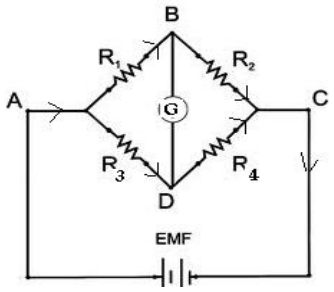
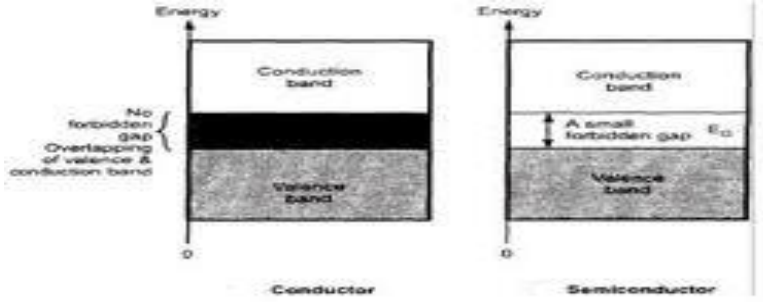
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
		Important Instructions to examiners: 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme. 2) The model answer and the answer written by candidate may vary but the examiner may try to assess 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 resistivity. State it's S. I. Unit.**		
		Definition	1	
		Unit	1	2
		It is also called specific resistance. 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)	**Draw neat circuit diagram of Whetstone's Network.**		
		Diagram with label	2	2
				
	c)	**State the principle of potentiometer.**	2	2
		Principle The fall of potential is directly proportional to the length of conducting wire. $V \propto L$ OR The potential difference between two points of conductive wire is directly proportional to the length/distance between the two points.		
	d)	**A capacitor of capacitance 5μF is connected to a 6V supply. Calculate the charge on the capacitor.**		
		Formula & Substitution	1	
		Answer with Unit	1	2
		Given: $C = 5\mu f = 5\times10^{-6}$ f V=6V Q=? We have, $C = \frac{Q}{V}$ $Q = C\times V$ $= 5\times10^{-6}\times6$ $= 30\times10^{-6}C$ OR $=30\mu C$.		

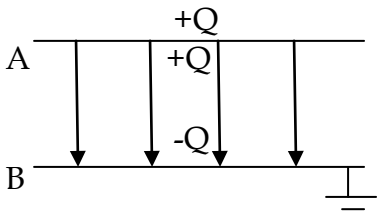
Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
1)	e)	**Draw the energy band diagram for conductors and semiconductors.** **Each Diagram**  	1	2
	f)	**Why Silicon requires 0.7 drop across it before it starts conducting?** **Appropriate Reason** Due to the presence of immobile positive and negative ions on opposite of the junction, electric field is created across the junction. This electric field is called as Barrier Potential. It acts as a barrier to oppose the flow of electrons and holes across the junction. When it starts in conducting state it required 0.7V to break this barrier potential.	2	2
	g)	**State two properties of photon.** **Any two Properties** i. It is an indivisible entity. The existence of photon is same as existence of electron. ii. Photon is electrically neutral. iii. They cannot be deflected by electric or magnetic field. iv. They travel with speed of light. v. Photon does not ionize.	2	2
	h)	**State two properties of X-rays** **Any two Properties** i. They are electromagnetic waves of very short wavelength ii. They travel with speed of light. iii. They affect photographic plates. iv. They produce fluorescence in many substances. v. They can be reflected or refracted under certain conditions. vi. They are not deflected by magnetic or electric field. vii. They have high penetrating power. viii. They produce photoelectric effect. ix. They are invisible to eyes. x. X-ray kill some form of animal cell	2	2

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
1)	i)	**Define optical pumping in LASER** **Definition** The process of raising the atoms from lower energy state to higher excited state using light medium is called optical pumping	2	2
	j)	**Give the full form of LASER.** **Full form** Light Amplification by Stimulated Emission of Radiation.	2	2
	k)	**State two properties of nano material.** **Any two properties** i. Mechanical property. ii. Structural property. iii. Thermal property. iv. Electric property. v. Magnetic property. vi. Optical property.	2	2
	l)	**Mention nano material of zero and one dimension.** **Each example** **Nano material of zero dimension** Nanoclusters **Nano material of one dimension-** Carbon nanotube, nanofiber etc. OR any relevant example.	1	2

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)		**Attempt any Four.**		16
	a)	The resistance of copper wire 200m long is 21Ω. If its thickness is 0.022cm, calculate its specific resistance and conductivity.		
		Two formulae and substitution	2	
		Two answer with unit	2	4
		Given : L= 200m R = 21Ω d = 0.022cm= 0.022×10^{-2}m r = 0.011×10^{-2}m $\rho = R\frac{A}{L}$ $\rho = R\frac{\pi r^2}{L}$ $\rho = 21\times\frac{3.14\times\ 0.011\times10^{-2\ \ 2}}{200}$ $\rho = 0.39\times10^{-8}\Omega m$ $\rho = 0.40\times10^{-8}\Omega m$		
		Conductivity = σ $\sigma = \frac{1}{\rho}$ $\sigma = \frac{1}{0.40\times10^{-8}}$ $\sigma = 2.5\times10^{8}/\Omega m$ $\sigma = 2.5\times10^{8}\ S/m$		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)	b)	**What is the unknown R, if the Whetstone's bridge is balanced** **Two formulae and substitution** **Two answer with unit** Given $R_1 = 10\Omega$ $R_2 = x\Omega$ $R_3 = 10\Omega$ $R_4 = 10\Omega$ *Formula* $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ $\frac{10}{x} = \frac{10}{10}$ $x = 10\Omega$ $x = \frac{RR_5}{R + R_5}$ $10 = \frac{R \times 15}{R + 15}$ $10\ R + 15\ = 15R$ $R = 30\Omega$ Unknown R is 30Ω	 2 2	 4

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)	c)	**Derive an equation of the capacity of a capacitor using parallel plate condenser.**		
		Diagram	1	
		Equation with symbol meaning	2	
		Final equation of capacity	1	4



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,

$$D = \frac{\Psi}{A} = \frac{Q}{A} \qquad \text{(Where, } \Psi \text{ is electric flux)}$$

$$\therefore \frac{Q}{A} = \varepsilon_0 kE$$

$$\therefore \frac{Q}{A} = \varepsilon_0 k \frac{V}{d}$$

$$\therefore \frac{Q}{V} = \varepsilon_0 k \frac{A}{d}$$

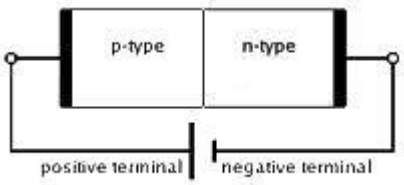
$$\because \frac{Q}{V} = C$$

$$\therefore C = \varepsilon_0 k \frac{A}{d}$$

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
2)	d)	**Three condensers are connected in series across 150V supply. The voltages across them are 40, 50 and 60V respectively and charge on each is $6X10^{-8}C$. Find the capacity of each conductor and also of the combination.**		
		Capacity of each conductor	1	
		Capacity of combination	1	4
		Given V_1= 40V; V_2= 50V; V_2= 60V and Q = $6X10^{-8}C$ We have $C = \frac{Q}{V}$ $C_1 = \frac{Q}{V_1} = \frac{6\times10^{-8}}{40} = 0.15\times10^{-8}F$ $C_2 = \frac{Q}{V_2} = \frac{6\times10^{-8}}{50} = 0.12\times10^{-8}F$ $C_3 = \frac{Q}{V_3} = \frac{6\times10^{-8}}{60} = 0.10\times10^{-8}F$ These three condenser are connected in series therefore their combination capacitance is C_s given by $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ $\frac{1}{C_s} = \frac{1}{0.15\times10^{-8}} + \frac{1}{0.12\times10^{-8}} + \frac{1}{0.10\times10^{-8}}$ $\frac{1}{C_s} = 10^8 \;\; 6.66 + 8.33 + 10 \;\; = 24.99\times10^8$ $C_s = \frac{1}{24.99\times10^8}$ $C_s = 0.040\times10^{-8}F$		

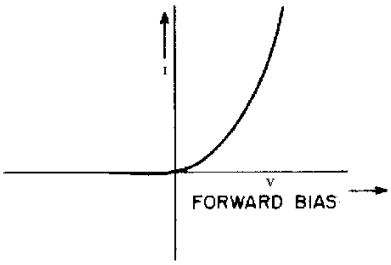
<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Stepwise Solution</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>2)</td><td>e)</td><td>Differentiate between n-type and p- type semiconductor
Any Four Points
<table>
<tr><th>Sr. No</th><th>N- type Semiconductor</th><th>P- type Semiconductor</th></tr>
<tr><td>1</td><td>When small amount of pentavalent impurity is added to a pure semiconductor is called N-type semiconductor</td><td>When small amount of trivalent impurity is added to a pure semiconductor is called P-type semiconductor</td></tr>
<tr><td>2</td><td>Impurity is used for doping is arsenic, anatomy, phosphorus</td><td>Impurity is used for doping is gallium, indium, boron, aluminium</td></tr>
<tr><td>3</td><td>It is called donor impurity</td><td>It is called acceptor impurity</td></tr>
<tr><td>4</td><td>There are excess of electrons</td><td>There are shortage of electrons</td></tr>
<tr><td>5</td><td>The electrons are majority carriers</td><td>The holes are majority carriers</td></tr>
</table></td><td>4</td><td>4</td></tr>
<tr><td></td><td>f)</td><td>Explain the effect of temperature on intrinsic semiconductors.
Explanation
At absolute zero temperature semiconductor behaves like insulators. At room temperature because of thermal energy, few electron-hole pairs are generated which constitute a small current i.e. it has small conductivity.
Further, if the temperature of semiconductor increases its conductivity increases.
It means that temperature of semiconductor increases its resistance decreases.
Thus semiconductor has negative temperature coefficient of resistance.</td><td>4</td><td>4</td></tr>
</table>

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	a)	**Explain the forward biasing of a PN junction diode. Draw its V-I characteristics.**		
		Each Diagram	1	
		Explanation	2	4

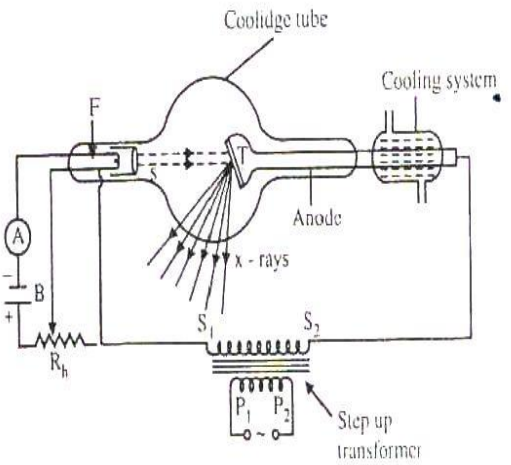


Explanation:

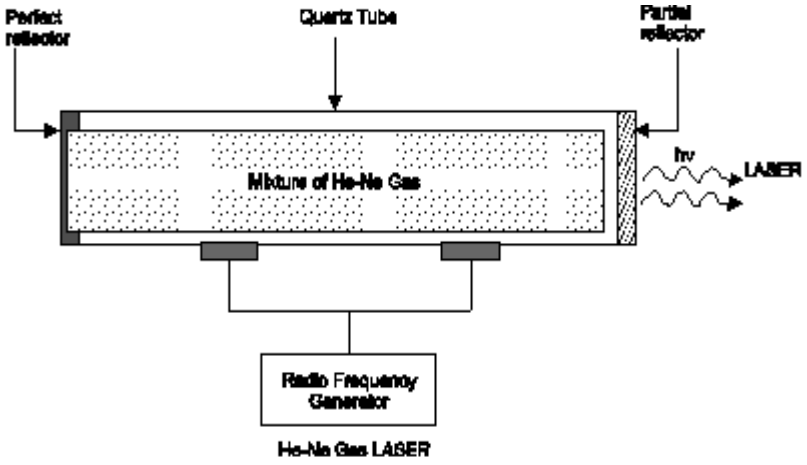
Above circuit diagram shows PN junction diode in forward bias mode. In forward bias mode P-type of semiconductor is connected to positive terminal and N-type of semiconductor is connected to negative terminal of battery. As voltage increases current starts flowing through diode. When the voltage applied 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.



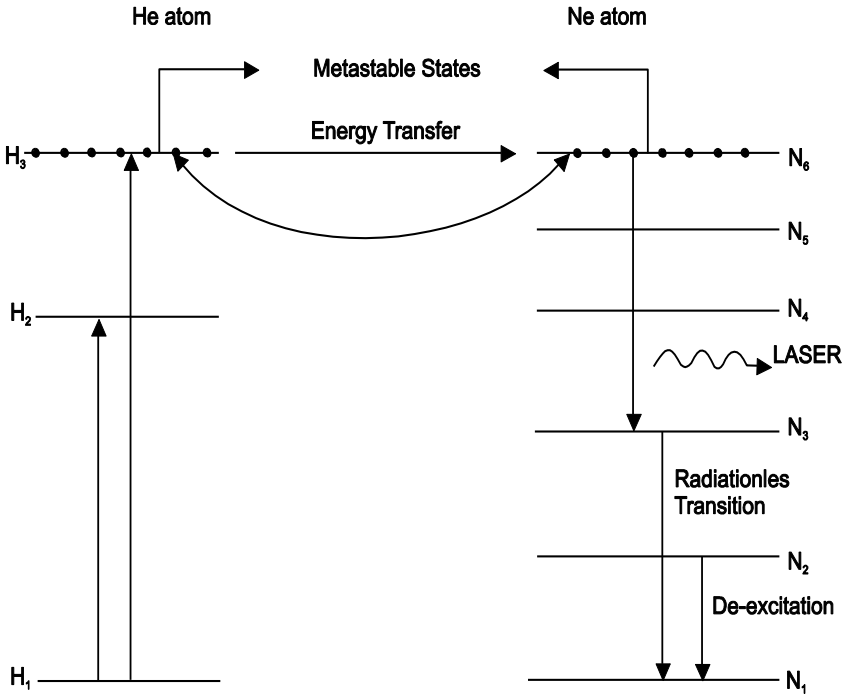
Voltage-current characteristic for a p-n junction.

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	b)	**Accelerated electrons emit photon of frequency $8x10^{18}$Hz Calculated energy of photon.**		
		Formula & Substitution	2	
		Answer with Unit	2	4
		Given h=6.625X10^{-34} Js, 1eV = 1.6X10^{-19} J		
		$E = h\nu$		
		$= 6.625\times10^{-34}\times8\times10^{18}$		
		$= 5.296\times10^{-15}\ joule$		
		$= 5.296\times10^{-15}\ joule$		
		$E = \frac{5.296\times10^{-15}\ joule}{1.6\times10^{-19}}$		
		$E = 3.31\times10^{4}\ eV$		
	c)	**Explain the production of X-rays using Coolidge tube using neat diagram.**		
		Diagram	2	
		Principle	1	
		Working	1	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.		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
		Working: When the cathode is heated by electric current it produced electron due to thermionic emissions. The beam of electron is then focused on the anode (target). The electrons from cathode are accelerated by applying of high voltage between cathode & anode using step up transformer. 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. By controlling the filament current, the thermionic emission of electron hence intensity of X- rays can be controlled.		
3)	d)	**Explain the construction and working of He-Ne Laser** **Each diagram** **construction** **working** **Construction :** 1. It consists of a quartz tube of about 80 cm length and 1.5 cm diameter. 2. The tube is filled with mixture of helium (He) and neon (Ne) gas. 3. The mixture consists of 90% helium atoms and 10% neon atoms. 4. At one end perfect reflector is fixed and at the other end partial reflector is fixed.	1 1 1	4



He-Ne Gas LASER

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	d)	**Working :** (1)When electric discharge is produced in the tube, He and Ne gas atoms are excited. Some excited levels of helium are close to some excited levels of neon. Therefore these excited helium atoms collide with excited atoms of neon and transfer the energy to neon atoms. (2) The actual lasing action is done by neon atoms. The neon atoms with extra energy from helium atom are forced to jump in ground state by emitting a photon. This produces the LASER light. The newly emitted photon triggers the next neon atom and increases the radiations. (3) Thus coherent, monochromatic, unidirectional LASER is produced by He-Ne gas LASER The energy level diagram of He-Ne LASER is shown below.  		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	e)	**i) Give the two application of Photoelectric Effect.**		
		Any two Applications • It is used in Lux-meter • It is used for automatic control of traffic signals • It is used to switch on and off automatically the street lights. • It is used in recording and reproduction of sound during shooting of film. • They are used in television sets, fire alarms • It is used in bulgar alarm	2	4
		ii) X-ray tube works on 80kV. Find the minimum wavelength of x-ray produced by x-ray tube		
		Formula with substitution	1	
		Answer with unit	1	04
		(h=6.634X10^{-34}Js, C=3X10^{8}m/s, e = 1.6X10^{-19}C)		
		$\lambda_{min} = \frac{hc}{eV}$ $\lambda_{min} = \frac{6.634\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times80\times10^{3}}$ $\lambda_{min} = \frac{19.90\times10^{-26}}{92.8\times10^{-16}}$ $\lambda_{min} = 0.155\times10^{-10}\,m$ *OR* $\lambda_{min} = \frac{12400}{V}$ $\lambda_{min} = \frac{12400}{80\times10^{3}}$ $\lambda_{min} = 0.155\times10^{-10}\,m$		

Que. No.	Sub. Que.	Stepwise Solution	Marks	Total Marks
3)	f)	**Describe four applications of nano-material in engineering field.** **Any four application** **Applications of nano-material in engineering field.** 1. **Data storage system –** Semiconductor material in the form of film can be deposited on substrate to form the chip. 2. **Use of nanomaterial in energy sector** – The conventional energy sources like coal, fuel are depleting day by day, thus use of alternative energy source is inevitable. 3. **Application in automobiles-** High mechanical strength material but light in weight can be produced by using nanotechnology. Nanopainting materials can be used to get uniform layer of coating on the vehicle body. 4. **Application in consumer goods –** Nanotechnology has wide applications in cosmetics, domestics products and textiles. Using nanomaterial fiber, one can get comfort of cotton clothes. 5. **Any other relevant application**	4	4