Physics 2002 NECTA SOLUTIONS

Section A:

1. (i) C. 0.2cm

ii) $W_1 = 10N$ $W_2 = 2N$ $\Delta W = W_1 - W_2 = 2N = W_w$ $\rho_w = 1 g/cm^3$ $\rho_l = 1.5 g/cm^3$

But $W_w = m_w g$ and $m_w = V_w \rho_w$ $\therefore$ $W_w \propto \rho_w$

$\therefore \frac{W_w}{\rho_w} = \frac{W_l}{\rho_l}$ $\therefore W_l = W_w \frac{\rho_l}{\rho_w} = 2N \frac{1.5}{1} = 3N$

$W_L = 3N$

$W_2 = W_1 - W_l = 10N - 3N = 7N$

iii) C iv) A v) E vi) B. vii) A viii) D

ix) C.

x) $I_1 = \frac{V}{R}$ $I_2 = \frac{\frac{1}{3}V}{2R} = \frac{1}{6}\frac{V}{R} = \frac{1}{6}I_1$

$\frac{\text{OLD CURRENT}}{\text{NEW CURRENT}} = \frac{I_1}{I_2} = \frac{I_1}{\frac{1}{6}I_1} = \frac{6}{1}$

D.

2. i) N ii) R iii) J. iv) T v) M
vi) A vii) C viii) O ix) K x) I

Section B.

3 a) i.) Momentum is the measure of the motion of a body. It is a vector quantity, and it is the product of mass and velocity.

$p = mv$

ii) Kinetic Energy is the energy of a body due to its motion. It is a scalar quantity and is equal to half mass times velocity squared.

$KE = \frac{1}{2}mv^2$

iii) Work is the product of force and the distance traveled in the direction of the force. Work is a vector quantity.

$W = F.x$

b.) $m = 2kg \quad V_1 = 4\ m/s \quad V_2 = 0\ m/s$

i.) $t = 0.1s$

$$Ft = m(V_2 - V_1)$$

$$F = \frac{m}{t}(V_2 - V_1) = \frac{2kg}{0.1s}(0\ m/s - 4\ m/s)$$

$$F = -80N$$

ii) $x = 2m$

$$V_2^2 = V_1^2 + 2ax \quad \therefore \quad 2ax = V_2^2 - V_1^2$$

$$a = \frac{1}{2x}(V_2^2 - V_1^2) = \frac{1}{2(2m)}((0\ m/s)^2 - (4\ m/s)^2) = \frac{1}{4m}(-16\ m^2/s^2)$$

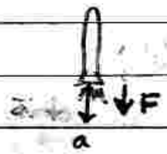
$$a = -4\ m/s^2$$

$$F = ma = 2kg(-4\ m/s^2)$$

$$F = -8N$$

c.) In 1s it accelerates 100kg from 0 m/s to 300 m/s.

$t = 1s \quad m = 100kg \quad u = 0\ m/s \quad v = 300\ m/s$



$$a = \frac{v-u}{t} = \frac{300\ m/s - 0\ m/s}{1s} = 300\ m/s^2$$

$$F = ma = 100\ kg\ (300\ m/s^2)$$

$$F = 30000\ N$$

$$W = F = 30,000N$$

∴ The approximate weight of the rocket that can just be raised is 30,000N

4. a) i.) The Kinetic Energy of gas molecules, or heat of the gas, is directly proportional to its temperature.

$$KE \propto T$$

ii)	Solid	Liquid	Gas
Volume	Least Volume	Greater Volume	Greatest Volume
Motion of Molecules	Vibrate about a fixed point	Move randomly	Move very quickly and very randomly
Intermolecular Forces	Strong Intermolecular forces	Weak intermolecular forces	Very weak intermolecular forces

b.) Before evaporation the molecule is a liquid. During evaporation the molecule absorbs energy from its environment in the form of latent heat. Now the molecule is a gas. During condensation the molecule releases the same latent

latent heat it absorbed during evaporation, and it becomes a liquid.

c.) i.) Linear Expansivity is the fractional increase in length of a solid per degree Celsius.

ii) $l_0 = 10m$ $\theta_0 = 20°C$ $\Delta L = 5cm = 0.05m$ $\alpha = 2\times10^{-5} K^{-1}$ $\theta = ?$

$\Delta L = l_0 \alpha \Delta\theta = l_0 \alpha (\theta - \theta_0)$

$\frac{\Delta L}{l_0 \alpha} = \theta - \theta_0 \therefore \theta = \theta_0 + \frac{\Delta L}{l_0 \alpha} = 20°C + \frac{0.05m}{10m \times 2\times10^{-5} K^{-1}}$

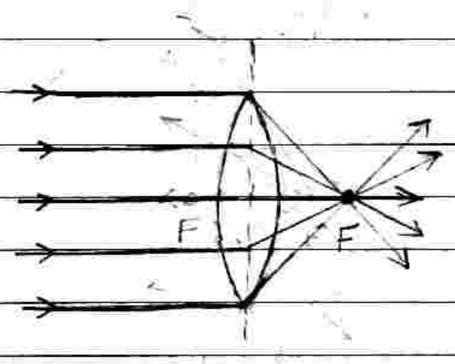
$\theta = 20°C + \frac{0.05}{0.0002} °C = 20°C + \frac{500}{2} °C$

$\theta = 270°C$

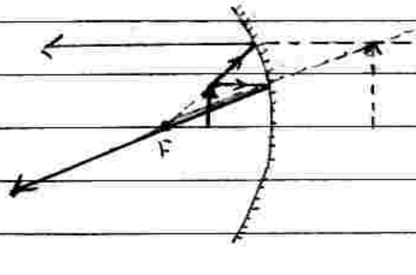
5. a.) i.) A real image is an image formed where rays actually converge. Real images are always inverted.

ii) In plane mirrors the images are virtual, erect, laterally reversed and the same size. In pin hole cameras the images are real, inverted, not laterally inverted, and usually diminished.

b.) i.) The principal focus of a convex lens is the location where incident parallel rays actually converge. The principal focus is behind the lens and has a positive focal length.



ii.)



The image is virtual, erect, magnified and farther.

c.) $u = 20cm$ $m = -2$

$m = -\frac{v}{u}$ ∴ $v = -mu = -(-2)(20cm)$

$\boxed{v = 40cm}$

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ∴ $f = \frac{uv}{u+v} = \frac{20cm(40cm)}{20cm + 40cm}$

$f = \frac{800 cm^2}{60 cm}$

$\boxed{f = 13.33 cm}$

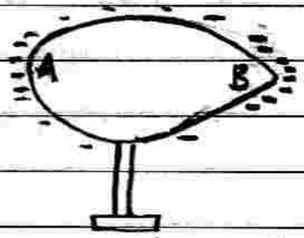
6. a.) i.) A capacitor consists of metal plates separated by an insulator, called a dialetric, and it is used to store electricity in an electric field.

Symbol of a capacitor : ⊣⊢

ii) An inductor consists of a coil of low resistance wire, and it is used to control changes in current by storing electricity in a magnetic field.

Symbol of inductor : —ʘʘʘ—

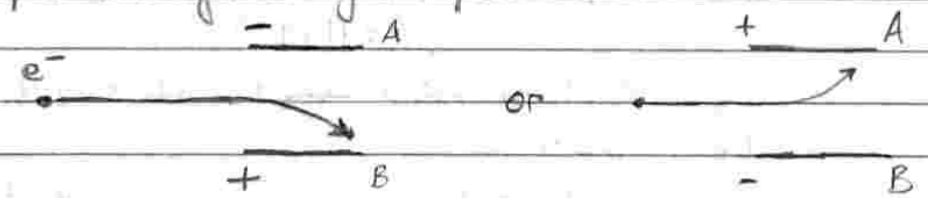
b.)



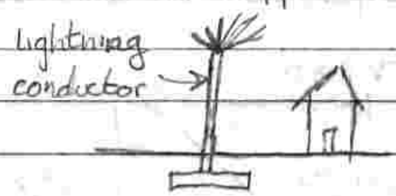
i.) The greatest potential occurs at the point B, followed by A. That is, the greatest potential occurs at the corners of the pear-shaped conductor.

ii) The greatest charge density occurs at the points A and B as well, with B greater than A.

c.) i.) As an electron passes between the plates A and B it will move towards the positively charged plate.



ii) A lightning conductor is made of a good conductor, like copper. The top of the conductor is taller than your house and is made of many copper wires. The wires are connected to a copper pole, which is connected to a copper base buried in the ground.



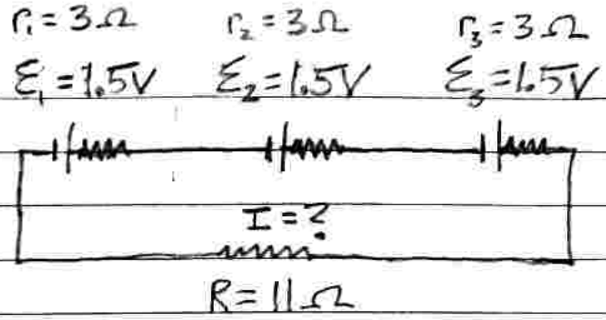
The lightning conductor is used to safely allow lightning to flow to the ground by providing a path of low resistance.

7 a.) i.) Emf, or electromotive force, of a cell is the driving force of the cell. The SI unit of emf is Volts (V).

ii) Resistivity is the ratio of electric field to current density. The SI unit of resistivity is ohm-meter ($\Omega \cdot m$). Resistivity is related to resistance by the equation:

$$R = \rho \frac{L}{A}$$

where ρ is resistivity, L is length, and A is area b.) i)



$R_{TOT} = r_1 + r_2 + r_3 + R = 3\Omega + 3\Omega + 3\Omega + 11\Omega$

$R_T = 20\Omega$

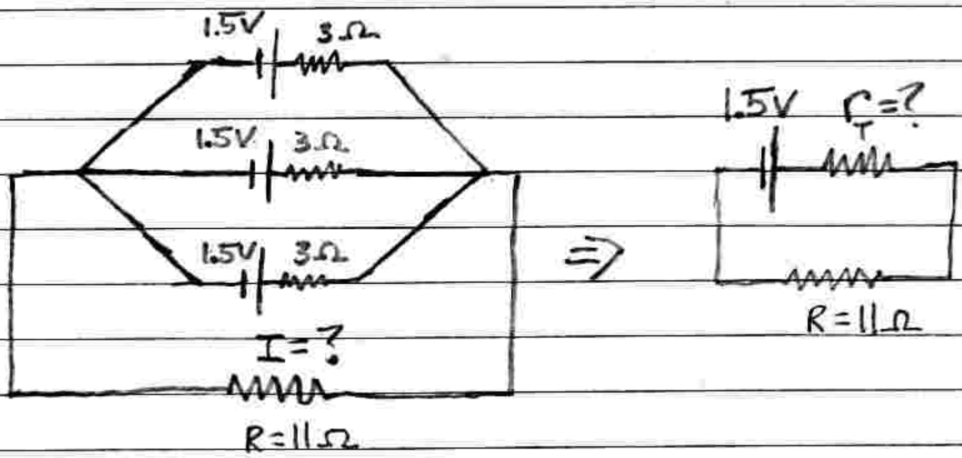
$V_{TOT} = \mathcal{E}_1 + \mathcal{E}_2 + \mathcal{E}_3 = 1.5V + 1.5V + 1.5V$

$V_T = 4.5V$

$I = I_T = \frac{V_T}{R_T} = \frac{4.5V}{20\Omega}$

$\boxed{I = 0.225A}$

ii)



$V_{TOT} = \mathcal{E}_1 = \mathcal{E}_2 = \mathcal{E}_3$

$V_T = 1.5V$

$\frac{1}{r_T} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} = \frac{1}{3\Omega} + \frac{1}{3\Omega} + \frac{1}{3\Omega}$

$\frac{1}{r_T} = \frac{1}{1\Omega}$

$r_T = 1\Omega$

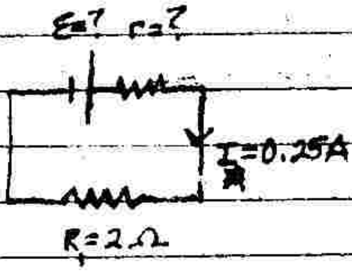
$R_{TOT} = r_T + R = 1\Omega + 11\Omega$

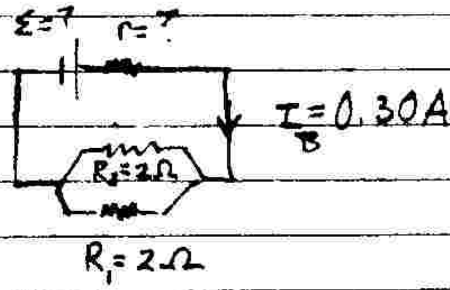
$R_{TOT} = 12\Omega$

$I = I_T = \frac{V_T}{R_T} = \frac{1.5V}{12\Omega}$

$\boxed{I = 0.125A}$

c.





$V_{TOT} = \mathcal{E}$

$R_{TOT} = r + R_1$

$I_{TOT} = \frac{V_{TOT}}{R_{TOT}}$

$I_A = \frac{V_T}{R_T} = \frac{\mathcal{E}}{r+R_1}$

$\therefore\ \mathcal{E} = I_A(r+R_1)$

$V_T = \mathcal{E}$

$R_{12} = \frac{R_1 R_2}{R_1+R_2} = \frac{2\Omega(2\Omega)}{2\Omega+2\Omega}$

$R_{12} = 1\Omega$

$R_T = R_{12} + r$

$I_B = \frac{V_T}{R_T}$

$I_B = \frac{\mathcal{E}}{R_{12}+r}$

$\therefore\ \mathcal{E} = I_B(R_{12}+r)$

$I_A(r+R_1) = I_B(R_{12}+r)$

$I_A r + I_A R_1 = I_B R_{12} + I_B r$

$I_A R_1 - I_B R_{12} = I_B r - I_A r$

$I_A R_1 - I_B R_{12} = r(I_B - I_A)$

$r = \frac{I_A R_1 - I_B R_{12}}{I_B - I_A} = \frac{0.25A(2\Omega) - 0.30A(1\Omega)}{0.30A - 0.25A}$

$r = \frac{0.5A\cdot\Omega - 0.3A\cdot\Omega}{0.05A} = \frac{0.2A\cdot\Omega}{0.05A}$

$\boxed{r = 4\Omega}$

$\mathcal{E} = I_A(r+R_1) = 0.25A(4\Omega+2\Omega) = 0.25(6\Omega)$

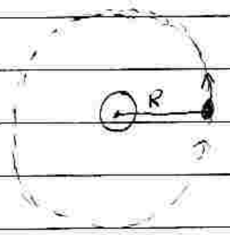
$\boxed{\mathcal{E} = 1.5V}$

) a.) A star is a heavenly body that produces light and heat through nuclear fusion. The ~~brightest~~ sun is the closest star to Earth.

b.) i) Jupiter is the ~~brightest~~ Largest planet in the solar system.

ii) The two brightest planets in the solar system are

c.)



$R = 42000\ km$

$t = 24hr$

$V = ?$

$V = \frac{2\pi R}{t} = \frac{2 \times \frac{22}{7} \times 42{,}000km}{24hr}$

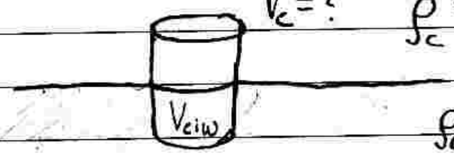
$\boxed{V = 11{,}000\ km/hr}$

Section C

9. a.) i) The law of floatation states that a floating body displaces its own weight of the fluid in which it floats.

ii) Archimedes' Principle states that when a body is totally or partially emmersed in a fluid, it experiences an upthrust equal to the weight of the fluid displaced.

b.)



$V_c = ?$ $\rho_c = 250\ kg/m^3$ $m_c = 0.02kg$

$\rho_w = 1000\ kg/m^3$

We need to find: $\frac{V_{ciw}}{V_c} = ?$

$V_c = \frac{m_c}{\rho_c}$

From Law of Floatation $M_{displaced\ water} = M_{cork}$

$\therefore m_{dw} = m_c$

From Archimedes' Principle $V_{displaced\ water} = V_{cork\ in\ water}$

$\therefore V_{ciw} = V_{dw}$

$$V_{dw} = \frac{m_{dw}}{\rho_w} = \frac{m_c}{\rho_w}$$

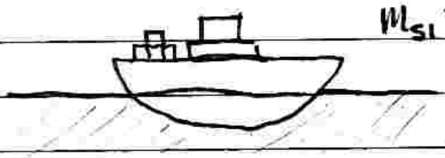
but $V_{ciw} = V_{dw}$

$$\therefore V_{ciw} = \frac{m_c}{\rho_w}$$

$$\frac{V_{ciw}}{V_c} = \frac{m_c/\rho_w}{m_c/\rho_c} = \frac{\rho_c}{\rho_w} = \frac{250 \text{ kg/m}^3}{1000 \text{ kg/m}^3}$$

$$\boxed{\frac{V_{ciw}}{V_c} = \frac{1}{4}}$$

c.) i)



$m_{s1} = 1200$ tonnes

$\rho_{sw} = 1030 \text{ kg/m}^3 = 1.03 \text{ tonne/m}^3$

$V_{sw} = ?$

From law of floatation $m_{sw} = m_{s1}$

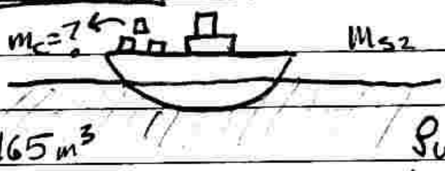
$m_{sw} = 1200$ tonnes

$$V_{sw} = \frac{m_{sw}}{\rho_{sw}} = \frac{1200 \text{ tonnes}}{1.03 \text{ tonnes/m}^3}$$

$$\boxed{V_{sw} = 1165 \text{ m}^3}$$

ii)

$m_c = ?$



m_{s2}

$V_w = 1165 \text{ m}^3$

$\rho_w = 1000 \text{ kg/m}^3 = 1 \text{ tonne/m}^3$

$m_w = V_w \times \rho_w = 1165 \text{ m}^3 \times 1 \text{ tonne/m}^3$

$m_w = 1165$ tonnes

From law of Floatation $m_{s2} = m_w$

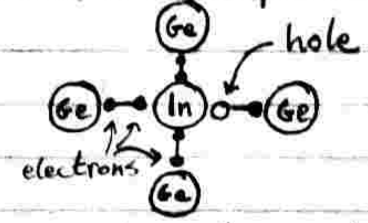
$m_{s2} = 1165$ tonnes

$m_c = m_{s2} - m_{s1}$

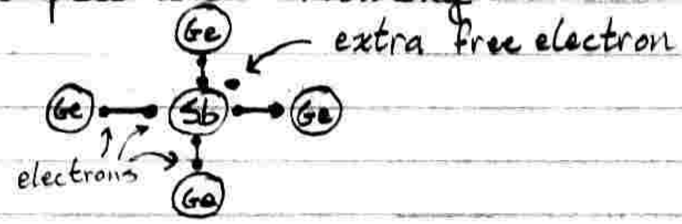
$= 1200 \text{ tonnes} - 1165 \text{ tonnes}$

$$\boxed{m_c = 35 \text{ tonnes}}$$

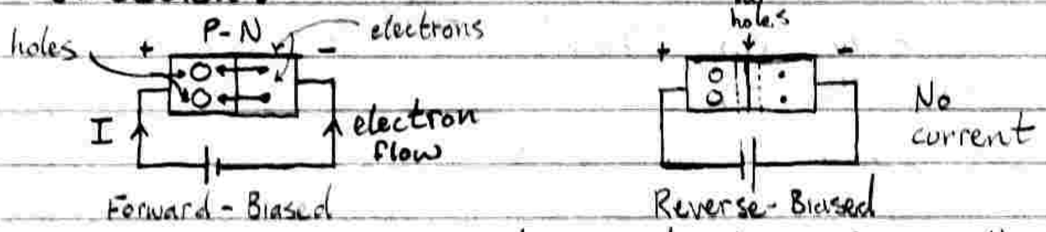
10.) a.) An extrinsic semiconductor is constructed of germanium or silicon doped with other atoms.
A P-type, or Positive-type semiconductor is doped with an atom with 3 free electrons, called an acceptor, which leaves a positive hole.
Eg: Germanium doped with Indium



An N-type, or Negative-type semiconductor is doped with an atom with 5 free electrons, called a donor, which leaves an extra free electron.
Eg: Germanium doped with Antimony



b.) A P-N Junction Diode is made of a P-type germanium crystal and an N-type germanium crystal joined together. The diode allows current to flow in only one direction:



When the diode is forward-biased the holes in the P-region move toward the N-region, and the electrons from the N-region move across: current flows. When the diode is reverse-biased the holes in the P-region move away from the N-region, and there are no holes for the electrons from the N-region to move into ∴ No current flows.

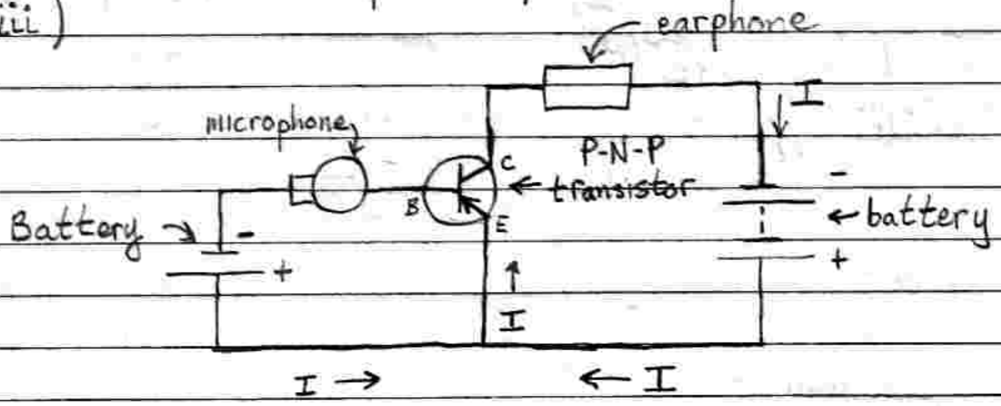
Applications: 1. Rectify AC to DC 2. LED's are used to provide light.

c.) i.) A is a P-N-P transistor.

B is a battery.

ii) The P-N-P transistor functions as an amplifier. A small change in the base-current from the microphone produces a large change in the collector current through the earphone, and the earphone produces sound.

iii)



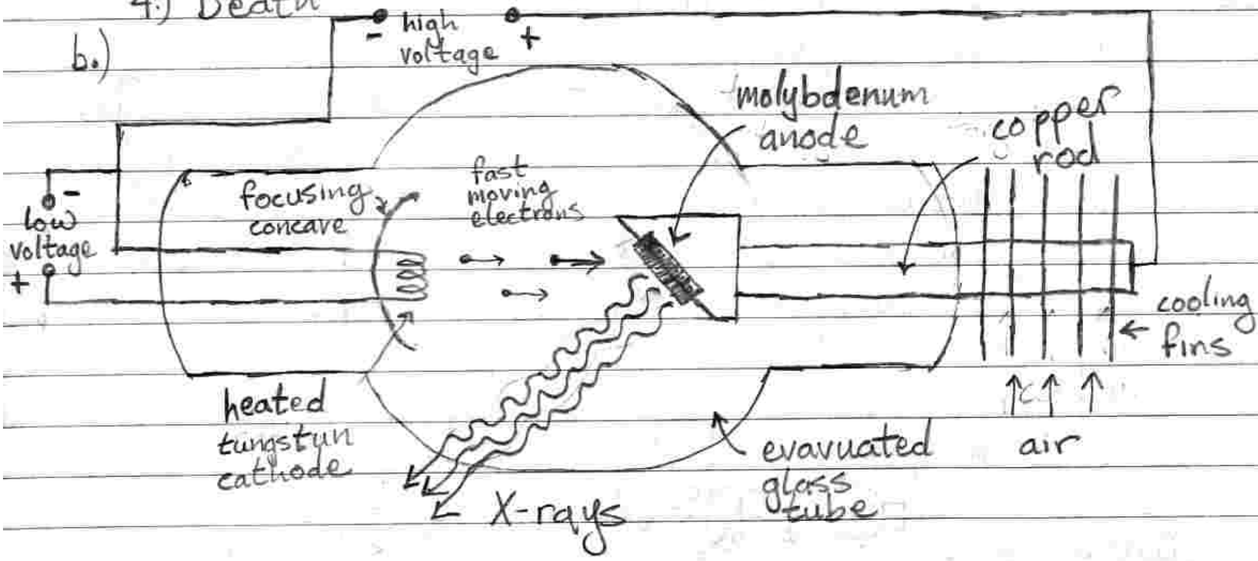
11.) a.) i) There are soft X-rays and hard X-rays.

- Soft X-rays are produced at low voltages, and they have low penetrating power, low energy, and long wavelengths.
- Hard X-rays are produced at high voltages, and they have high penetrating power, high energy, and short wavelengths.

ii) When human beings are exposed to X-rays, the X-rays produce ions, which can change or destroy living cells. The damaged cells can stop functioning correctly, which may lead to :

1.) Cancer
2.) Leukimia
3.) Hereditary defects in children
4.) Death

b.)



The heated tungstun cathode causes thermionic emmision of electrons. These fast moving electrons strike the molybdenum anode. Electrons in the molybdenum absorb the energy of the fast moving electrons, and they move up to higher energy levels. As these electrons fall back to lower energy levels they emit X-rays. The energy of the X-ray photon that is emitted is equal to the change in energy level of the electron.

c.)