MARKING SCHEME

1. (a) (i) Principle of energy conservation. (02 marks)

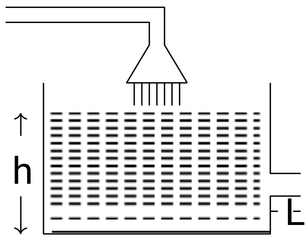
(ii) According to Bernoulli's equation

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

When pressure is high, velocity of liquid flow is low and vice-versa, Also according to continuity as the cross-section area decrease the velocity increases (AV=constant) so pressure decreases. (03 marks)

(c) (i) When two ships come closer to each other, the air velocity between narrow-gap increases and the pressure decreases, so the pressure on outer surface exceed the pressure in the gap and hence ships are pulled toward each other. (02 marks)

(ii) Consider



(00$\frac{1}{2}$ marks)

According to poiseuille formula

$$V = \frac{\pi \Delta P r^4}{8\eta L}$$

$\Delta P = \rho g h$ (0

$$V = \frac{\pi \rho g h r^4}{8\eta L}$$

2

$$h = \frac{8V\eta L}{\pi \rho g r^4}$$

$$h = \frac{1.5 \times 10^{-2} \times 8 \times 10^{-3} \times 2 \times 10^{-1}}{\pi \times 1000 \times 9.8 \times 1 \times 10^{3}}$$ (00$\frac{1}{2}$ marks)

$h = 0.076m$ (02 marks)

(d) (i) During the winter the temperature is low as the result engine oil has high viscosity. (02 marks)

(ii) According to Bernoulli equation

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$$

$p_1 = p_2$, Also neglect the speed at the top of the tank

Then, $\rho g h_1 = \frac{1}{2}\rho V_2^2 + \rho g h_2$

$\Delta = h_1 - h_2 = 0.30m$

The speed of water as it emerges from the hole

$V_2 = \sqrt{2g(h_1 - h_2)}$

$V_2 = \sqrt{2 \times 9.8 \times 0.3}$

$V_2 = 2.42 m/s$ (01$\frac{1}{2}$ marks)

Then, Flow rate $Q = A_2 V_2$ Q=

$6.5 \times 10^{-4} \times 2.42$

$Q = 1.6 \times 10^{-3} m^3/s$ (00$\frac{1}{2}$ marks)

Also using equation of continuity

$A_3 V_3 = A_2 V_2$

$A_3 = \frac{1}{2} A_2$

$V_3 = \frac{A_2}{A} V_2$

$V_3 = 2V_2$

$V_3 = 2.42 \times 2$

$V_3 = 4.84 m/s$ (01 marks)

Since pressure is constant throughout the fall

$\frac{1}{2}\rho V_2^2 + \rho g h_2 = \frac{1}{2}\rho V_3^2 + \rho g h_3$

$h_2 - h_3 = \frac{4.84^2 - 2.42^2}{2 \times 9.8}$

$h_2 - h_3 = 0.90 m$ (01 marks)

2. (a) (i) For the propagation of sound a material medium is required. As there is no air in the moon the sound wave can no travel so they cannot talk to each other. (03 marks)

(ii) Evidence that sound is the form of energy is in the fact that it can do work. Sound wave creates mechanical vibration in the medium in which it travels. Example sound can set eardrum in motion, makes window rattle or shatter a glass (03 marks)

(b) (i) - When a source of sound as well as listener moves in the same direction with the same speed. (01 marks)

- When source or observer is at the center of the circle and the other is moving around the circle at the constant speed. (01 marks)

(ii) From $V_{vbc} = \frac{CAF}{2f_o\cos\theta}$ (01 marks)

$$V_{vbc} = \frac{4.4\times10^3\times1.5\times10^{-3}}{2\times5\times10^6\times\cos30^\circ}$$

$V_{vbc} = 0.76m/s$

Rate = $\frac{\pi d^2}{4}$ vbc (02 marks)

Rate= $\frac{\pi\times(1\times10^{-3})^2}{4}$ 0.76

Rate= $0.6\times10^{-3}m^3/s$ (01 marks)

Volume rate of blood flow is $0.6\times10^{-3}m^3/s$ (01 mark)

(c) (i) From scattering $\alpha = \frac{1}{\lambda^4}$

The sky appear blue because the scattered light has large mixture of shorter wave length (violet and blue) than longer wave length (yellow and red). (02 marks)

(ii) From $\sin\theta_m = N\lambda_m$ ($00\frac{1}{2}$ marks)

$\theta_m = \sin^{-1} N\lambda_m$ ($00\frac{1}{2}$ marks)

Since $\lambda_1 = 5890Å$ and $\lambda_2 = 5890Å$

All are first order

$\theta_1 = \sin^{-1}(\lambda_1 N)$

$\theta_1 = \sin^{-1}(6000\times5890\times10^{-8})$

$\theta_1 = 20^\circ\ 42'$ (01 marks)

Also

$\theta_2 = \sin^{-1}(\lambda_2 N)$

$\theta_2 = \sin^{-1}(6000\times5896\times10^{-8})$

$\theta_2 = 20^\circ\ 43'$ (01 marks)

$\Delta\theta = \theta_2 - \theta_1$

$\Delta\theta = 20^\circ\ 43' - 20^\circ\ 42'$

$\Delta\theta = 1'$ (01 marks)

3. (a) (i) *

Temperature- decrease with increase in temperature (01 marks)

* Impurities- impurities lower surface tension. (01 marks)

(ii) From $P = P_o + \frac{2\gamma}{R}$ (01 marks)

R=Radius of bubble

γ =Surface tension

$P = 1.013 \times 10^{-5} + \frac{2 \times 0.05}{1 \times 10^{-3}} + 0.5 \times 1200 \times 9.8$ (01 marks)

$P = 1.073 \times 10^{5} Pa$ (02 marks)

(b) (i) At O K, the kinetic energy of the gas molecules becomes zero. Therefore more decrease in kinetic energy is not possible. (02 marks)

(ii) From perfect gas equation

$PV = Nkt$ ($00\frac{1}{2}$ marks)

where N=Number of molecules present in very dilute gas

$P = \frac{N}{V} \times kt$ ($00\frac{1}{2}$ marks)

$\frac{N}{V}$ = 5 molecules per cm^3 = 5×10^6 molecules per cm^3 ($00\frac{1}{2}$ marks)

$k = 1.38 \times 10^{-23} Jk^{-1}$

$t = 3k$ ($00\frac{1}{2}$ marks)

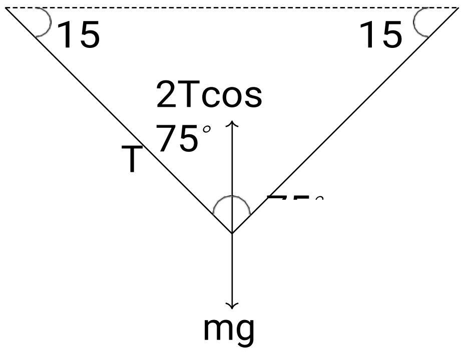
$P = (5 \times 10^6) \times (1.38 \times 10^{-23}) \times 3$ (01 marks)

$P = 2.07 \times 10^{-16} M/m^2$ (01 marks)

(c) (i) Since, Breaking force=Breaking stress × Area

Where wire is cut to half there is no change in the maximum load the wire can support. (02 marks)

(ii) Consider the figure bellow



(01 marks)

r = 0.5cm = 0.005m

A = $\pi r^2 = \pi \times 0.005^2$

2Tcos 75° = mg (01 marks)

$$T = \frac{mg}{2\cos 75^\circ}$$

$$T = \frac{45 \times 9.8}{2\cos 75^\circ}$$

$T = 852N$ (02 marks)

$$Y = \frac{TL}{Al}$$

$$\frac{l}{L} = \frac{T}{AY}$$

$$\frac{l}{L} = \frac{852}{\pi \times (0.005)^2} \times 20 \times 10^1$$

$\frac{l}{L} = 5.4 \times 10^{-5}$ (01 marks)

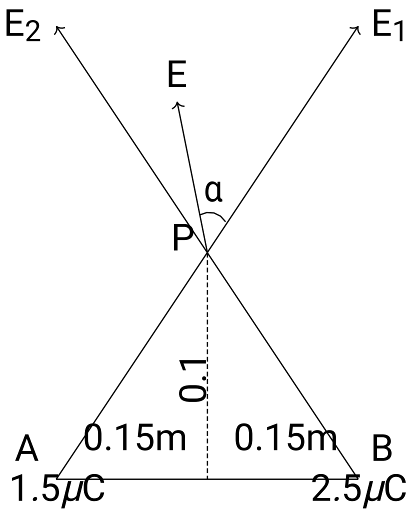
4. (a) (i) $E_m = E_2 - E_1$

$$E_m = \frac{k}{r^2}(q_2 - q_1)$$

$$E_m = \frac{9 \times 10^9}{(0.15)^2}(2.5 \times 10^{-6} - 1.5 \times 10^{-6})$$

$E_m = 4 \times 1065 m^{-1}$ toward q_1 (02 marks)

(ii) Consider the figure



$P_A = P_B = \sqrt{0.15^2 + 0.1^2}$ (01 marks)

$P_A = P_B = 0.18$ m

$$E_1 = 9 \times 10^9 \times \frac{q_1}{(PA)^2}$$

$E_1 = 0.42 \times 10^6\ Vm^{-1}$

Then $E_2 = 9 \times 10^9 \times \frac{q_2}{(PB)^2}$

$E_2 = 9 \times 10^9 \times \frac{2.5 \times 10^{-6}}{(0.18)^2}$

$E_2 = 0.69 \times 10^6 Vm^{-1}$ (01 marks)

But $\cos\frac{\theta}{2} = \frac{0.1}{0.18} = 0.5556$

$\frac{\theta}{2} = \cos^{-1}(0.556)$

$\frac{\theta}{2} = 56.25^\circ$

$\theta = 112.5^\circ$

$E = \sqrt{(0.42 \times 10^6)^2 + (0.69 \times 10^6)^2 + 2 \times 0.42 \times 10^6 \times 0.69 \times 10^4 \cos 112.5^\circ}$

$E = 6.56 \times 10^5 Vm^{-1}$

Electric field is $6.56 \times 10^5 Vm^{-1}$ (02 marks)

(b) (i) Capacitance, $c = 8\mu f$

Resistance, $R = 0.5\mu\Omega$ $E = 200V$ (02 marks)

$I_o = \frac{E}{R}$

$I_o = \frac{200}{0.5 \times 10^6}$

$I_o = 4 \times 10^{-4} A$ (01 marks)

Initial charging current is $4 \times 10^{-4} A$

(ii) The current

$I_t = I_0 e^{\frac{-t}{Rc}}$

$I_t = 4 \times 10^{-4} e^{-\frac{4}{0.54 \times 8}}$ ($00\frac{1}{2}$ marks)

$I_t = 1.47 \times 10^{-4} A$

Current after 4 seconds is $1.47 \times 10^{-4} A$ (01 marks)

Potential difference

$V_t = V_0(1 - e^{\frac{-t}{Rc}})$

$$V_t = 200(1 - e^{\frac{-4}{4}})$$

$V_t = 126.42\ V$ (01 marks)

The voltage at 4 second is 126.42V

(c) (i) $V_C = k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$

$$V_C = 9 \times 10^9 \left(\frac{200 \times 10^{-6}}{0.8} - \frac{100 \times 10^{-6}}{0.2}\right)$$

$V_C = 9 \times 10^9 (2.5 \times 10^{-4} - 5 \times 10^{-4})$

$V_C = -2.25 \times 10^6 V$ (01 marks)

Then at point D

$V_D = k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$

$$V_D = 9 \times 10^9 \left(\frac{200 \times 10^{-6}}{0.2} - \frac{100 \times 10^{-6}}{0.8}\right)$$

$V_D = 9 \times 10^9 (1 \times 10^{-3} - 1.25 \times 10^{-4})$

$V_D = 7.9 \times 10^6 V$ (01 marks)

(ii) Work done

$w = q\Delta V$

$w = q(V_o - V_C)$ (02 marks)

$w = 5 \times 10^{-4}(7.9 \times 10^6 - (-2.25 \times 10^6))$ $w = 5075J$

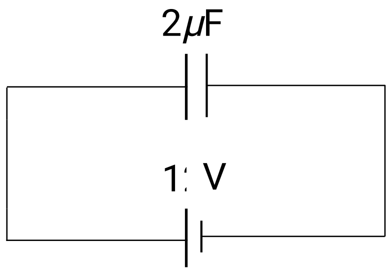
Work done is 5075J (01 marks)

(d) (i) Capacitance of a capacitor is the ratio of charge on the plate to the potential difference across the plate.

$$C = \frac{\text{charge on either plate}}{\text{PD across plates}}$$

$$C = \frac{Q}{V}$$ (02 marks)

(ii) First case

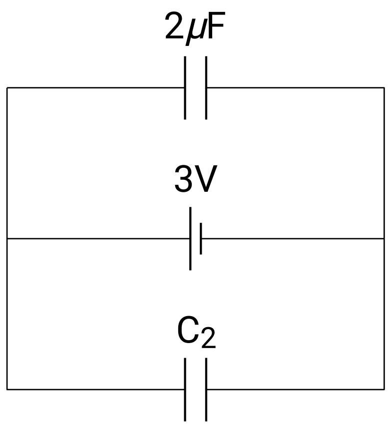


From $q_1 = CV$

$q_1 = 12V \times 2\mu f$

$q_1 = 24\mu C$ (01 marks)

Second case



(01 marks)

For series arrangement charge is the same $q = (C_1 + C_2)V$

$24\mu C = (2\mu f + C_2)3V$

$C_2 = 6\mu f$

Capacitance of C_2 is $6\mu f$ (01 marks)

5. (a) (i) Magnetic flux is total number of magnetic lines of force crossing the surface normally.

It's SI unit is weber (Wb) (02 marks)

ii. From $|e| = \frac{d\varphi}{dt} = \frac{d}{dt}(3t^2+5t+2)$ (01 marks)

$e = (6t + 5)mV$

Inserting t = 10s

$e = (6 \times 10 + 5)mV$

$e = 65 \times 10^{-3}V$ (01 marks)

$I = \frac{e}{R}$

$I = \frac{65 \times 10^{-3}}{6.5}$

$I = 10^{-2}A$ (02 marks)

The induced current in the coil at t = 10*s* is $10^{-2}A$

(b) (i) Due to sudden break, a large induced e.m.f is set up across the gap in the switch. Due to this sparking take place. (02 marks)

(ii) From $LI = N\Phi$ ($00\frac{1}{2}$marks)

$LI = NBA$

$L = \frac{NBA}{I}$ ($00\frac{1}{2}$marks)

But $B = \mu_0 RI$

$B = \frac{\mu_0 NI}{2\pi r}$ (01 marks)

$L = \frac{N \times \mu_0 NIA}{2\pi rI}$

$L = \frac{N \times \mu_0 NA}{2\pi r}$

$L = \frac{4\pi \times 10^{-7} \times 1200^2 \times 12 \times 10^{-4}}{2\pi \times 0.15}$ (0 marks)

$L = 2.304 \times 10^{-3}H$ (01 marks)

(c) (i) Metallic piece gets heated due to eddy currents produced in it.

(ii) $Q = \frac{\Phi_i - \Phi_f}{R}$, $\Phi_f = 0$ (01 marks)

$Q = \frac{\Phi_i}{R}$

But $\Phi_i = BAN$

$Q = \frac{BAN}{R}$

$$Q = \frac{100 \times 3 \times 10^{-2} \times 20 \times 10^{-4}}{5}$$ (01 marks)

$Q = 1.2 \times 10^{-3}C$ (01 marks)

When reversed

$$Q = \frac{2BAN}{R}$$ (01 marks)

$$Q = \frac{2 \times 100 \times 3 \times 10^{-2} \times 20 \times 10^{-4}}{5}$$ (01 marks)

$Q = 2.4 \times 10^{-3}C$ (01 marks)

6. (a) (i) * Half-life-is the time during which half of atom of radioactive substance will disintegrate. (01 marks)

* Activity-is the rate of disintegration of radioactive substance. (01 marks)

(ii) From $N = \frac{mass}{M_V} NA$

$$N = \frac{1}{235} \times 6.02 \times 10^{23}$$

$N = 2.5617 \times 10^{23}$ particles. (02 marks)

$A = \lambda N$

$$\lambda = \frac{A}{N}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

$$A = \frac{\ln 2}{t_{\frac{1}{2}}} N$$

$$A = \frac{\ln 2 \times 2.5617 \times 10^{21}}{4.5 \times 10^{9} \times 365 \times 60 \times 60}$$

$A = 300293.45^{-1}$

$A = 3.0 \times 10^{5}$ disintegration/second. (02 marks)

(b) (i) Nuclear fusion-is the process of combining two light nuclei to form a heavy nucleus with the release of huge amount of energy due to mass defect. (02 marks)

(ii) Nuclear fission-is the process of splitting of heavy nucleus into two medium-mass nuclei in a nuclear reaction with a release of huge amount of energy due to mass defect. (02 marks)

(iii) Chain reaction- is the nuclear fission which once started continues till all the atoms of the fissionable material are disintegrated. (02 marks)

(iv) Critical mass-is the mass of fissionable material for which the neuron

Multiplication factor k=1. **(02 marks)**

(c) Since both alpha (2e) and sodium nucleus (lle) have positive charges, the kinetic energy will be converted to potential energy at closet distance (d)

$$K.E = P.E = \left(\frac{(2e)(11e)}{4\pi\varepsilon_0 d}\right) = 8M_eV$$

$$d = \left(\frac{e^2}{4\pi\varepsilon_0}\right)(22)\frac{1}{8M_eV}$$

But $\frac{e^2}{4\pi\varepsilon_0} = 1.44\ M_eVfm$

$d = 1.44\ M_e\ Vfm \times 22 \times \frac{1}{8M_eV}$

$d = 3.960$ fm

from formula of nuclear radius

$R = (1.44 \text{ fm}) \times (23)^{1/3}$

$R = 4.095$ fm

Where $f = 10^{-15}$

The difference of 3.3% is small. However it is important to note that

$R = R_0\ A^{1/3}$ is an empirical formula derived from alpha scattering experiment