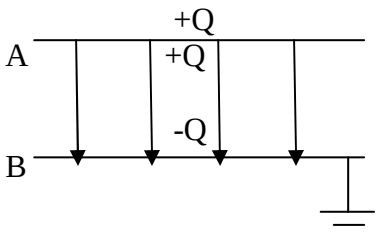
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
		Important Instructions to examiners: 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme. 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate. 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills). 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn. 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer. 6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding. 7) For programming language papers, credit may be given to any other program based on equivalent concept.		

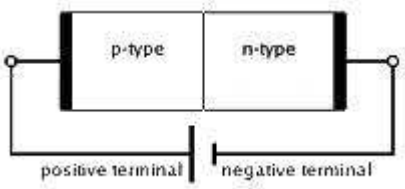
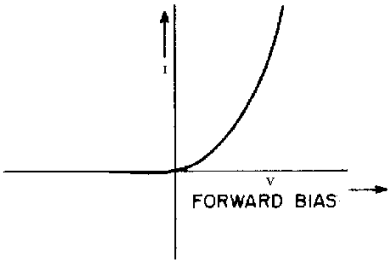
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
1)		**Attempt any Nine**		**18**
	a)	**Define specific resistance and state its SI Unit**		
		Definition	1	
		unit	1	2
		It is defined as a resistance of wire of unit length and unit cross-sectional area. OR The resistance of 1m long conductor having $1m^2$ area of cross-section. SI unit is ohm-meter OR Ω-m.		
	b)	**State the working principle of Wheatstone's network.** **principle** **Principle:-** It is an arrangement of four resistances. If the values of three resistances are known we can find the value of unknown resistance by using balancing condition.	2	2
	c)	**Mention uses of potentiometer.** **Any two uses** **Uses** i) To measure emf of cell. ii) To compare emf of two cells. iii) To determine internal resistance of cell. iv) To determine accurately potential difference (P.D) across the component.	2	2
	d)	**When a charge of 0.04 μC is given to a capacitor, its potential is raised to 200 Volts, find its capacitance.**		
		Formula and substitution	1	
		Answer with Unit	1	2
		Given: $Q = 0.04\ \mu C = 0.04\times10^{-6}\ C$ $V=200\ V$ $C=?$ We have, $C = \frac{Q}{V} = \frac{0.04\times10^{-6}}{200}$ $C = 0.0002 \times 10^{-6}\ F$ OR $C=0.0002\ \mu F$		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
1)	e)	**Define conduction band and valence band.** **Each definition** **Conduction band:-**The energy band which is occupied by conduction electrons is called conduction band. **OR** The lowest unfilled energy band is called conduction band. **Valence band:-**The energy band which is occupied by valence electrons is called valence band. **OR** A band having highest band energy is called valence band.	1	2
	f)	**Explain how P-N junction diode is formed.** When P-type of material is added to N-type of material then the P-N Junction diode is formed. In the P-region concentration of hole is more and in N-region concentration of electron is more. When P-N junction is formed some electron from N-region cross the junction and diffuse into the P-region. Similarly some holes from P- region cross the junction and diffuse into N-region. Recombination of holes and electrons takes place in the junction.	2	2
	g)	**State Planck's quantum Hypothesis** **Statement** **Planck's Hypothesis:** According to this theory energy is not emitted or absorbed continuously but in a discrete units or packets called photon or quanta.	2	2
	h)	**Find minimum wavelength of X rays produced by an X ray tube operated at 12 V.** **Formula and substitution** **Answer with Unit** Given : V = 12V $\lambda = \frac{12400}{V} = \frac{12400}{12}$ $\lambda = 1033.33\ A^0 = 1033.33 \times 10^{-10}$ m	1 1	2
	i)	**State the properties of LASER.** **Any two Properties** i) **The light is coherent:** The light with waves, all exactly in same phase. ii) **The light is monochromatic:** The light whose waves all have the same frequency or wavelength. iii) **The light is unidirectional:** The light produces sharp focus. iv) **The beam is extremely intense:** The light has extreme brightness	2	2

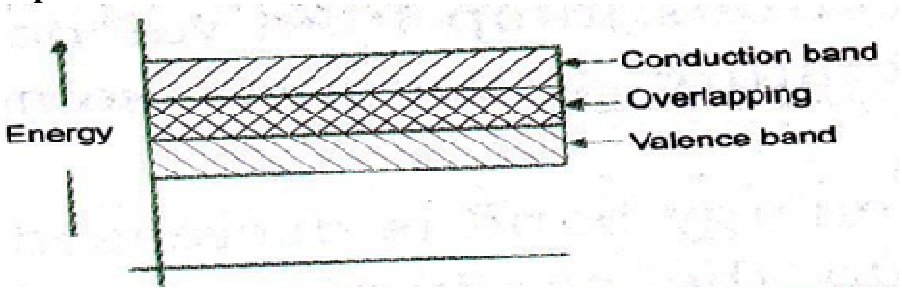
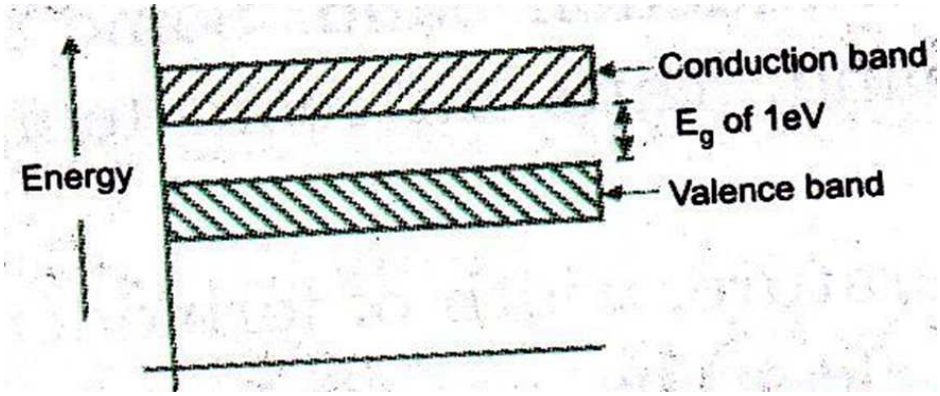
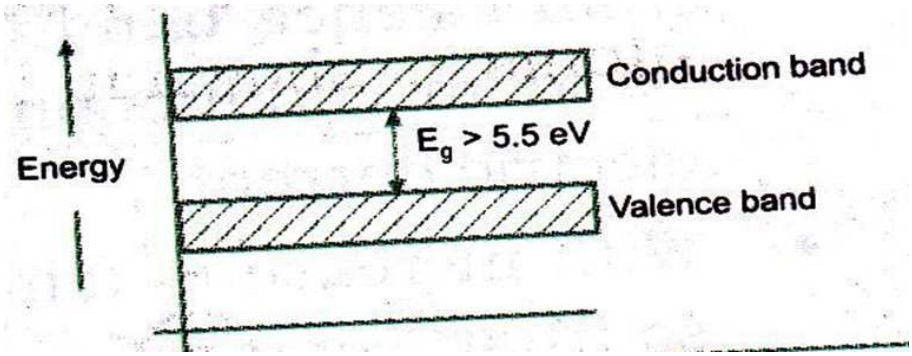
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
1)	j)	**Define spontaneous and stimulated emission.** **Each definition** **Spontaneous emission:** When the electron jumps from higher energy state to lower energy state on its own accord, the emission is known as spontaneous emission. **Stimulated emission:** When the electron jumps from higher energy state to lower energy state by triggering, (supplying external energy) the emission is known as stimulated emission.	1	2
	k)	**What is nanotechnology? Define nanoscale.** **Each definition** **Nanotechnology:-**The branch of engineering that deals with things having the dimensions smaller than 100 nm is called nanotechnology. **Nanoscale:-**The scale range from 1nm to 100 nm is called nanoscale. **Any relevant answer may be considered.**	1	2
	l)	**State two properties of nanoparticles.** **Any two properties.** i) Mechanical property. ii) Structural property. iii) Thermal property. iv) Electric property. v) Magnetic property. vi) Optical property.	2	2

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2		**Attempt any Four**		16
	a)	**Calculate resistance of 3 m length of wire having diameter 0.6 mm and specific resistance 0.35 x 10^{-6} Ωm.**		
		Formula and substitution	2	4
		Answer with Unit	2	
		Given : L= 3m Diameter (d) =0.6 mm Radius (r) = $\frac{d}{2}$ =0.3 x 10^{-3} m ρ = 0.35 x 10^{-6} Ωm R = ? Formula $R = \frac{\rho L}{A} = \frac{\rho L}{\Pi r^2} = \frac{0.35 \times 10^{-6} \times 3}{3.14 \times (0.3 \times 10^{-3})^2}$ **R =3.715 Ω**		
	b)	**Four resistance in Wheatstone's network are 2Ω, 4Ω,R3Ω and 6Ω respectively in a cyclic order, calculate the resistance R3 to balance the network.**		
		Formula and substitution	2	4
		Answer with Unit	2	
		Given: R_1 = 2Ω, R_2=4Ω, R_3=? R_4= 6 Ω We have $\frac{R_1}{R_2} = \frac{R_4}{R_3}$ $R_3 = \frac{R_4 \times R_2}{R_1} = \frac{6 \times 4}{2}$ **R_3 = 12 Ω**		
	c)	**Obtain an expression for the capacity of parallel plate condenser.**		4
		Diagram	1	
		Explanation	3	
		Final equation of capacity		
				

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2	c)	Consider two metal plates A and B as shown above, Let A = Area of each plate d= Distance between two plate +Q = Charge given to A -Q= Charge induce to inner side of B V=P. D. between two electrode k = Dielectric constant of the medium Then, The electric flux density D between the two plate is given by, $D = \varepsilon_0 k.E$ Where, E = Electric Intensity ε_0 = Permittivity of free space But, $D = \frac{\Psi}{A} = \frac{Q}{A}$ (Where, Ψ is electric flux) $\therefore \frac{Q}{A} = \varepsilon_0 kE$ $\therefore \frac{Q}{A} = \varepsilon_0 k \frac{V}{d}$ $\therefore \frac{Q}{V} = \varepsilon_0 k \frac{A}{d}$ $\because \frac{Q}{V} = C$ $\therefore C = \varepsilon_0 k \frac{A}{d}$		
	d)	**Three condensers of capacitance 6µF , 12 µF and 16 µF are connected in series.A potential difference of 220 volt is applied to the combination. How much charge will be drawn across the capacitor.** **Formula and substitution** **Answer with Unit** Given : C_1= 6µF , C_2= 12µF , C_3= 16µF V = 220 V Formula $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_2}$ $\frac{1}{C_s} = \frac{1}{6} + \frac{1}{12} + \frac{1}{16}$	2 2	4

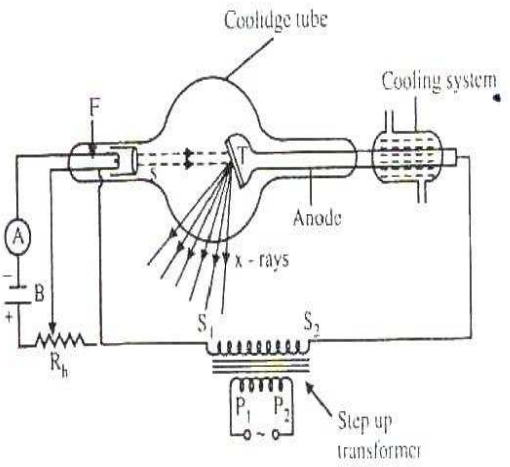
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)	d)	$\frac{1}{C_s} = \frac{8+3+4}{48}$ $\frac{1}{C_s} = \frac{15}{48}$ $C_s = 3.2\ \mu F$ Now $C = \frac{Q}{V}$ $Q = C_s V = (3.2 \times 10^{-6}) \times 220$ **$Q = 704 \times 10^{-6}$ C OR Q = 704 µC**		
	e)	**With I-V curve ,Explain forward biased characteristics of P-N Junction diode.** **Each Diagram** **Explanation**  **Explanation:** Above circuit diagram shows PN junction diode in forward bias mode. In forward bias mode P-type of semiconductor is connected to positive terminal and N-type of semiconductor is connected to negative terminal of battery. As voltage increases current starts flowing through diode. When the voltage applied across PN junction reaches to 0.7V (Si) the current flows through the diode i.e. the diode start conducting current. Following graph shows current voltage characteristics of PN junction forward bias.  *Voltage-current characteristic for a p-n junction.*	1 2	4

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)	f)	**What is photodiode? Explain the principle of photodiode.** **Meaning** **Explanation** **Photodiode:-** It is P-N junction diode with forward bias arrangement which generates electric current when light falls on it. **Principle of the photodiode:** When light is incident on suitably arranged semiconductor diode, then it produces current in the circuit. Light energy → Electrical energy **Explanation:** i) It is covered with a film having exposure window at the junction (at depletion region) of diode and it is always connected in reverse biased condition. ii) When light enters in depletion region, then electron hole pairs are generated which constitutes the current. iii) This photo current depends on the intensity of light.	1 3	4

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)		**Attempt any four of the following**		16
	a)	**Draw energy band diagrams and explain the classification of solids into conductors, semiconductors and insulators, on the basis of band theory of solids.**		
		Diagram	2	
		Explanation	2	4
		 Conductor		
		 Semiconductor		
		 Insulator		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	a)	Explanation: As shown above **conductor, semiconductor and insulators** are distinguished from each other by band theory. In **conductors** there is no energy gap between valance band and conduction band, they are overlapped on each other. So electrons can jump from valance band to conduction band easily and material conducts the current. In **semiconductors** the energy gap between valance band and conduction band is very small i.e. 1eV. So electrons can jump from valance band to conduction band when small amount of energy is supplied to it. Therefore conductivity of semiconductors is in between conductors and insulators. In **insulators** the energy gap between valance band and conduction band is very large i.e. 5.5eV. So electrons cannot jump from valance band to conduction band when some amount of energy is supplied to it. Therefore insulators cannot conduct the current.		
	b)	**If the light of wavelength 4000 A^0 is incident on metal surface of work function 5 eV, will the electrons be ejected or not?** **h =6.63 x10^{-34}Js ,Velocity of light = 3 x 10^8 m/s** **Formula** **Answer with unit** **Conclusion** **Given** $\lambda = 4000\ A^0 = 4000 \times 10^{-10}$ m $W_0 = 5eV = 5 \times (1.6 \times 10^{-19}) = 8 \times 10^{-19}$ J $h = 6.63 \times 10^{-34}$Js $C = 3 \times 10^8$ m/s We have $\upsilon = \frac{c}{\lambda} = \frac{3\times10^8}{4000\times10^{-10}} = 0.75 \times 10^{15}$ Hz And $\upsilon_0 = \frac{W_0}{h} = \frac{8\times10^{-19}}{6.63\times10^{-34}} = 1.206 \times 10^{15}$ Hz **Since $\upsilon < \upsilon_0$ electrons will not be ejected.** **OR** $\lambda = 4000\ A^0$ We have $\lambda_0 = \frac{hc}{W_0} = \frac{6.63\times10^{-34}}{8\times10^{-19}} = 2486\ A^0$ **Since $\lambda > \lambda_0$ electrons will not be ejected.**	1 2 1	4

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	C)	**Explain the production of X-rays using Coolidge tube with a neat labeled diagram**		
		Diagram	2	
		Explanation of Production	2	4

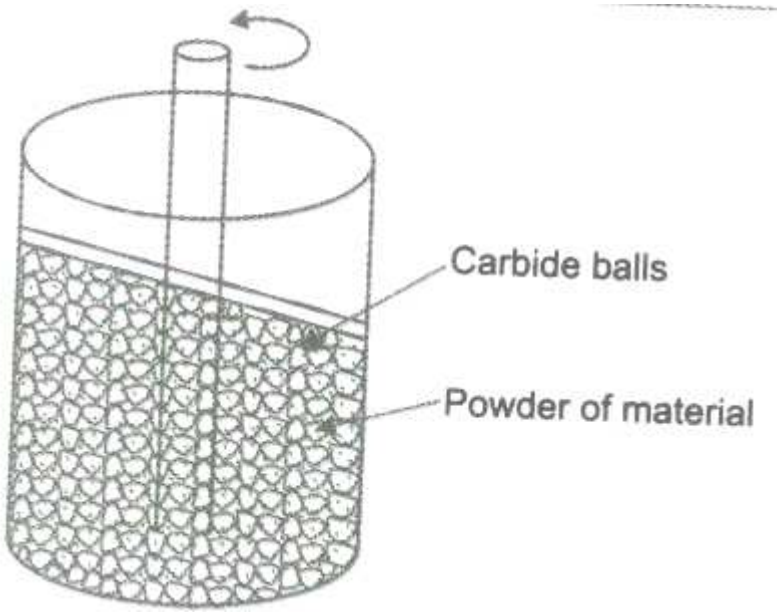


T – Target
F – Metal filament
S – Cylinder
A – Ammeter
B – Battery
R_h – Rheostat
P_1 P_2 – Primary of transformer
S_1, S_2 – Seconday of transformer

Principle:
When fast moving electrons are suddenly stopped then X- rays are produced.

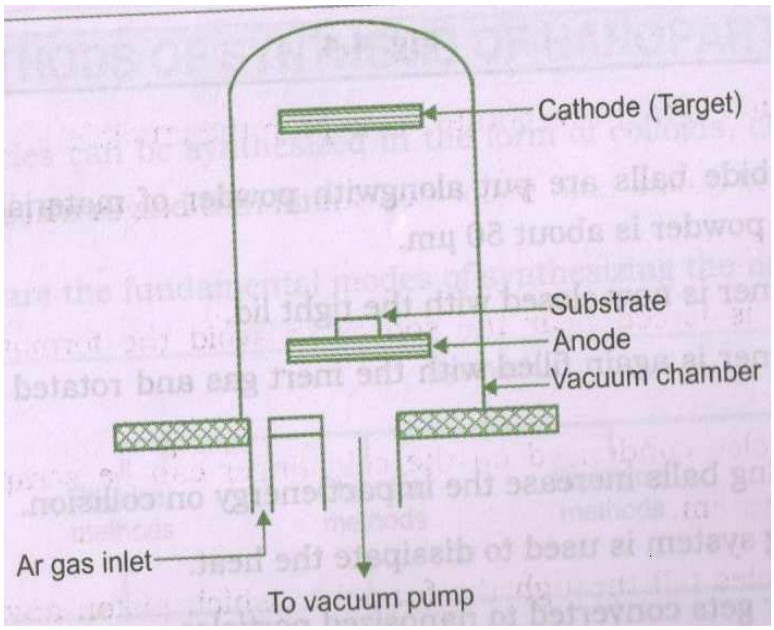
Production:
1. When the cathode is heated by electric current it produced electron due to thermionic emissions.
2. The beam of electron is then focused on the anode (target).
3. The electrons from cathode are accelerated by applying of high voltage between cathode & anode using step up transformer.
4. When these fast moving electrons are suddenly stopped by tungsten anode, they lose their kinetic energy and x rays are produced from the target. Some amount of Kinetic energy is converted to large amount of heat.
5. By controlling the filament current, the thermionic emission of electron hence intensity of X- rays can be controlled.
6. The X-rays of high penetrating power and higher frequency are called hard X-rays and those with low frequency are called soft X-rays.
7. The intensity of X-ray depends on filament current, penetrating power of X-ray depends on P.D. between cathode and anode.

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	d)	**Mention any four engineering applications of LASER.** **Each Application** i) Lasers are used for engraving and embossing of printing plates For example- number plate, name plate etc., ii) Lasers are used in cutting, drilling and welding metals. iii) Lasers are used in holography iv) Lasers are used in computer printers v) Lasers are used for 3D, Laser scanners vi) Lasers are used in controlled heat treatment vii) Lasers are used for data transfer through optical fiber from one computer to other viii) Lasers are used to find flaws or defect in material.	1	4
	e)	**State any four characteristics of photoelectric effect.** **Any four characteristics** i) A metal emits electrons only when the incident (light) radiation has frequency greater than critical frequency (υ_0) called threshold frequency. Threshold frequency different for different metals. ii) Photoelectric current is directly proportional to intensity of light and independent of frequency. iii) The velocity of photoelectron is directly proportional to the frequency of light. iv) For a given metal surface, stopping potential is directly proportional to the frequency and is not dependent on intensity light. v) The rate of emission of photoelectrons from the photocathode is independent of its temperature i.e. photoelectric emission is different from thermionic emission. vi) The process is instantaneous.	4	4

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	f)	**Explain any two physical methods of synthesis of nanoparticles. Any two methods.** **Physical method :** There are two main types of physical methods. I) Mechanical method II) Vapour deposition method In Mechanical method : A) **High Energy Ball Milling method**.  **Principle:** • Harden carbide balls are kept in the rotating container along with powder of material whose nanoparticles are to be formed.	4	4

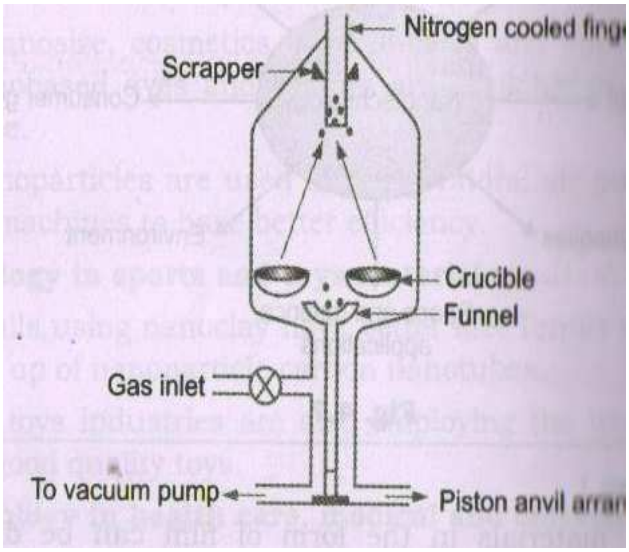
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	f)	**Procedure:** • Heavy carbide balls are put along with powder of material of interest. The size of the powder is about 50µm. • The container is now closed with tight lid. • The container is again filled with inert gas and rotated at few hundreds of rpm. • Heavy milling balls increase the impact energy on collision. • The cooling system is used t odissipate the heat. • The powder gets converted to nanosized particles. • Nanoparticles of Co , Ag-Fe , Al-Fe etc are made by using ball milling. B) **Melt mixing method** : **Principle:** • Nanoparticles of desired meal can be arranged during the formation of the glass. **Procedure:** • Glass consists of heterogeneous elements**.** • In molten material of the glass the stream of desired metal is passed with very high velocity. • The melt of the glass material and desired nanoparticle material is homogenized before cooling. • The different colors of the glass are due to different nanoparticles of the metals added. c) **Vapour deposition method:** **a) Sputtering** **Principle:** Atoms are ejected from the surface by the bombardment of positive ions and then these ejected atoms are made to condense on the substrate to form a thin film. Procedure: D.C. voltage of 1.5 kV is applied across the anode and the cathode at current density of 1 to 10 mA / $cm^{2.}$ Neutral gas like argon inside the chamber at the pressure10^{-1} to 10^{-2} Torr is sent. Due to discharge of electricity, positive ion strikes the target. These positive ions remove the neutral atoms from the target. These atoms eventually condense the thin film on the substrate.		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	f)	Vapour Deposition Method.		



d) **Physical vapour deposition** :

Metals or high pressure metal oxides are evaporated and nanoparticles get condensed on the cold finger.



Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	f)	**Procedure :** Metal which is to be evaporated is kept ion the crucible. Evaporated atoms collide with gas molecules and condense on the cold finger. Inert gas is forced near the source to avoid the formation of bigger particles. Nanoparticles condense on the cold finger can be scraped off inside the vacuum system. Nanoparticles fall to the funnel in which piston anvil arrangement is provided. Using piston anvil arrangement Nanoparticle powder can be compacted into pallet form. The size of Nanoparticle is less than 5 nm.		