JUNE 2002

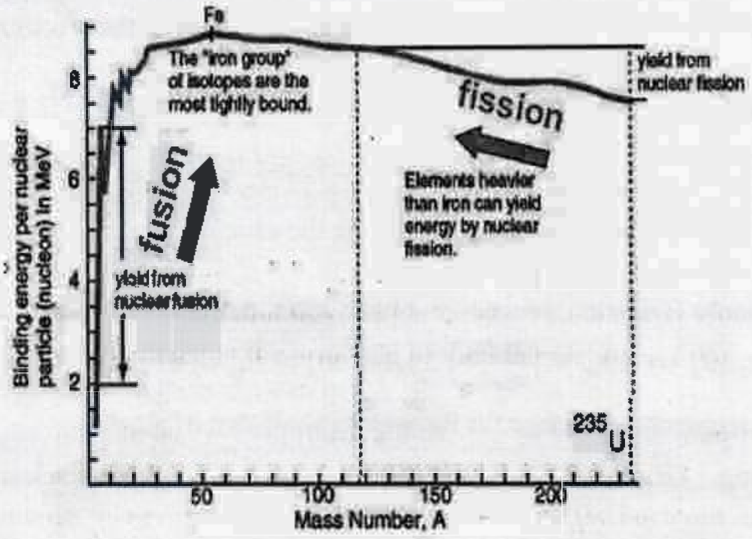
1.(i) Optical fibres are thin flexible glass rods with diameter almost equal to that of a human hair used to transmit light using the principle of total internal reflection.

(ii) Total internal reflection

(b) In medicine, optical fibres are used in endoscopy to transmit and guide light to some spots in the human body.

2.Binding energy is the energy required to free all the nucleons in the nucleus of an atom.

(b)



3.By the second law of thermodynamics, $\Delta Q = \Delta U + \Delta W$, where $\Delta W = P\Delta V$

In the process ab, $\Delta V = 0 \Rightarrow \Delta W = 0 \Rightarrow \Delta U = \Delta Q \Rightarrow \Delta U = 150\ J$

(ii) In the process abd, $\Delta Q_{abd} = \Delta U_{abd} + \Delta W_{abd} \Rightarrow \Delta U_{abd} = \Delta Q_{abd} - \Delta W_{abd}$

$\Rightarrow \Delta U_{abd} = \Delta Q_{ab} + \Delta Q_{bd} - \Delta W_{ab} - \Delta W_{bd}$

$\Delta U_{abd} = 150J + 600J - 0 - (8.0 \times 10^4)(5.0 - 2.0)10^{-3}J = 510J$

4.(i) F is the magnitude of the force of attraction between m_1 and m_2, G is the gravitational constant, m_1 and m_2 are masses and r is the mean distance between the centers of gravity of m_1 and m_2

(ii) $F = \frac{Gm_1m_2}{r^2} \Rightarrow G = \frac{Fr^2}{m_1m_2} \Rightarrow [G] = \frac{[F][r]^2}{[m]^2} = \frac{Nm_2}{kg^2} = \frac{kgms^{-2}m_2}{kg^2} = kg^{-1}m^3s^{-2}$

(b) (i) A physical equation is said to be homogeneous when all the terms in the equation have the same base units or dimensions. For terms to be added, subtracted or equated, they must have the same base units or dimensions. If an equation is not homogeneous, it means the terms in the equation do not have the same base units or dimensions and hence the equation must be wrong.

(ii) Some physical equations have dimensionless constants e.g K e $= \frac{1}{2}mv^2$. So homogeneity with respect to units or dimensions cannot be used to test the correctness of a physical equation. It is only valid for equations with no dimensionless constants.

5.(i) Scattering refers to the irregular reflection or refraction of waves

(ii) Signal attenuation is the loss in the intensity of the signal due to the absorption of the signal energy by the transmitting medium. Signal attenuation is taken care of by the use of booster or repeaters.

(b) (i) $A \propto \frac{1}{\lambda^4} \Rightarrow A_1\lambda_1^4 = A_2\lambda_2^4 \Rightarrow A_2 = \left(\frac{\lambda_1}{\lambda_2}\right)^4 A_1 \Rightarrow A_2 = \left(\frac{850}{1500}\right)^4 (2.0) = 0.21\ dBkm^{-1}$

(ii) The decibel is the measuring unit of intensity level

6. Molecules of liquid and gases undergo translational motion whereas those of solid undergo vibrational motion.

(ii) Intermolecular forces of attraction are negligible in gases whereas in liquids and solids, the intermolecular force of attraction is strong

(b) (i) and (ii) Describe any observation of Brownian motion.

7. The charged particle (e.g electron) enters the field at right angles to the field and experiences a maximum force on it. From Fleming left hand rule, the force experienced by the electron is always perpendicular to its direction of motion in the field. Since the field strength is constant, therefore the force is constant ($F = Bev$) .The speed is constant but the direction of motion changes which implies the velocity changes. If the velocity changes, then the electron accelerates. But there is no tangential acceleration. Therefore the existing acceleration is centripetal, giving rise to a centripetal force. Hence the path of the electron is circular.

(b) (i) Centripetal force= magnetic force$\Rightarrow$ $F_c = Bev = 0.5 \times 1.6 \times 10^{-19} \times 3.0 \times 10^5 = 2.4 \times 10^{-14}$ N

(ii) The electron will spiral inwards.

8.(i) Specific latent heat of fusion is the thermal energy required to change the state of a unit mass of a substance from solid to liquid at the melting point of the substance

(ii) Consult your textbooks or note books (Diagram, procedure, observation, calculations and conclusion)

b(i) $Q_w = Q_a \Rightarrow m_w c_w \Delta\theta_w = m_a c_a \Delta\theta_a \Rightarrow \Delta\theta_w = \left(\frac{m_a c_a}{m_w c_w}\right)\Delta\theta_a$ but $m_a = m_a = m$ and $c_w = 2c_a$

$\Rightarrow \Delta\theta_w = \frac{mc_a}{m(2c_a)} = \frac{1}{2}\Delta\theta_a$. Thus the temperature change for the water is half that of alcohol.

(ii) Heat lost by molten lead in melting+ heat lost by lead in cooling= heat used to melt ice+ heat used in warming the melted ice.

i. e $m_p l_p + m_p c_p(327 - \theta) = m_i l_i + m_i c_w(\theta - 0)$

$\Rightarrow 10 \times 2.4 \times 10^3 + 10(1.28 \times 10^3)(327 - \theta) = 1 \times 3.34 \times 10^5 + 1 \times 4200\theta$

$\Rightarrow 24500 + 12800(327 - \theta) = 334000 + 4200\theta$

$\Rightarrow 4210100 - 12800\theta = 334000 + 4200\theta \Rightarrow 3876100 = 17000\theta \Rightarrow \theta = \frac{3876100}{17000} = 228.0°C$

Heat lost by lead, $Q = m_p l_p + m_p c_p(327 - \theta) = 10 \times 2.4 \times 10^3 + 10(1.28 \times 10^3)(327 - 228.0)$

$\Rightarrow Q = 24500 + 1267200 = 1291700J$

(c) The match handle is made of wood which is a poor conductor. Also, the gap between the flame and the fingertips is air which is also a poor conductor of heat. Hence the energy reaching the fingertips is small.

(d) (i) Young's modulus is defined as the ratio of the tensile stress to the tensile strain

(ii) Consult your note books (Diagram, procedure, observation, calculations and conclusion)

(e) The stress is maximum at A. This is because when the string is loaded, the maximum force is at A.

f) (i) $Stress = \frac{Force}{area} = \frac{102 \times 9.8}{0.1 \times 10^{-4}} = 1.0 \times 10^8$ Pa

(ii) $strain = \frac{extension}{original\ length} = \frac{2.2 \times 10^{-3}}{2.0} = 1.1 \times 10^{-3}$

(ii) $E = \frac{Stress}{Strain} = \frac{10 \times 10^8}{1.1 \times 10^{-3}} = 9.1 \times 10^{10}$ Pa

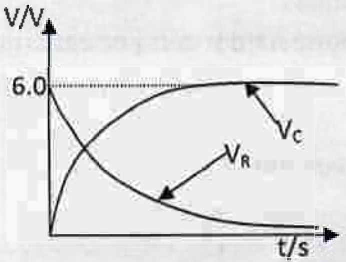
9.(a) (i) $Q = CV \Rightarrow C = \frac{Q}{V} \Rightarrow C = \frac{3.5 \times 10^{-3}}{6.0} = 5.8 \times 10^{-4}F$

(ii) Initial current, I_0 = slope of graph at $t = 0 \Rightarrow I_0 = \frac{\Delta Q}{\Delta t} = \frac{(3.5 - 1.0)10^{-3}}{0 - 100} = -2.5 \times 10^{-5}A$, the negative sign shows that the current is decreasing with time.

$R = \frac{V}{I} = \frac{6.0}{2.5 \times 10^{-5}} = 2.4 \times 10^5 \Omega$

time constant, $\tau = RC = 5.8 \times 10^{-4} \times 2.4 \times 10^5 = 139.2$ s

(iii)



b) (i) $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{9\times10^{-12}\times2.8\times10^{-3}}} = 1.0\times10^6 Hz = 1.0$ MHz

(ii) $Q_{max} = CV_{max} = 9\times10^{-12}\times12 = 1.08\times10^{-10}C$

$I_{max} = \omega Q_{max} = 2\pi f Q_{max} = 2\pi\times1.0\times10^6\times1.08\times10^{-10} = 6.79\times10^{-4}$ A

(c) (i) Resultant force= slope of momentum– time graph

$F_{AB} = \frac{(20-10)10^3}{(10-5)(60)} = 33.3N, F_{BC} = 0\,N, F_{CD} = \frac{(0-20)10^3}{(20-15)(60)} = -66.7N$

(ii) Total displacement $= \frac{\text{Area under graph}}{\text{mass}}$

$= (S_1) + (S_2) + (S_3)$

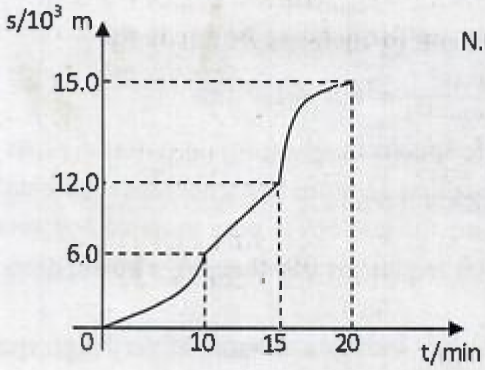
$S_1 = \frac{1}{2}\left(\frac{10\times60}{1000}\right)(20\times10^3) = 6.0\times10^3 m, S_2 = \left(\frac{(15-10)(60)(20\times10^3)}{1000}\right) = 6.0\times10^3$ m,

$S_3 = \frac{1}{2}\frac{(20-15)(60)(20\times10^3)}{1000} = 3.0\times10^3$ m,

total displacement= $(6.0+6.0+3.0)10^3 = 1.5\times10^4 m$

OR since the area enclosed by the graph is a trapezium, total displacement is given by

$S = \frac{1}{2}\frac{(5+20)(60)(20\times10^3)}{1000} = 1.5\times10^4$ m



N.B

- ✓ Between A and B, the car is accelerating, meaning the gradient of the displacement – time graph should increase with time.
- ✓ Between B and C, the car is moving at constant speed, meaning the gradient should be constant. Hence a straight line
- ✓ Between C and D car is decelerating. Hence the slope of the graph should decrease with time

(b) (i) By the principle of conservation of linear momentum,

$m_c v_{max} = (m_c + m_v)v \Rightarrow v = \frac{m_c}{(m_c+m_v)}v_{max}$, but $v_{max} = \frac{P_{max}}{m} = \frac{20\times10^3}{1000} = 20\ ms^{-1}$

$\Rightarrow v = \left(\frac{1000}{1000+1500}\right)20 = \left(\frac{1000}{2500}\right)20 = 8\ ms^{-1}$

Initial kinetic energy just before collision, $Ke_{initial} = \frac{1}{2}mv_{max}^2 = \frac{1}{2}(1000)(20)^2 = 2.0\times10^5 J$

Kinetic energy of the interlocked, $Ke_{final} = \frac{1}{2}(1000+1500)(8)^2 = 8.0\times10^4 J$

Some of the initial kinetic energy of the car is lost as heat and sound while some is used in deformation.

10. (a) (i) A line emission spectrum is the spectrum of light radiated by individual atoms in a hot gas when the electrons in the atom jump from higher energy levels to a lower energy levels. The spectrum consists of colored lines on a dark background.

A line absorption spectrum is produced when a beam of white light is passed through a cool gas, such that the photons whose energies are equal to the excitation energies of the gas atoms are absorbed. An absorption spectrum consists of dark lines on a colored background.

The table below summarizes the differences between line absorption spectrum and line emission spectrum

Line emission spectrum	Line absorption spectrum
A series of colored lines	Series of dark lines
The radiation has not passed through an absorption medium	Radiation has passed through an absorption medium
A result of excited electrons falling from higher to lower energy level	Results from an electron taking energy to go from a lower to a higher energy level
An example is the light from a hydrogen or sodium vapour	An example is white light passed through a hydrogen or sodium vapour

b) (i) The ground state of an atom is its lowest energy level available. Electrons have the least energy in the ground state, so this is the case for a normal atom. The highest energy level is given the value zero and the lower values are therefore negative.

(ii) The ground state energy is $E_1 = -13.6$ eV, and the energy at infinity is $E_\infty = 0$. The energy difference $E_\infty - E_0 = 0 - -13.6\text{ eV} = 13.6\text{ eV}$, which is the ionization energy.

(iii) $\Delta E = hf \Longrightarrow E_5 - E_1 = hf \Longrightarrow f = \frac{(-0.54+13.6)(1.6\times10^{-19})}{6.6\times10^{-34}} = 3.2\times10^{15}\text{Hz}$, which lies in the ultraviolet region of the electromagnetic spectrum.

(iv) The maximum wavelength will correspond to the minimum energy difference i.e $E_3 - E_2$

$\Longrightarrow E_{min} = E_3 - E_2 = \frac{hc}{\lambda_{max}} \Longrightarrow \lambda_{max} = \frac{hc}{E_3 - E_2} = \frac{6.6\times10^{-34}\times3.0\times10^{8}}{(-1.5 - -3.4)(1.6\times10^{-19})} = 6.5\times10^{-7}$ m

This wavelength lies in the visible region of the electromagnetic spectrum.

(c) (i) The fact that the $\alpha-$ particles were reflected back suggests that an atom has a nucleus. Since only few were reflected back through angles greater than 90^0, it means the nucleus is very massive and small.

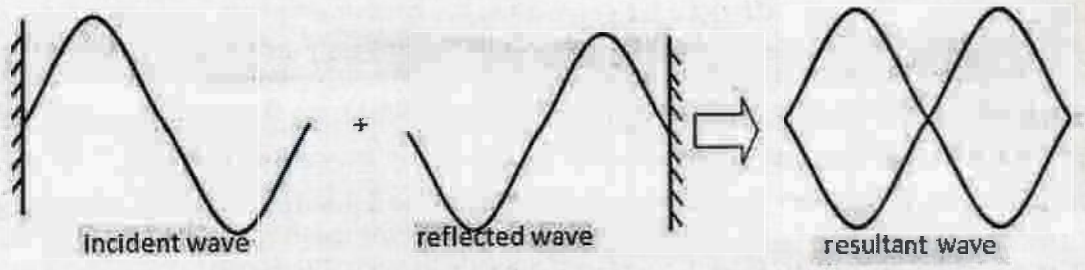
(ii) The fact that some of the $\alpha-$particles were reflected through angles greater than 90^0 also suggests that the nucleus is massive and positively charged.

(d) Electromagnetic waves can travel through a material medium as well as a vacuum at very high speeds while mechanical waves require a material medium for their propagation. Examples of electromagnetic waves include: x – rays, gamma rays, infra– red, visible light, etc. examples of mechanical waves include: sound waves, water waves, waves produced in a spring, seismic waves, etc

(e) Differences between stationary and progressive waves

	Stationary Wave	Progressive Wave
Energy	No net transfer of energy from one point to another. Energy is confined within the wave and there is interchange of K.E. and P.E.	Energy is transported in the direction of travel of the wave travel.
Phase	All particles between two adjacent nodes are in phase. Particles on opposite sides of a node will be in antiphase.	All particles within one wavelength vibrate with different phase.
Amplitude	Varies from zero at nodes to maximum at antinode.	Same amplitude for all particles in the wave
Wavelength	2 x distance between adjacent nodes or antinodes.	Distance between adjacent particles which are in phase.
Frequency	All particles vibrate in SHM with same frequency except at nodes.	All particles vibrate in SHM with same frequency.
Waveform	Does not advance.	Advances in the direction of velocity of wave.

A stationary wave is produced when two progressive waves have the same amplitude, wavelength and frequency and travelling in opposite directions interfere.

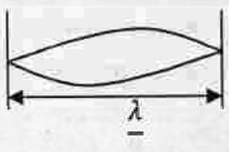


(f) (i) Harmonics are frequencies which are integral multiples of the fundamental frequency

(ii) Wavelength= twice distance between antinodes = 2x 10 =20 m; Amplitude= 10 cm

(iii) $v = f\lambda = 600 \times 0.2 = 120\ ms^{-1}$

In the fundamental mode of vibration, the whole string is half the wavelength (see diagram below)



$l = 60cm = 0.6m \Rightarrow \frac{\lambda}{2} = 0.6 = 1.2m \Rightarrow f_0 = \frac{120}{1.2} = 100Hz$

Edukamer