Cameroon GCE A-LEVEL PHYSICS CORRECTIONS 2003

JUNE2003

1.(a) (i) In terms of medium of transmission, we have mechanical and electromagnetic waves

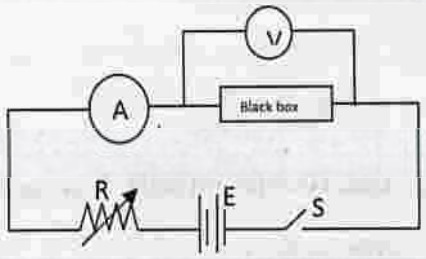
(ii) In terms of the mode of propagation we have transverse and longitudinal waves.

✓ Examples of mechanical waves are: water waves, sound waves, waves produced in a slinky spring, shock waves etc..

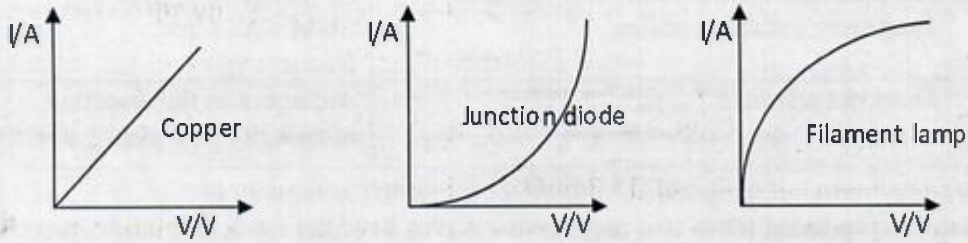
✓ Examples of electromagnetic waves include: visible light, x-rays, gamma says, radio waves, etc

- ✓ Examples of longitudinal waves are: sound waves, waves produced in a spring when displaced along its axis etc
- ✓ Examples of transverse waves include: all electromagnetic waves, waves produced in a spring when displaced perpendicularly along its axis.

2.(i)



(ii)



3.(i) ${}^{220}_{86}X \rightarrow {}^{212}_{84}Y + 2\left({}^{0}_{-}\beta\right) + 2{}^{4}_{2}He$

(ii) $A = A_0e^{-\lambda t} \Rightarrow \ln\left(\frac{A_0}{A}\right) = \lambda t \Rightarrow t = \frac{1}{\lambda}\ln\left(\frac{A_0}{A}\right) \Rightarrow t = \frac{T_{\frac{1}{2}}}{\ln 2}\ln\left(\frac{A_0}{A}\right) \Rightarrow t = \frac{6.10^{10}}{\ln 2}\ln\left(\frac{1.9}{.7}\right) = 8.64 \times 10^{6}yr$

4.(i) $d\sin\theta = m\lambda \Rightarrow \frac{1}{N}\sin\theta = m\lambda \Rightarrow \sin\theta = Nm\lambda \Rightarrow \theta = \sin^{-1}(Nm\lambda) \Rightarrow \theta = \sin^{-1}(1 \times 600 \times 10^{3} \times 5.9 \times 10^{-7}) \Rightarrow \theta = \sin^{-1}(0.354) = 20^{o}$

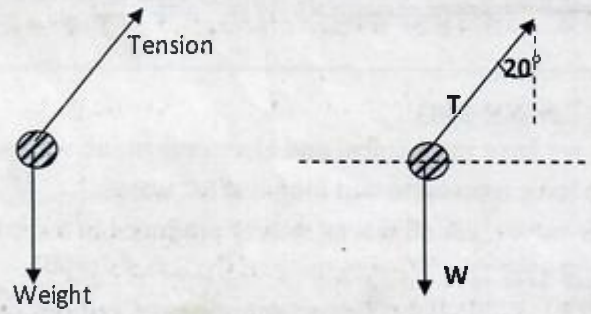
(ii) For the third order image, $m = 3 \Rightarrow \sin\theta = 3 \times 600 \times 10^{3} \times 5.9 \times 10^{-7} = 1.062$, which is greater than one. Hence the third order image is not possible.

From $d\sin\theta = m\lambda \Rightarrow m \propto \frac{1}{\lambda}$. Thus if the wavelength is increased, the number of orders will decrease.

5.(a) $P = \frac{1}{3}\rho\overline{c^2} \Rightarrow c^2 = \frac{3P}{\rho} \Rightarrow c_{rms} = \sqrt{\frac{3P}{\rho}} \Rightarrow \sqrt{\frac{3\times1.0\times10^{5}}{2.6}} = 339.77\ ms^{-1}$

(b) The speed of sound in air at S.T.P which is $330mS^{-1}$ is less than the root mean square of nitrogen molecules at S.T.P. This is as a result of random motion.

6.(i)



Projecting

Vertically, $T\cos 20 = mg$ .....(1)

Horizontally, $T\sin 20 = ma$ .....(2)

Solving (1) and (2) simultaneously,

$a = 3.6\ ms^{-2}$

(ii) At constant speed, the bob oscillates about the equilibrium position. That is the bob describes simple harmonic motion about the equilibrium.

7.(a) **Crystalline** Solid are materials which have a basic repeating structure called a unit cell, possess cleavage planes, have definite melting points and show long range order. An example is sodium chloride.

Amorphous materials have no particular order arrangement of atoms, no definite melting points and posses no cleavage planes. An example is glass.

Polymeric materials are materials made up of long chains built up from simpler units called monomers. They can be stretched to about ten times their original length. An example is rubber.

NB: A unit cell is the fundamental unit from which the entire crystal may be constructed by purity translation (like bricks in a wall).

8.(i) Specific latent heat of vaporization is the heat required to change the state of a unit mass of a substance from liquid to gas at constant temperature, While latent heat of vaporization is the heat required to change the state of a substance from liquid to gas at constant temperature.

ii) Consult your text books or note books

b) Electrical energy lost by heater = heat gained by water + heat gained by kettle

ie $Pt = mc\Delta\theta + C\Delta\theta \Rightarrow t = \left(\frac{Mc+C}{P}\right)\Delta\theta = \frac{(15\times10^{3}\times4200+400)(100-20)}{2000} = 18.52$ s

ii) Time taken to convert water of mass m to steam is t=5(60)-18.52= 281.48s

$\Rightarrow Pt = ml_v \Rightarrow m = \frac{Pt}{l_v} = \frac{2000\times281.48}{2.0\times10^{6}} = 0.21$ kg

This result is not realistic as the mass of water evaporated is greater than the initial mass of the water.

c) $Pt = ml_v \Rightarrow t = \frac{ml_v}{P} = \frac{15\times10^{-3}\times2.0\times10^{6}}{2000} = 15$ s.

Assumption: All the electrical energy supplied goes to boil and evaporate all the water. No heat is absorbed by the kettle and no energy is lost to the surrounding.

(d) (i) Consult your notes

(ii) Consult your textbooks

(e) (i) By the principle of conservation of linear momentum:

Momentum before collision= Momentum after collision.

$\Rightarrow mu_A + m_Bu_B = m_Av_A + m_Bv_B \quad \Rightarrow v_B = \frac{mu_A + mBuB - m_Av_A}{m_B} = \frac{(2m)(5)+(m)(2)-(2m)(3)}{m} \Rightarrow V_B = 60\,ms^{-1}$

ii) Initial K.e$=\frac{1}{2}m_Av_A^2+\frac{1}{2}m_Bu_B^2=\frac{1}{2}(2m)(5)^2+\frac{1}{2}(m)(2)^2 = 27m$

Final kinetic energy$=\frac{1}{2}m_Av_A^2+\frac{1}{2}m_Bv_A^2 = \frac{1}{2}(2m)(3^2)+\frac{1}{2}(m)(6^2) = 27m$

Since initial k.e is equal to the final k.e, the collision is elastic

Or coefficient of restitution$=\frac{\text{velocity of separation}}{\text{velocity of approach}} = \frac{v_A-v_B}{u_B-u_A} = \frac{3-6}{2-5} = \frac{-3}{-3} = 1$

Since the coefficient of restitution is unity, the collision is elastic.

(f)

9.(i) Photoelectric effect is the ejection of electrons from the surface of a metal when radiation of sufficient frequency falls on it.

ii) Electrons are emitted only when the frequency of the incident radiation above some threshold value, no matter how intense the light is.

- The maximum kinetic energy of the emitted electrons depends on the frequency of the incident radiation.
- Photoelectrons are emitted almost at once when radiation of a sufficiently high frequency strikes the metal.
- The number of photoelectrons ejected is proportional to the intensity of the incident radiation.

iii) The classical theory agrees with the number of photoelectrons with intensity, but cannot explain why this increase in intensity cannot lead to an increase in the kinetic energy of the ejected electrons. The

classical theory cannot explain why the maximum kinetic energy of the emitted electrons is frequency dependent but independent of the intensity. According to the classical theory, the kinetic energy of the electrons could be increased with any frequency of radiation simply by making the light more intense. Classical theory cannot explain why the emission of electrons is instantaneous. The expectation of classical physics is that photoelectrons will absorb energy over period of time as the radiation continues to fall, eventually gaining energy to be ejected.

(b) (i) $eV_s = hf - \Phi \Longrightarrow V_s = \left(\frac{h}{e}\right) f - \left(\frac{1}{e}\right) \Phi$

Slope of graph $= \frac{0{\cdot}75-0{\cdot}25}{(6.6-5.2)10^{14}} = 3.57 \times 10^{-15}\ V\,s \Longrightarrow \frac{h}{e} = 3.57 \times 10^{-15}$

$\Longrightarrow h = 3.57 \times 10^{-15} \times 1.6 \times 10^{-15} = 5.71 \times 10^{-34}\ Js$

(ii) $V_s = \left(\frac{h}{e}\right) f - \left(\frac{1}{e}\right) \Phi$, choosing the intercept $(5.2 \times 10^{14}, 0.25)$;

$\Longrightarrow 0.25 = \left(\frac{5.71\times10^{-34}}{1.6\times10^{-19}}\right)(5.2 \times 10^{14}) - \frac{\Phi}{1.6\times10^{-19}}$

$\Longrightarrow 0.25 \times 1.6 \times 10^{-19} = 5.71 \times 10^{-34} \times 5.2 \times 10^{14} - \Phi \Longrightarrow \Phi = 2.57 \times 10^{-19}\ J = 1.61\ eV$

(c) (i) Thermionic emission is the emission of free electrons from the surface of metals when it is sufficiently heated electrically the metal must be of high melting point such as tungsten. In this process, the work function of the metal must be overcomed.

ii) See notes for the structure of the electron gun.

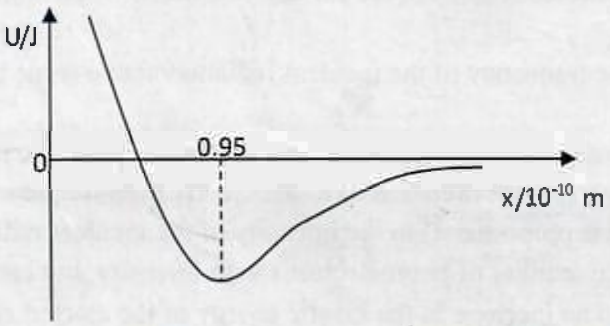
d)

	Force	Kinetic energy
Solids	Strong intermolecular forces of attraction	Lowest kinetic energy
Liquids	Weak intermolecular forces of attraction	Small kinetic energy but intermediate between phase of solids and gazes
Creases	Negligible intermolecular forces of attraction	Largest kinetic energy compare

(e)(i) There exist two kinds of forces between the molecules-repulsive and attractive forces. Below the equilibrium, face is repulsive (i-e in the range $(0 < r \leq 0.95x10^{-10}m)$ the strength of the repulsive force decreases towards the equilibrium position. Force is attractive for separation greater than the equilibrium position at the equilibrium the net force is zero.

ii) At and near the equilibrium separation ($0.95x10^{-10}$m, the force extension is linear Skagit line). The linear nature means the displacement of the molecules is proportional to the force, provided the force is not strong ofmolecu les, which is hook's law.

(iii)

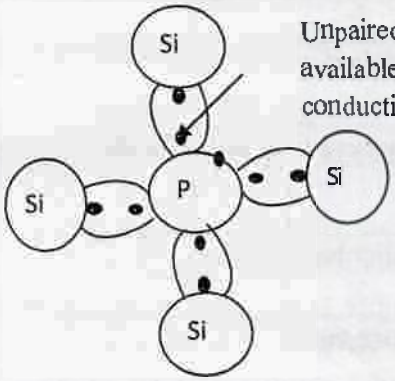


iv) Work done in separation molecules is the area between the graph and separation axis from equilibrium separation to infinity (try to do it). Count the number of squares between the curve and the separation axis from equilibrium separation, and then multiply it by the area of one square.

v) The work represents the latent heat of vaporization of the material.

10. (a) i) Copper conducts by the movement of free mobile electrons. When the temperature of the copper increases the amplitude of vibration of the atoms increases leading to more collision by free mobile electrons with the atoms and hence the resistance increases hence the conductivity, of the copper drops. Silicon is a pure semiconductor, so conduction is by free mobile electrons and holes under an applied pd.. At OK, all the electrons in pure silicon are found in the valence. As temperature increases, electrons leave the valence band and enter the conduction band and the conductivity increases.

ii) Ann-type semi conductor is produced by "dopping" a pure semi conductor (e.g silicon) with a pentavalent element, such that the materials conductivity is dominated by electrons. The pentavalent element donates conduction electron to the silicon.



Unpaired electron available for conduction

Phosphorous has five electrons in the outermost shell. When covalent bonds are formed between an atom of phosphorous and four silicon atoms, the central atom (phosphorous) has an extra unpaired electron. The unpaired electron is available for conduction and moves to the conduction band. This lead to the formation of an n – type semiconductor since the dominated charge carriers are electrons.

Formation of a p – n junction: A p – n junction is produced when a crystal of a pure semiconductor is doped such that one half is p – type and the other half is n – type. Immediately the junction is created, electrons from then – type side migrate to fill some of the dominant holes on the p – type side. Conversely, holes move to then –type side to be captured by electrons.

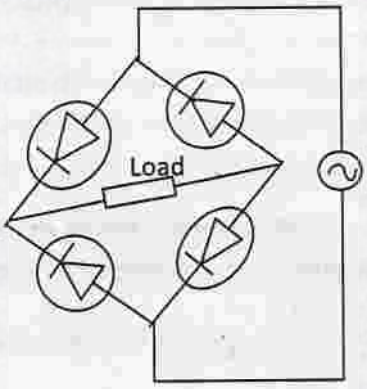
The information given in this question is incomplete. So the solution will be in terms of unknowns

(b) (i) By KVL, $V_{CC} - I_C R_C - V_{CE} = 0$. At saturation, $V_{CE} = 0 \Rightarrow I_C = \frac{V_{CC}}{R_B}$

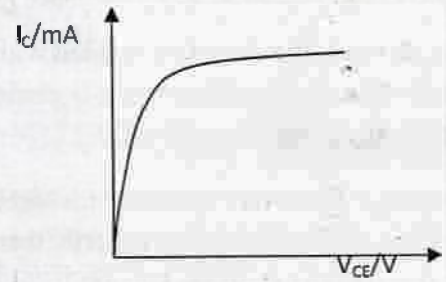
By KVL, $V_{CC} - I_B R_B - I_B R_B = 0$, but $V_{CC} = I_C R_C \Rightarrow V_{BE} = I_C R_C - I_B R_B = I_B(\beta R_C - R_B)$

(ii) $R_B = \frac{V_{BE}}{I_E} = I_E R_{BE} = I_B(\beta R_C - R_B) \Rightarrow R_B = \beta I_C + \frac{I_E R_E}{I_B}$, with $I_E = I_B + I_C$

(c)(i)



ii



(d) (i) The tuning circuit selects only one station because the capacitance is not variable (has only one value) and so the corresponds to one resonant frequency hence selects only one station.

(ii) The demodulator extracts the information signals from the carrier waves.

The amplifier boosts up the strength of the signals

(ii) The function of the demodulator is to extract the information from the carrier wave. The amplifier boosts up the strength of the signal

(e) (i) Amplitude modulation is the process is a process whereby the audio signal is superimpose on the carrier wave signal by varying the amplitude, whereas frequency modulation is the process whereby the audio signal is superimpose unto the carrier signal by varying the frequency.

The differences between AM and FM can be summarized in the table below

	Amplitude modulation	Frequency modulation
Circuit	Simple	Complex
Commercial Aspects	Cheaper	Expensive
Bandwidth	Greater bandwidth	Smaller bandwidth
Range	Longer range	Shorter range

(ii) $f_r = \frac{1}{2\pi\sqrt{LC}} \Rightarrow L = \frac{1}{(2\pi f_r)^2 C} \Rightarrow L = 1.27 \times 10^{-8}\text{H}$

(iii) By the use of a variable capacitor.

(f) (i) If the satellite is to circle the plane of the equator, then the centripetal force is provided by the gravitational attraction between satellite and the earth.

centripetal force on satellite= gravitational attraction between satellite and the earth

$i.e\ \frac{mv^2}{r} = \frac{GM_e m}{r^2} \Rightarrow v = \sqrt{\frac{GM_e}{r}} = \sqrt{rg} = \sqrt{6.4 \times 10^6 \times 9.8} = 7.9 \times 10^3 ms^{-1} = 7.9\ kms^{-1}$.

Therefore, the satellite must be provided with a velocity of about 7.9 kms^{-1} so that it can attain a required circular orbit. To do this, the satellite is carried by a rocket to the required height of the orbit, and then projected along a tangent to the orbit.

(ii) Suppose the direction of rotation the satellite is the same as that of the earth and the satellite stays in a fixed position above the surface of earth, then it is in a geostationary orbit and hence has a period of 24 hrs.

Centripetal force on satellite= gravitational attraction between the earth and the satellite

$m\omega^2 r = \frac{GM_e m}{r^2} \Rightarrow \omega 2 = \frac{GM_e}{r^3} \Rightarrow T^2 = \frac{4\pi^2 r^3}{GM_e}$, *with* $r = R_e + h$, where R_e is the radius of the earth and h is the height of the orbit above the satellite above the earth surface.

$$\Rightarrow R_e + h = \sqrt[3]{\frac{T^2GM}{4\pi^2}} - e \Rightarrow h = \sqrt[3]{\frac{T^2R^2g}{4\pi^2}} - R_e = \sqrt[3]{\frac{(24\times60\times60)^2\times(6.4\times10^6)_2\times9.8}{4\pi^2}} - 6.4\times10^6 = 3.7\times10^7 m$$