rays is recorded by the electrometer.

Working: The ionization current is measured for different values of glancing angle ‘θ’. A plot is then obtained between ‘θ’ and ionization current .For certain values of ‘θ’, the intensity of Ionization current increases abruptly.

Whenever the crystal receives X-rays at an angle of incidence satisfying Bragg’s law

$2d \sin\theta = n\lambda$,constructive interference takes place and maximum intensity occurs .The rise in current occurs more than once as ‘θ’ is varied because the law is satisfied for various values of ‘n’ i.e., $2d \sin \theta = 1\lambda, 2\lambda, 3\lambda$ etc.

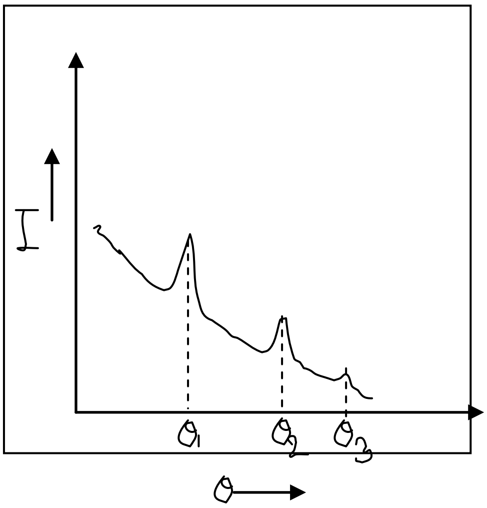
Turn table on which powdered crystal is taken

Vernier scale

slit

Coolidge tube (Source of X-ray)

Electrometer



Crystal structure identification

d_{100}:d_{110}:d_{111}	**1:1/√2:1:√3**	**SC**
d_{100}:d_{110}:d_{111}	**1:2/√2:1:√3**	**BCC**
d_{100}:d_{110}:d_{111}	**1:1/√2:2:√3**	**FCC**

3.b.The required formula is $d_{hkl} = \dfrac{a}{\sqrt{h^2 + k^2 + l^2}}$

From Bragg's law, 2d SinΘ = nλ

d = 1.5À

a = 4.23À

4.a.

Shock waves: When air undergoes large and rapid compression (following an explosion/the release of engine gases in to an exhaust pipe/when an air craft or a bullet flies at supersonic velocity) a thin wave of large pressure change is produced. This discontinuity is pressure propagates as a wave known as shock wave. A shock wave develops when the flow is supersonic.

Applications:

- Aerodynamics – hypersonic shock tunnels, scramjet engines.
- High temperature chemical kinetics – ignition delay
- Rejuvenating depleted bore wells
- Material studies – effect of sudden impact pressure, blast protection materials
- Investigation of traumatic brain injuries
- Needle-less drug delivery
- Wood preservation

4.b.

Mach number is the ratio of velocity of fluid causing the shock wave generation to the velocity of sound in the medium. It represents the compressibility nature of the medium.

Subsonic waves: These are sound waves with Mach number less than 1. Velocity of the object is less than velocity of sound.

Ex: Low intensity shock waves produced during the motion of ordinary aircrafts.

Super sonic waves: These are shock waves with Mach number greater than 1. Velocity of the object is greater than velocity of sound.

Ex: shock waves produced during the motion of jet planes, bullets etc.

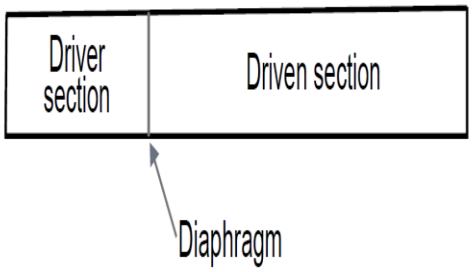
Hypersonic Wave: These are the shock waves with Mach number > 5.

Ultrasonic waves are the sound waves with frequency greater than 20,000Hz.

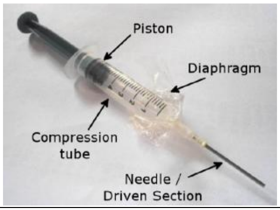
5.a. **Reddy shock tube:**

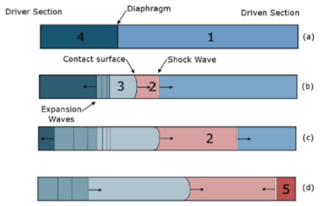
A shock tube is a device used to study the changes in pressure & temperature which occur due to the propagation of a shock wave. A shock wave may be generated by a small explosion caused by the buildup of high pressure which cause diaphragm to burst.

It is hand driven open ended shock tube.It was conceived with a medical syringe. A plastic sheet placed between the plastic syringe part and the needle part constitutes the diaphragam.



- A high pressure (driver) and a low pressure (driven) side separated by a diaphragm.
- When diaphragm ruptures, a shock wave is formed that runs along the driven section.
- Shock strength is decided by driver to driven pressure ratio, and type of gases used.



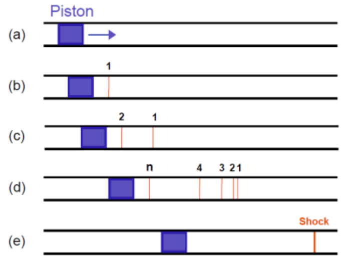


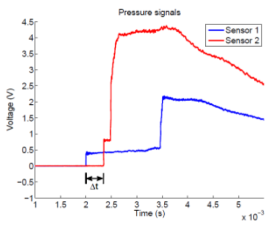
Working:

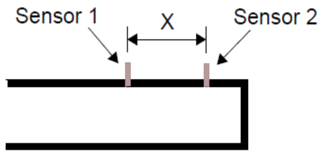
- The piston is initially at rest and accelerated to final velocity V in a short time t.
- The piston compresses the air in the compression tube. At high pressure, the diaphragm ruptures and the shock wave is set up. For a shock wave to form, $V_{piston} > V_{sound}$.

  Formation of shock wave:

  As the piston gains speed, compression waves are set up. Such compression waves increase in number. As the piston travels a distance, all the cpmpression waves coalesce and a single shock wave is formed. This wave ruptures the diaphragm.







$$U_s = \frac{X}{\Delta t}$$

5.b.

Mach Number =

$$\frac{V_{Shoch}}{V_{Sound}} = \frac{dx/dt}{340} = \frac{0.080/100\times10^{-6}}{340} = 2.35$$

6.a. Nano materials possess dimensions of 0.1 to 100nm.Their properties are dependent on their dimensions. Many parameters such as density of states, energy gap, electrical &, thermal conductivity etc, are different from that from their bulk counterparts.

6.a. Density of states:

It is defined as the number of energy levels per unit energy range per unit volume.

g(E)(dE) = $\left[\frac{8\sqrt{2}\pi m^{\frac{3}{2}}a^3}{h^3}\right]E^{\frac{1}{2}}$ dE

Bulk Material (3D):

Densitv

Energy E

(2D)

Density of

Energy E

g(E)(dE) = $\frac{m^*}{\pi\left(\frac{h}{2\pi}\right)^2}\left(E-E_i\right)$ dE

(1D)

Density of

Energy E

g(E)(dE) = $\frac{1}{\left(\frac{h}{2\pi}\right)}\sqrt{\frac{m*}{2(E-E_i)}}$ dE

0D

Density of states

Energy E

6.b. **Sol-gel Method:**

This method involves two types of materials ‘Sol’ and ‘Gel’.

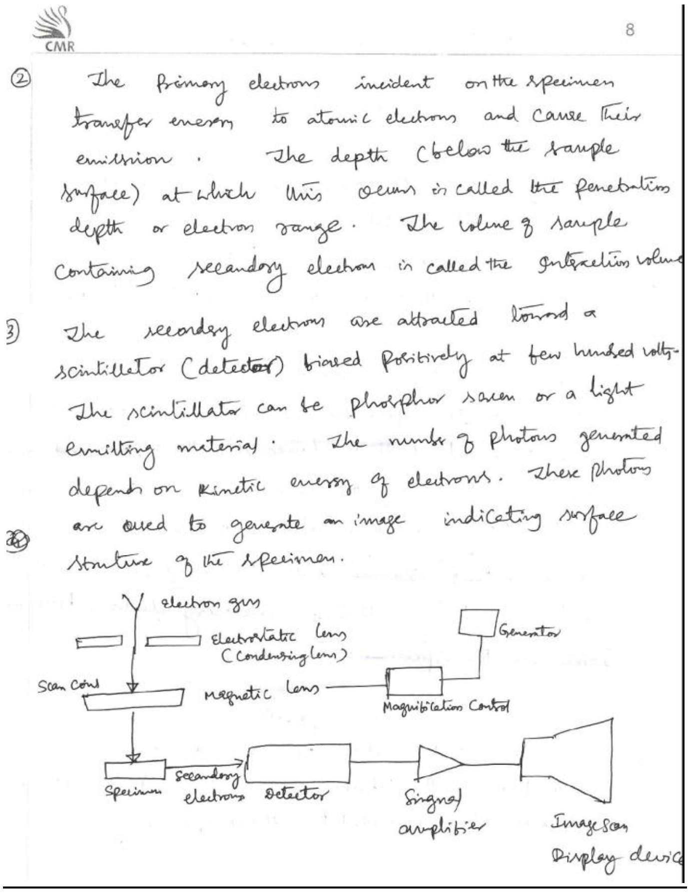
Principle:Sol-Gel method involves formation of ‘sols’ in a liquid and then connecting the sol particles to form a network.By drying the liquid, it is possible to obtain powders, thin films etc.,

Methods for sol-gel formation: Sol can be obtained by,

•Hydrolysis
•Condensation and Polymerization of monomers to form particles
•Agglomeration of particles

After the formation of sol by hydrolysis, evoparation of solvent results in formation of network (gelation) which extends throughout the liquid medium known as gel. Si-O_2-ZnS :Mn^{2+} sol is prepared by this method.

7.a.**Scanning electron Microscope:**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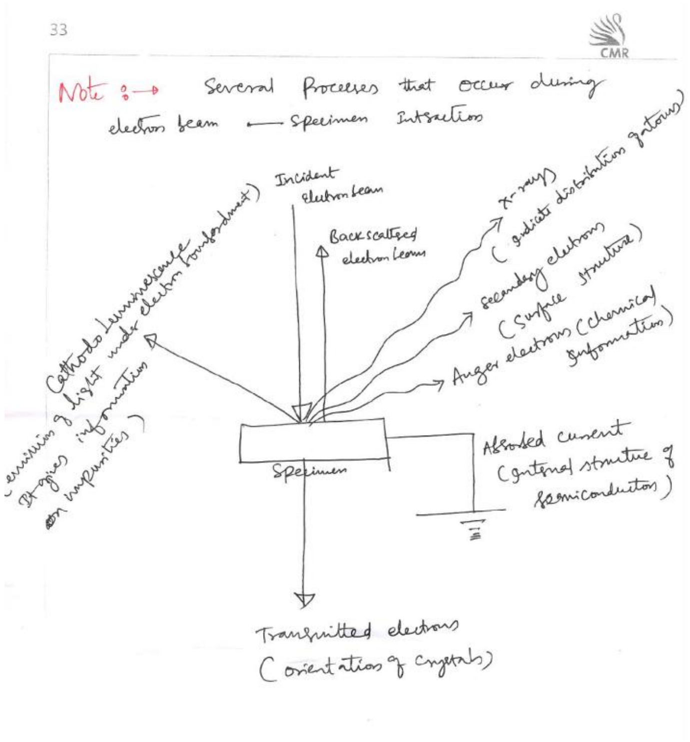
② The primary electrons incident on the specimen transfer energy to atomic electrons and cause their emission. The depth (below the sample surface) at which this occurs is called the penetration depth or electron range. The volume of sample containing secondary electron is called the interaction volume

③ The secondary electrons are attracted toward a scintillator (detector) biased positively at few hundred volts. The scintillator can be phosphor screen or a light emitting material. The number of photons generated depends on kinetic energy of electrons. These photons are used to generate an image indicating surface structure of the specimen.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7.b. **Carbon nano tubes:**

A carbon nano tube (CNT) is a cyclindrical rolled up sheet of graphene which is a single layer of Graphite atoms arranged in hexagonal pattern.Each nanotube is a single molecule composed of millions of atoms. The length of CNT is around 100µm.Their hexagonal structure provides great tensile strength and elastic properties. Graphene sheet can be rolled in more than one way, producing different types of CNT's like arm chair, Zig-Zag and Chiral structures.
They possess high thermal and electrical conductivity,chemical reactivity.

Arm Chair:

Zig Zag

Chiral

Rolling up the carbon sheet along one of the symmetry axis gives either a zig-zag (m=0) tube or an armchair tube. If the carbon-carbon bonds that parallel to the tube axis it produces a "zig-zag" pattern at the open end. These tubes are referred to as "zig-zag" tubes. If the carbon-carbon bonds are perpendicular to the tube axis, they are referred as "armchair" tubes.It is also possible to roll up the sheet in a direction that differs from a symmetry axis to obtain a chiral nanotube. As a well as the chiral angle, the circumference of the cylinder can also be varied.

Applications :
1.Energy storage: Graphite electrodes are commonly used in cells,batteries.
2.Hydrogen storage:Suitable Hydrogen storage system is necessary for fuel cells.Due to their small dimensions, CNT can store Hydrigen in inner cores.
3.Supercapacitors:They have hig capacitance.Very large capacities result from the high nanotube surface area.
4.Making of Nanoprobes and sensors
5.Making of Semiconductor devices such as ansistors
6. High efficiency PV cells.