QUESTION ONE

Qn 1

(a)(i) Force for which the work done in moving a body round a closed path is zero ✓ (1)

OR: Force for which the work done in moving a body from one point to another is independent of the path taken.

(ii) Eg. Gravitational force, ✓ Magnetic force, ✓ Electric force, Elastic force.. (Any two ½ @) (1)

b(i) The sum of kinetic energy and potential energy (M.E) is constant in the absence of dissipative forces ✓ (1)

(ii) (diagram: A at bottom with speed U, B at height h above with speed V)

At A $K.E = \frac{1}{2}mu^2$ ✓

$P.E = 0$ ✓

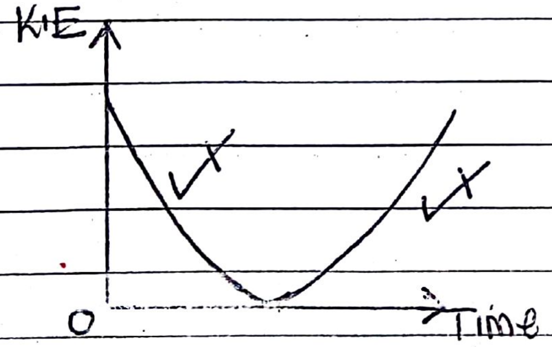
$\therefore$ Total energy $E_A = K.E + P.E = \frac{1}{2}mu^2$ ✓

At B $K.E = \frac{1}{2}mv^2$ ✓, $P.E = mgh$ ✓

$E_B = \frac{1}{2}mv^2 + mgh$ ✓ But $v^2 = u^2 - 2gh$ ✓

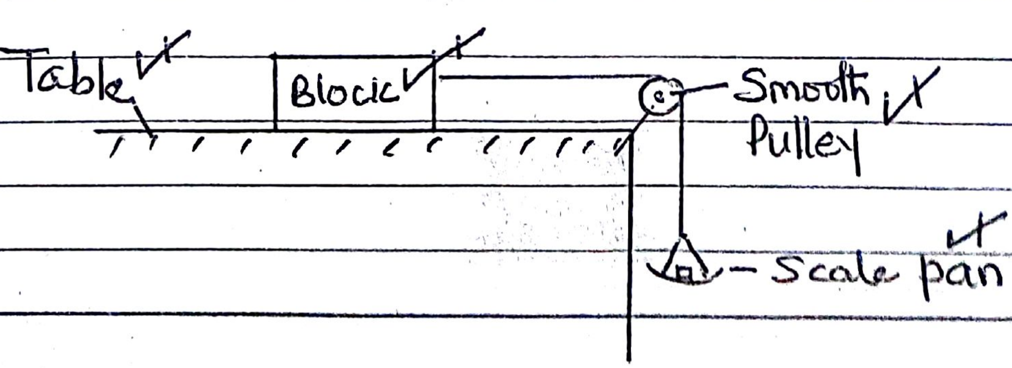
$\Rightarrow E_B = \frac{1}{2}m(u^2 - 2gh) + mgh = \frac{1}{2}mu^2$ ✓ (5)

(iii)



(1)

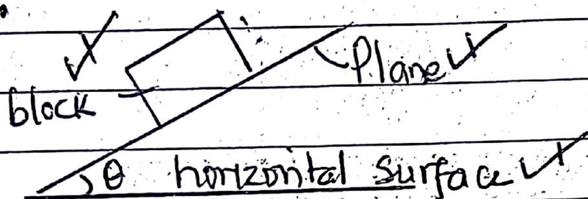
(c)



(Any Two ½@) (1)

A block of mass M is placed on a flat table and connected to a scale pan as shown in the diagram above. Small weights are added in bits onto the scale pan until the block just starts to move. The total weight of scale pan and weight added is obtained, W_T. Then coefficient of static friction $\mu = \frac{W_T}{Mg}$ (3)

ALT.



(any two ½@) (1)

A block is placed on a horizontal plane. The plane is tilted gently until the block just starts to slide. The angle of tilt θ is measured and recorded, then $\mu = \tan\theta$ (3)

c(ii) Wastes energy, causes tear and wear, causes noise, generates heat (Any two ½@) (1)

d(i) $F = \mu(m+M)g$ ~~μmg~~ $= 0.3 \times 0.52 \times 9.81 = 1.53N$ (2)

(ii) ~~F = ma~~ $F = (m+M)a$ OR

Initial total K.E just after collision = Work done against friction

$\frac{1}{2}(M+M)V_1^2 = \mu(m+M)gS$

$V_1^2 = 2\mu gS$

$V_1 = \sqrt{(2 \times 0.3 \times 9.81 \times 2.3)}$

$V_1 = 3.68\ ms^{-1}$

$-1.53 = 0.52a$

$a = -2.94\ ms^{-2}$

$V^2 = u^2 + 2as$

$0 = V_1^2 - 2 \times 2.94 \times 2.3$

$V_1 = 3.68\ ms^{-1}$ = Common velocity just after collision

$\Rightarrow mu = (M+M)V_1$

$0.02u = 0.52 \times 3.68 \Rightarrow u = 95.68\ ms^{-1}$ (4)

(20)

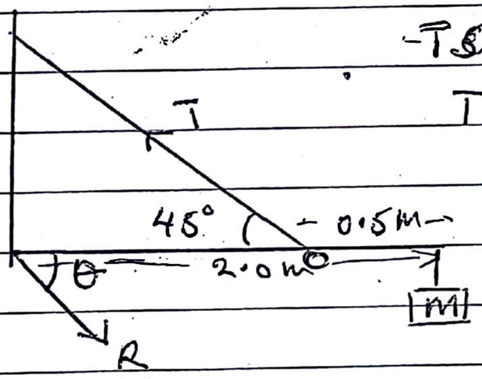
QUESTION TWO

2(a)(i) When a body is in mechanical equilibrium the sum of the clockwise moments about any point is equal to the sum of the anti-clockwise moments about the same point ✓ (01)

(ii) Centre of gravity is the point where the resultant force on the body due to gravity acts ✓ (01)

A uniform body is one whose centre of gravity is the same point as its geometrical centre ✓

(b)(i)



equating ✓ ✓

$-T\sin 45 \times 1.5 = 20 \times 9.81 \times 2$ ✓

$T = \dfrac{20 \times 9.81 \times 2}{1.5\sin 45}$

$\therefore T = 370N$ ✓ (03)

(ii) $R\cos\theta = 370\cos 45$ ✓ ---- (1)

Taking moments about O

$R\sin\theta \times 1.5 = 20 \times 9.81 \times 0.5$ ✓ ---- (2)

(2) ÷ (1) $\tan\theta = \dfrac{20 \times 9.81 \times 0.5}{370 \times \cos 45 \times 1.5}$ ✓

$= 0.24997$

$\theta = 14.03°$ ✓

From (1), $R = \dfrac{370\cos 45}{\cos 14.03} = 270N$ ✓ (03)

Subject .... Paper code ..../...... Personal Number

Take moments about R

2b (iii) $500 \sin 45 \times 1.5 = x \times 9.81 \times 2$ ✓✓

$x = \frac{500 \times \sin 45 \times 1.5}{9.81 \times 2} = 27.03 kg$ ✓✓

∴ Extra mass $= 27.03 - 20 = 7.03 kg$ ✓ (02)

(c)(i) Young's Modulus is the ratio of tensile stress to tensile strain ✓ (01)

(ii) • Vernier reading taken as masses are loaded and unloaded ✓ to ensure that the elastic limit is not exceeded ✓

• Two identical wires are used ✓ to eliminate errors due to temperature (thermal) changes ✓

• Both wires are suspended from the same support ✓ to eliminate errors in extension due to the yielding of the support ✓ (06)

• Thin wires are used ✓ to produce a measurable (large) extension when a small force is applied ✓

• Long wires are used ✓ to produce measurable (large) extension ✓

• Average diameter of wire ✓ is got to obtain accurate X-sec. area ✓

• Wires should be free of kinks ✓ to get accurate original length ✓

(iii) Rubber consists of coiled molecules ✓✓ while a metal does not ✓✓. When load is applied to the rubber the molecules uncoil ✓✓ leading to a larger extension (02)

20

Question 3

(a) Planets revolve in elliptical orbits with the sun at one focus. ✓ 3

20/20

The imaginary line joining the sun to any planet sweeps out equal areas in equal time intervals. ✓

The square of the period of revolution of a planet is proportional to the cube of the mean distance from the sun to the planets. ✓

(b)(i) Is the path in space followed by a satellite whose period of revolution is equal to the period of rotation of the earth. ✓ 1

OR Is the path in space followed by a satellite which appears stationary when viewed from the earth's surface.

(ii) $\frac{GmM_s}{r^2} = M_s r\omega^2$ but $\omega = \frac{2\pi}{T}$ ✓ 4

$\frac{Gm}{r^2} = r\left(\frac{4\pi^2}{T^2}\right)$

$T = 2\pi\sqrt{\frac{r^3}{Gm}}$ ✓

ALTERNATIVE

$F_g = \frac{GM_s m}{r^2}$, $F_c = \frac{M_s V^2}{r}$

M_s - mass of satellite, V - velocity of satellite

$\frac{GM_s m}{r^2} = \frac{M_s V^2}{r}$

but $V = \omega r$

$Gm = (\omega r)^2 r = \omega^2 r^3$

$\omega = \frac{2\pi}{T}$ ✓

$Gm = \left(\frac{2\pi}{T}\right)^2 r^3$

$T^2 = \frac{4\pi^2 r^3}{Gm}$

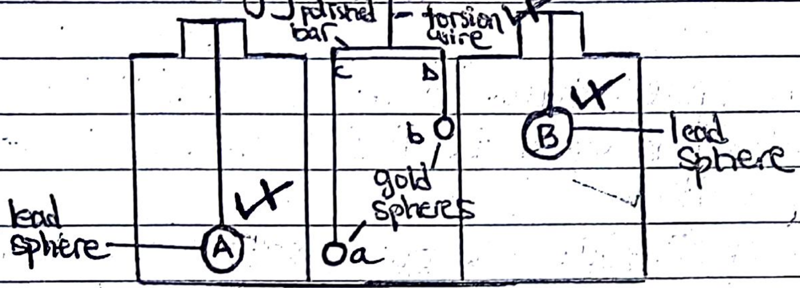
$T = 2\pi\sqrt{\frac{r^3}{Gm}}$ ✓

(i) $M\cdot E = -\frac{GMm}{2r} = -\frac{6.67\times10^{-11}\times5.97\times10^{24}\times200}{2(3.59\times10^{7}+6.4\times10^{6})}$ substitution, value for r 3

$M\cdot E = -9.41\times10^{8}\ J$

(ii) Since mechanical energy $m\cdot E = -\frac{GMm}{2r}$ reduces, radius r reduces and satellite falls into orbit of smaller radius, from $K\cdot e = GMm/2r$ when radius r reduces Kinetic energy increases. 3

d)



Two identical gold spheres a and b each of mass m are suspended as above, from the ends of a highly polished bar CD of length l. Two large spheres A and B each of mass M are brought in position near a and b respectively. Distance d between a and A is measured and the deflection θ of bar CD is measured by the lamp and scale method. Torque of couple on CD 6

$= \frac{GmM}{d^2}\times l$

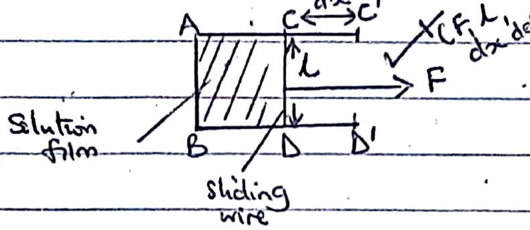
$\Rightarrow \frac{GmMl}{d^2} = c\theta$

where c = torsion of wire per radian, thus G can be calculated.

QUESTION FOUR

4(a) (i) Surface tension is force per unit length acting at right angles to one side of an imaginary line drawn in the liquid surface whereas surface energy is the work done in increasing area of the surface by $1m^2$ under isothermal conditions. ✓ 01

(ii)



If a wire frame ABCD is put in a solution of surface tension γ and a film of the solution forms on ABCD; and if a force F is used to extend the film to $ABC'D'$, then;

Surface tension, $\gamma = \frac{F}{2L}$ ✓ and surface energy $\sigma = \frac{F \times dx}{2L \times dx}$ ✓✓ 03

$\therefore \sigma = \frac{2\gamma L\, dx}{2L\, dx} = \gamma$ ✓

(iii) Given any volume, a sphere is the shape with minimum surface area, hence minimum surface energy; therefore most stable. ✓ 03

(b) $2(4\pi r_1^2) + 2(4\pi r_2^2) = 2(4\pi R^2)$ ✓ ; $\therefore R = \sqrt{r_1^2 + r_2^2} = 4.47cm.$ ✓

$\therefore P_i - P_o = \frac{4\gamma}{R}$ ✓ $= \frac{4 \times 2.5 \times 10^{-2}}{4.47 \times 10^{-2}}$ ✓ $= 2.24\,Pa.$ ✓ 04

c (i) Bernoulli's principle – the sum of the pressure at any point in an incompressible non-viscous fluid with stream line flow plus the K.E per unit volume plus the P.E per unit volume is constant. ✓ 01

(ii) Wind blowing at a high speed over the roof of the building causes the pressure above the roof to decrease. ✓ The pressure inside the building where the air is slow is greater. ✓ This difference in pressure causes a resultant force that pushes the roof off the building ✓ 03

P.T.O

Q4 c (iii)

Minimum force to lift aeroplane = 8000 × 9.81 = 78480 N.

If V is the velocity of the aeroplane; then

velocity of air below the wings, $V_b = V$

Velocity of air above the aeroplane, $V_a = \frac{V}{0.25} = \frac{V_b}{0.25}$

$\Rightarrow V_a = 4V.$

From Bernoulli's principle:

$P_b + \frac{1}{2}\rho V_b^2 = P_a + \frac{1}{2}\rho V_a^2$

$\therefore P_b - P_a = \frac{1}{2}\rho(V_a^2 - V_b^2) = \frac{1}{2}\rho(16V^2 - V^2)$

$\therefore P_b - P_a = \frac{1}{2} \times 1.3 \times 15V^2 = 9.75V^2$

But force = Pressure × Area

$\Rightarrow 78480 = 9.75V^2 \times 8.0$

$\therefore V = 31.72 ms^{-1}.$

05

20

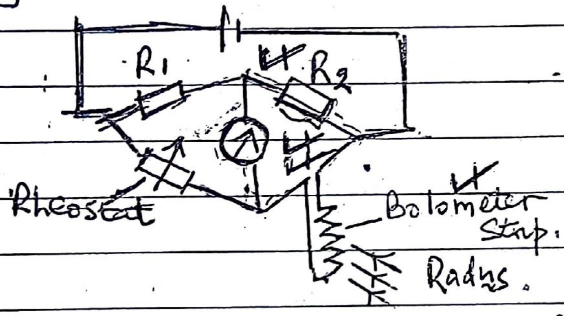
Subject .... Paper code ..../...... | Personal Number

Subject .... Paper code ..../...... | Personal Number

5) (a)(i) - Property must vary linearly with temperature. ✓
- Property must vary continuously with temperature. ✓
- Property should change considerably for small temp. changes. ✓ (02)
- Property must be measurable over a wide range of temperature. ✓

(ii) It is b'se different thermometric properties vary differently with temperature and they only agree at fixed points. (01)

(b)

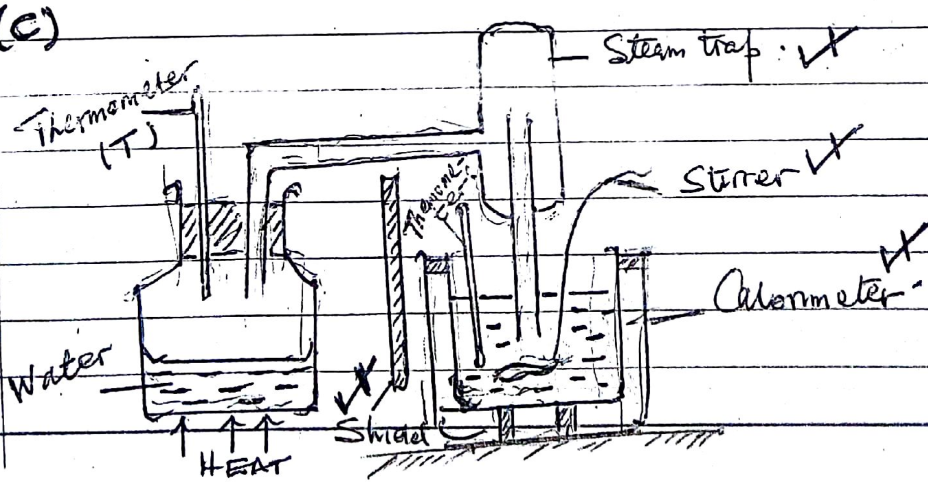


(02)

The strip is connected to the wheatstone-bridge circuit as shown above.

The rheostat is adjusted ✓ until the galvanometer shows no deflection. ✓ When the radns fall on the strip ✓ they are absorbed ✓ and its temp. rises ✓ leading to an increase in resistance ✓. The galvanometer deflects ✓ showing the presence of radns. ✓ (04)

(c)



(02)

5 cont.

The initial temp. of water in the Calorimeter θ_2 and mass M_1 of Calorimeter and water are measured. Steam from boiling water is passed into water in the Calorimeter. After a measurable temp. rise the final temp. of water in the Calorimeter θ_f is measured. The mass m_2 of the Cal. and water is again measured. Therefore the mass of condensed steam $m_s = m_2 - m_1$. Temperature θ_3 of steam measured by thermometer is recorded. The mass of the Calorimeter m_c is obtained by weighing

$\therefore$ $m_s l_v + m_s c(\theta_3 - \theta_f) = [(m_1 - m_c)c + C](\theta_f - \theta_2)$

$\Rightarrow$ l_v can be obtained. defining c and C (05)

(d) Rate of evaporation $= 0.016$ kg per min

$= \frac{0.016}{60}$ kg s^{-1}

$P = m l_v + mc\Delta\theta$

$\therefore$ $600 = \frac{0.016}{60} \times l_v + \frac{0.016}{60} \times 4200 \times (100-80)$ (04)

$\Rightarrow$ $l_v = 2.2 \times 10^6$ J kg^{-1}

20

QUESTION SIX

6(a)

(i) It is temperature attained when molecules slow down and acquire the least possible energy. ✓ 01

ii, It is temperature added to the explaling observed maximum temp to cater for heat lost to the surroundings. ✓ 01

(b)

(i) The total pressure of a mixture of gases is equal to the sum of partial pressures of the individual gases (provided they do not interact chemically). ✓ 01

(ii) $P = \frac{1}{3}\rho\overline{c^2}$, $\rho = \frac{M}{V}$

$P = \frac{1}{3}\frac{M}{V}\overline{c^2}$ ✓ $= \frac{1}{3}\frac{Nm\overline{c^2}}{V}$, where m = mass of 1 molecule

$\therefore PV = \frac{1}{3}Nm\overline{c^2}$ ✓ $M = Nm$

Suppose the gas has two compents 1 and 2

$P_1V = \frac{1}{3}N_1m_1\overline{c_1^2}$ ✓

$P_2V = \frac{1}{3}N_2m_2\overline{c_2^2}$ ✓

$\therefore P_1V + P_2V = \frac{1}{3}N_1m_1\overline{c_1^2} + \frac{1}{3}N_2m_2\overline{c_2^2}$ ✓

$(P_1+P_2)V = \frac{2}{3}N_1 \cdot \frac{1}{2}m_1\overline{c_1^2} + \frac{2}{3}N_2 \cdot \frac{1}{2}m_2\overline{c_2^2}$ 08

At temp T

$\frac{1}{2}m_1\overline{c_1^2} = \frac{1}{2}m_2\overline{c_2^2} = \frac{3}{2}K_BT$ ✓

$\therefore (P_1+P_2)V = (N_1+N_2)K_BT$

But $PV = NK_BT$ ✓

Since $N = N_1 + N_2$, then $P = P_1 + P_2$. ✓

Subject .... Paper code ..../...... Personal Number

OR

$P = \frac{1}{3}\rho \overline{c^2}$, $\rho = \frac{M}{V}$

$= \frac{1}{3}\frac{M}{V}\overline{c^2} = \frac{1}{3}\frac{Nm}{V}\overline{c^2}$

$\therefore PV = \frac{1}{3}Nm\overline{c^2}$ $M = Nm$

$\Rightarrow N = \frac{3PV}{m\overline{c^2}}$

If the gas has components 1 and 2

$N_1 = \frac{3P_1V}{m_1\overline{c_1^2}}$ and $N_2 = \frac{3P_2V}{m_2\overline{c_2^2}}$

$N = N_1 + N_2$

$\frac{3PV}{m\overline{c^2}} = \frac{3P_1V}{m_1\overline{c_1^2}} + \frac{3P_2V}{m_2\overline{c_2^2}}$ $\Rightarrow \frac{P}{m\overline{c^2}} = \frac{P_1}{m_1\overline{c_1^2}} + \frac{P_2}{m_2\overline{c_2^2}}$

08

At the same temp,

$\frac{1}{2}m_1\overline{c_1^2} = \frac{1}{2}m_2\overline{c_2^2} = \frac{1}{2}m\overline{c^2}$

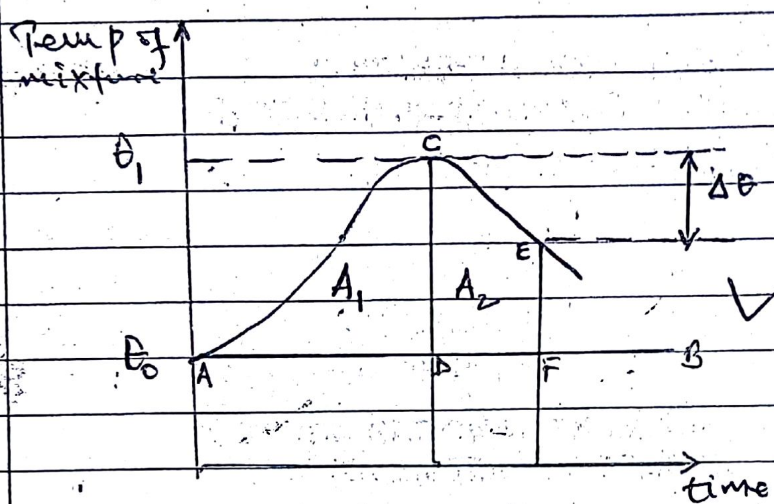
$\therefore P = P_1 + P_2$

(c) Pour a liquid in a calorimeter and place it on a table. Place a thermometer into the liquid and after some time record the temp of the surroundings, θ_0.
Gently place the heated solid into the liquid and stirr.
Note and record the temp of the mixture at a suitable time interval until the temp of the mixture has fallen by about 1°C.

02

below the observed max temp, θ_1.

Plot a graph of temp against time.



Draw a line AB through θ_0 parallel to the time axis.

Draw a line CD through θ_1 parallel to the temp axis.

Draw a line EF beyond CD parallel to the temp axis and note $\Delta\theta$.

Estimate the areas A_1 and A_2 under the graph by counting the squares on the graph paper.

The cooling correction, θ is given by

$$\theta = \frac{A_1}{A_2} \times \Delta\theta \ ^\circ C.$$

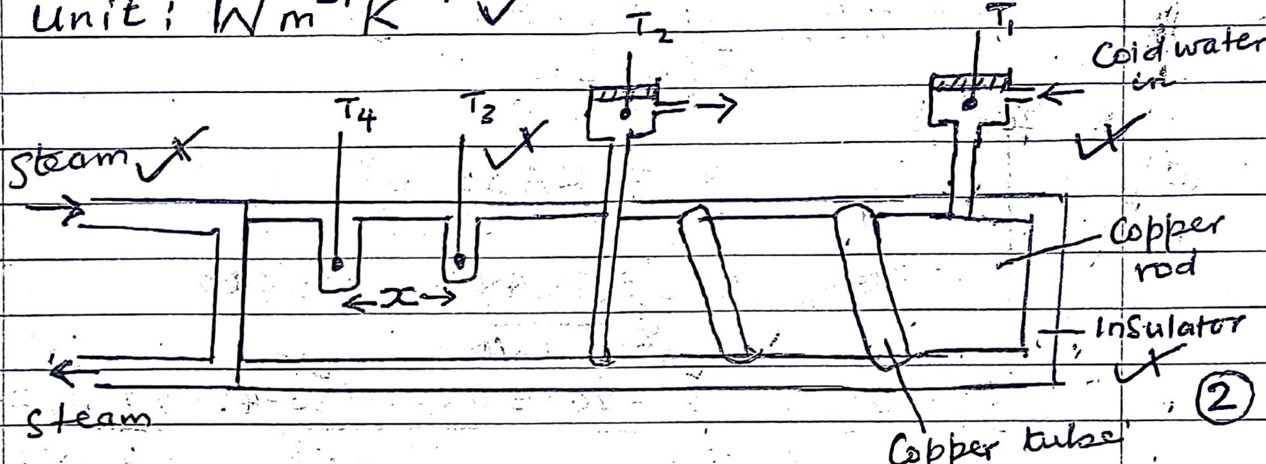
06½

2 om

QUESTION SEVEN

7(a) Thermal Conductivity is the rate of heat flow per unit area of Cross section per unit temperature gradient ✓
unit: $Wm^{-1}K^{-1}$ ✓ (2)

(b)



(2)

The diameter d of the rod is measured using a micrometer screw gauge ✓. Two holes are drilled in the rod at a known distance x ✓.
Thermometers T_4 and T_3 are inserted in the holes which are filled with a good conducting fluid ✓. On the other end a copper tube is wound round the rod and cold water is let in at a steady rate. Thermometers T_1 and T_2 measure the temperatures of inflowing and outflowing water respectively (3)
Steam is used to heat the copper rod.
At steady state ✓, the temperatures θ_4, θ_3, θ_2 and θ_1 of thermometers T_1, T_2, T_3 and T_4 respectively are recorded ✓.
The mass of water collected per second, m ✓ is measured and recorded.

Subject .... Paper code ..../...... Personal Number

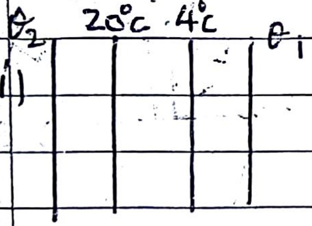
-15.

Then $\frac{Q}{t} = \frac{K\pi d^2}{4}\frac{(\theta_4-\theta_3)}{x} = mC_w(\theta_2-\theta_1)$

where C_w = specific heat capacity of water

$\therefore K = \frac{4x\,m\,C_w(\theta_2-\theta_1)}{\pi d^2(\theta_4-\theta_3)}$ ✓ (1)

(c)(i)



$\frac{Q}{t} = KA\frac{\Delta\theta}{L}$ ✓✗

$\frac{Q}{t} = \frac{0.72A(\theta_2-20)}{4\times10^{-3}}$ = ~~0.20~~

$\therefore \frac{Q}{t} = \frac{0.72A(\theta_2-20)}{4\times10^{-3}} = \frac{0.025A(20-4)}{1.5\times10^{-3}} = \frac{0.72A(4-\theta_1)}{4\times10^{-3}}$ ✓✗ ✓✗ ✓✗

$\theta_2 = 21.48°c$ ✓✗ $\theta_1 = 2.52°c$ ✓✗ (3)

(ii) $\frac{Q}{t} = \frac{0.025\times16\times2}{1.5\times10^{-3}}$ ✓ $= 533.3\ Js^{-1}$

In two hours heat that flows $= 533.3\times2\times3600$ ✓ (3)

$= 3.84\times10^6 J$ ✓

d(i) A black body is one which absorbs all incident ~~ration~~ radiations falling on it and transmitts and reflects none ✓ (1)

(ii) A Welder puts on dark glasses which absorbs U-V ✓ radiations ✓ which destroys the retina.

This cuts down the intensity of light ✓. (3)

(iii) $\lambda T = 2.9\times10^{-3}$ ✓✗

$6000\lambda = 2.9\times10^{-3}$ ✓✗ (2)

$\lambda = 4.8\times10^{-7} m$ ✓

20

QUESTION EIGHT

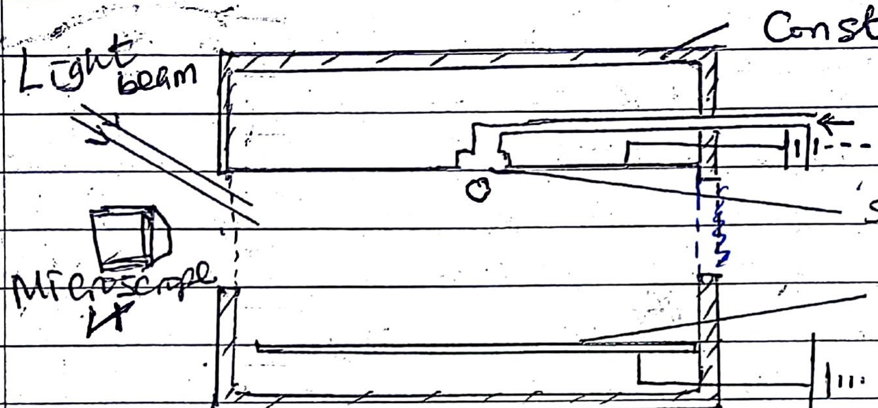
8(a)(i) Avogadro's Constant is the number of atoms in one mole of a substance. ✓ 1

Faraday's constant is the charge required to liberate one mole of monovalent ions during electrolysis! ✓

(ii) $F = N_A Q$ ✓ $\Rightarrow 96500 = 6.02 \times 10^{23} Q$ ✓ 2

$Q = 1.6 \times 10^{-19}$ C ✓

b.



2

Oil is sprayed above the upper metal plate! With no p.d between the plates one oil drop is observed as it falls between the plates! The distance, x fallen in time, t is obtained! and terminal velocity V_0 of the drop is determined.

At terminal velocity;

$$\frac{4}{3}\pi r^3 \rho_0 g = \frac{4}{3}\pi r^3 \rho_a g + 6\pi\eta r V_0 \quad ----(1)$$

$$\Rightarrow r = \left(\frac{9\eta V_0}{2g(\rho_0 - \rho_a)}\right)^{\frac{1}{2}}$$ ✓

A p.d is applied across the plates and is adjusted until the drop becomes stationary! P.d, V and separation, d between the plates are measured and recorded. $E = \frac{V}{d}$ is calculated.

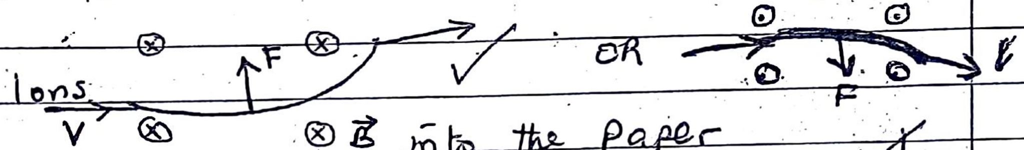
$$\frac{4}{3}\pi r^3 \rho_0 g = \frac{4}{3}\pi r^3 \rho_a g + EQ \quad ----(2)$$

$$Q = \frac{6\pi\eta V_0}{E}\left(\frac{9\eta V_0}{2g(\rho_o-\rho_a)}\right)^{\frac{1}{2}}$$ ✓✓

ρ_o = density of oil
ρ_a = density of air ✓
η = viscosity of air

5

Using several drops the charge on each drop is obtained. The charge on each drop is an integral multiple of e ✓ which is the electron charge.

c. 

⊗ $\vec{B}$ into the paper ✓✓

Magnetic force, $F = BQV$ acts on the ions ✓. The force is perpendicular to both $\vec{B}$ and $\vec{V}$ ✓ according to Fleming's left hand rule. The ions describe circular path ✓ of radius, r given by $BQV = \frac{mV^2}{r} \Rightarrow r = \frac{mV}{BQ}$ ✓ where Q is the charge on the ions.

3

d i) $V_0 = \frac{2\times10^{-3}}{35.7}$ ✓ $= 5.6\times10^{-5}$

$$r = \left(\frac{9\eta V_0}{2g(\rho_o-\rho_a)}\right)^{\frac{1}{2}} ✓ = \left(\frac{9\times1.8\times10^{-5}\times5.6\times10^{-5}}{2\times9.81(880-1.29)}\right)^{\frac{1}{2}}$$ ✓

$\therefore r = 7.254\times10^{-7}$ m ✓ (3)

ii) $Q = \frac{\frac{4}{3}\pi r^3 g}{E}(\rho_o-\rho_a)$ ✓, $E = \frac{V}{d} = \frac{6.0\times10^{-3}}{103}$ ✓

$= \frac{4}{3}\times3.14\times(7.254\times10^{-7})^3\times9.81(880-1.29)\times\frac{6.0\times10^{-3}}{103}$ ✓

$= 8.025\times10^{-19}$ ✓ (3)

$Q = ne \Rightarrow n = \frac{8.025\times10^{-19}}{1.6\times10^{-19}}$ ✓

$\therefore n = 5$ ✓

TOTAL: 20

QUESTION NINE

9 (a)(i) • For any given metal surface, there is min. freq. of radn below which no photoelectric emission occurs. ✓
• There is no detectable time lag btn irradiation and emission of ēs. ✓
• The k.e. of photoelectrons ranges from zero to max, and the max. k.e. ∝ freq. of the incident radn but is indep. of its intensity. ✓
• The no. of ēs emitted per second ∝ Intensity of the incident radn. ✓ (4)

(ii) • Use of a photocell in a burglar alarm. ✓
• When an intruder intercepts Infrared radn incident on the photocell ✓, the flow of current is interrupted. ✓
• An alarm is then set off. ✓ (4)

(b)(i) No. of ~~photons~~ electrons emitted per sec by the lamp $= \frac{3.2\times10^{-3}}{5\times1.6\times10^{-19}}$ ✓

$= 4.0\times10^{15}$ ✓ photons per second

Photons per second incident on the sphere $= \frac{4.0\times10^{15}\times\pi\times(8.0\times10^{-3})^2}{4\pi\times0.8^2}$ ✓

$= 1.0\times10^{11}$ ✓ photons per second

∴ No. of ēs emitted per second $= \frac{1.0\times10^{11}}{10^6}$

$= 1.0\times10^{5}$ ✓ (4)

(ii) Max. ke $= 5-3 = 2\text{eV}$ ✓

$= 2\times1.6\times10^{-19}$ ✓

$= 3.2\times10^{-19}\text{ J}$ ✓ (2)

ALT (a)(ii) Photocell ✓
When radiation falls on the cathode of a photocell, the emitted electrons move to the anode ✓ current flows ✓ and it is used to generate a potential difference ✓

1.(c)(i) Bragg's law: For constructive interference of diffracted X-rays to occur, the path difference is an integral multiple of the wavelength of the x-rays ✓ or $2d\sin\theta = n\lambda$ (with symbols defined). (1)
(d- interatomic spacing, θ = glancing angle, n = order of diffraction, λ - wavelength of the x-rays)

(ii) Density $\rho = \frac{M}{V}$ ✓

Vol. of crystal molecule with atomic spacing $d = d^3$ ✓

1 mole weighs M grams ✓

$\therefore$ 1 molecule weighs $\frac{M \times 10^{-3}}{N_A}$ ✓

$\therefore$ Density of a molecule $= \frac{M \times 10^{-3}}{N_A d^3}$ ✓

From Bragg's law; $d = \frac{n\lambda}{2\sin\theta}$ ✓

$$\therefore \rho = \frac{M \times 10^{-3}}{N_A\left(\frac{n\lambda}{2\sin\theta}\right)^3}$$ ✓ (5)

$$= \frac{M\sin^3\theta}{125\, N_A (n\lambda)^3}$$ ✓

Total 20

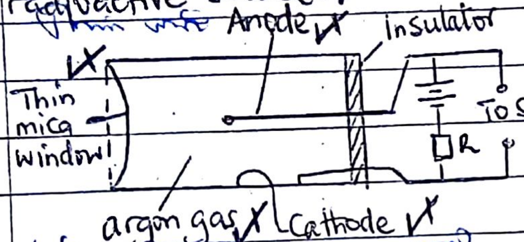
Subject .... Paper code ..../...... Personal Number

QUESTION TEN

10(a)(i) Is a halogen gas placed in a GM-tube to prevent positive ions from causing the release of electrons from the cathode ✓ (1)

(ii) Is the activity detected by the GM-tube in the absence of the radioactive source. ✓ (1)

b(i)

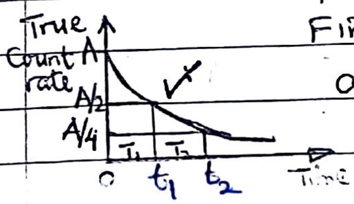


When an ionising particle enters the tube through the window, argon atoms are ionised, forming ion pairs. The electrons are accelerated to the anode and the positive ions drift to the cathode ✓. A discharge occurs and a current flows in the external circuit. A p.d develops across a large resistance R ✓ which is amplified and passed to a scaler ✓ or counter. The magnitude of the pulse registered gives the extent to which ionisation occurred. ✓ The bromine vapour acts as ------ (6)

+ at low pressure, bromine vapour (halogen)

(ii) Switch on the GM-tube, note and record the background count rate A_0. Place a source of ionising radiation near the GM-tube window. Note and record the count rate at equal time intervals. ✓ For each count rate recorded subtract the background count rate to get the true count rate.

Plot a graph of true count rate against time ✓



Find time T_1 taken for activity to reduce to $A/2$ and time T_2 taken for activity to reduce to $A/4$ from $A/2$ ✓

∴ Half life $= \frac{1}{2}(T_1 + T_2)$ ✓ or $\frac{1}{2}t_2$

$A = A_0 e^{-\lambda t}$

c(i) Activity, $A_0 = \lambda N_0$ ✓ but $\lambda = 0.693/T_{1/2}$ ✓

$\Rightarrow A_0 = 0.693 N_0 / T_{1/2}$ $\Rightarrow 2.0 \times 10^6 = 0.693 N_0 / 14.3 \times 24 \times 60 \times 60$

$\therefore N_0 = 3.57 \times 10^{12}$ atoms ✓ (3)

(ii) $A = A_0 e^{-\lambda t}$ ✓ $= 2.0 \times 10^6 e^{-\frac{0.693 \times 30}{14.3}}$ ✓ $= 49.5\ s^{-1}$ ✓ 4.67×10^{5} (3)

(iii) $A = \lambda N$ $\Rightarrow$ $49.5 = 0.693 N / 14.3 \times 24 \times 60 \times 60$ ✓

$\therefore N = 8.83 \times 10^{7}$ atoms ✓ (8.33×10^{11} Atoms) (2)

(20)

b(ii) ALT $T_{\frac{1}{2}} = \frac{0.693t}{\ln(A/A_0)}$

i.e $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$

But from $A = A_0 e^{-\lambda t}$

$\ln A = \ln A_0 - \lambda t$

$\lambda t = \ln\left(\frac{A_0}{A}\right)$

$\therefore \lambda = \frac{\ln(A_0/A)}{t}$

$T_{\frac{1}{2}} = \frac{0.693t}{\ln\left(\frac{A_0}{A}\right)}$.

P510/1
PHYSICS
Paper 1
Nov./Dec.2015
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Answer **five** questions, including at least **one**, but not more than **two** from each of the sections **A**, **B** and **C**. Any additional question(s) answered will **not** be marked.*
Non-programmable scientific calculators may be used.
Assume where necessary:

Acceleration due to gravity, g = $9.81 ms^{-2}$
Electron charge, e = 1.6×10^{-19} C
Electron mass = 9.11×10^{-31} kg
Mass of the earth = 5.97×10^{24} kg

Planck's constant, h	=	6.6×10^{-34} Js
Stefan's-Boltzmann's constant, σ	=	$5.67\times 10^{-8} Wm^{-2}K^{-4}$
Radius of the earth	=	6.4×10^{6} m
Radius of the sun	=	7×10^{8} m
Radius of earth's orbit about the sun	=	1.5×10^{11} m
Speed of light in a vacuum, c	=	$3.0\times 10^{8} ms^{-1}$
Thermal conductivity of copper	=	$390 Wm^{-1}K^{-1}$
Thermal conductivity of iron	=	$75 Wm^{-1}K^{-1}$
Specific heat capacity of water	=	$4200 Jkg^{-1}K^{-1}$
Universal gravitational constant, G	=	$6.67\times 10^{-11} Nm^2kg^{-2}$
Avogadro's number, NA	=	$6.02\times 10^{23} mol^{-1}$
Density of water	=	$1000 kgm^{-3}$
Gas constant, R	=	$8.31 Jmol^{-1} K^{-1}$
Charge to mass ratio, e/m	=	$1.8\times 10^{11} Ckg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0\times 10^{9} F^{-1}m$
Specific heat capacity of copper	=	$400 Jkg^{-1} K^{-1}$
Specific latent heat of fusion of ice	=	$3.3\times 10^{5} JKg^{-1}$

Turn Over

SECTION A

1. (a) (i) What is meant by a **conservative force**? *(01 mark)*

(ii) Give **two** examples of a conservative force. *(01 mark)*

(b) (i) State the law of conservation of **mechanical energy**. *(01 mark)*

(ii) A body of mass, m, is projected vertically upwards with speed, u. Show that the law of conservation of mechanical energy is obeyed throughout its motion. *(05 marks)*

(iii) Sketch a graph showing variation of kinetic energy of the body with time. *(01 mark)*

(c) (i) Describe an experiment to measure the coefficient of static friction. *(04 marks)*

(ii) State **two** disadvantages of friction. *(01 mark)*

(d) A bullet of mass 20 g moving horizontally strikes and gets embedded in a wooden block of mass 500 g resting on a horizontal table. The block slides through a distance of 2.3 m before coming to rest. If the coefficient of kinetic friction between the block and the table is 0.3; calculate the

(i) friction force between the block and the table. *(02 marks)*

(ii) velocity of the bullet just before it strikes the block. *(04 marks)*

2. (a) (i) State the **principle of moments**. *(01 mark)*

(ii) Define the terms **centre of gravity** and **uniform body**. *(02 marks)*

(b) Figure **1** shows a body, M of mass 20 kg supported by a rod of negligible mass horizontally hinged to a vertical wall and supported by a string fixed at 0.5 m from the other end of the rod.

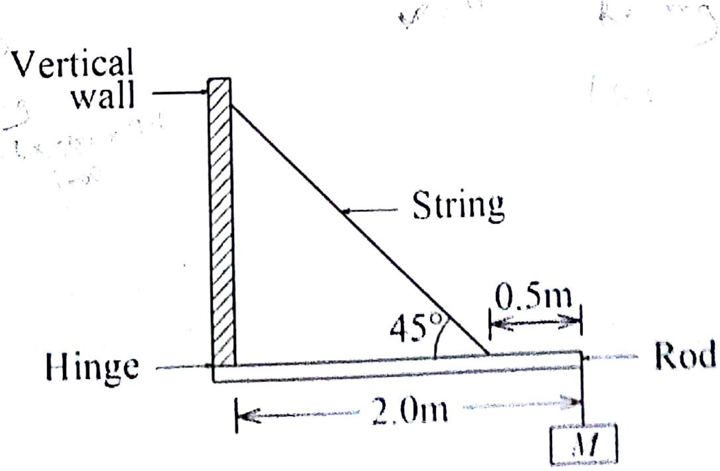


Fig. 1

Calculate the

(i) tension in the string. *(03 marks)*

(ii) reaction at the hinge. *(03 marks)*

(iii) maximum additional mass which can be added to the mass of 20 kg before the string can break given that the string cannot support a tension of more than 500 N. *(02 marks)*

(c) (i) Define **Young's Modulus.** *(01 mark)*

(ii) Explain the precautions taken in the determination of Young's modulus of a wire. *(06 marks)*

(iii) Explain why a piece of rubber stretches much more than a metal wire of the same length and cross-sectional area. *(02 marks)*

3. (a) State **Keplers' laws** of planetary motion. *(03 marks)*

(b) (i) What is a **parking orbit**? *(01 mark)*

(ii) Derive an expression for the period, T, of a satellite in a circular orbit of radius r, above the earth in terms of the mass of the earth m, gravitational constant G and r. *(04 marks)*

(c) (i) A satellite of mass 200 kg is launched in a circular orbit at a height of 3.59×10^7 m above the earth's surface. Find the mechanical energy of the satellite. *(03 marks)*

(ii) Explain what will happen to the satellite if its mechanical energy was reduced. *(03 marks)*

(d) Describe a laboratory method of determining the universal gravitational constant, G. *(06 marks)*

4. (a) (i) Distinguish between **surface tension** and **surface energy**.*(01 mark)*

(ii) Show that surface energy and surface tension are numerically equal. *(03 marks)*

(iii) Explain why water dripping out of a tap does so in spherical shapes. *(03 marks)*

(b) Two soap bubbles of radii 2.0 cm and 4.0 cm respectively coalesce under isothermal conditions. If the surface tension of the soap solution is 2.5×10^{-2} Nm^{-1}, calculate the excess pressure inside the resulting soap bubble. *(04 marks)*

(c) (i) State **Bernoulli's principle.** *(01 mark)*

(ii) Explain how wind at a high speed over the roof of a building can cause the roof to be ripped off the building. *(03 marks)*

(iii) An aeroplane has a mass of 8,000 kg and total wing area of 8.0 m^2. When moving through still air, the ratio of its velocity to that of the air at its lower surface is 1.0, whereas the ratio of its velocity to that of the air above its wings is 0.25. At what velocity will the aeroplane be able to just lift off the ground?
(*Density of air = 1.3 kgm*$^{-3}$). (*05 marks*)

SECTION B

5. (a) (i) State **four** desirable properties a material must have to be used as a thermometric substance. (*02 marks*)

(ii) State why scales of temperature based on different thermometric properties may not agree. (*01 mark*)

(b) With the aid of a diagram explain how a bolometer is used to detect thermal radiation. (*06 marks*)

(c) Describe, with the aid of a diagram an experiment to determine specific latent heat of vaporisation of steam using the method of mixtures. (*07 marks*)

(d) A 600 W electric heater is used to raise the temperature of a certain mass of water in a thermos flask from room temperature to 80^0C. The same temperature rise is obtained when steam from a boiler is passed into an equal mass of water at room temperature in the same time. If 16 g of water were being evaporated every minute in the boiler, find the specific latent heat of vaporisation of steam, assuming no heat loses. (*04 marks*)

6. (a) Define the following;

(i) Absolute zero. (*01 mark*)

(ii) Cooling correction. (*01 mark*)

(b) (i) State **Dalton's law of partial pressures**. (*01 mark*)

(ii) The kinetic theory expression for the pressure p, of an ideal gas of density ρ, and mean square speed, $\overline{c^2}$ is $p = \frac{1}{3}\rho\overline{c^2}$
Use the expression to deduce Dalton's law. (*05 marks*)

(c) Explain clearly the steps taken to determine the cooling correction when measuring the specific heat capacity of a poor conductor by the method of mixtures. (*07 marks*)

(d) The density of air at 0^0C and pressure of 101 kPa is 1.29 kgm^{-3}. Calculate pressure of 200 kPa . (*05 marks*)

7. (a) Define **thermal conductivity** of a material and state its unit. *(02 marks)*

(b) Describe an experiment to determine the thermal conductivity of copper. *(06 marks)*

(c) A double glazed window has two glass sheets each of thickness 4.0 mm, separated by a layer of air of thickness 1.5 mm. If the two inner air-glass surfaces have steady temperatures of 20^0C and 4^0C respectively, find the

(i) temperatures of the outer air-glass surfaces. *(03 marks)*

(ii) amount of heat that flows across an area of the window of 2 m^2 in 2 hours. *(03 marks)*

(Conductivity of glass = $0.72\ Wm^{-1}K^{-1}$ and that of air $=0.025\ Wm^{-1}K^{-1}$)

(d) (i) What is a **black body**? *(01 mark)*

(ii) Explain how a welder can protect the eyes from damage. *(03 marks)*

(iii) Calculate the wavelength of the radiation emitted by a black body at 6000 K. *(02 marks)*

(Wien's displacement constant = 2.9×10^{-3}mK)

SECTION C

8. (a) (i) Define **Avogadro's constant** and **Faraday's constant**. *(02 marks)*

(ii) Show that the charge carried by a monovalent ion is 1.6×10^{-19}C. *(02 marks)*

(b) With the use of a labelled diagram, describe Millikan's oil drop experiment for the determination of the charge of an electron. *(07 marks)*

(c) A beam of positive ions moving with velocity $\vec{V}$ enters a region of a uniform magnetic field of density $\vec{B}$ with the velocity at right angles to the field $\vec{B}$. By use of a diagram, describe the motion of the ions. *(03 marks)*

(d) A charged oil drop of density 880 kgm^{-3} is held stationary between two parallel plates 6.0 mm apart held at a potential difference of 103 V. When the electric field is switched off, the drop is observed to fall a distance of 2.0 mm in 35.7 s. (*Viscosity of air = $1.8 \times 10^{-5}\ Nsm^{-2}$, Density of air = $1.29\ kgm^{-3}$*)

(i) Calculate the radius of the drop. *(03 marks)*

(ii) Estimate the number of excess electrons on the drop. *(03 marks)*

9. (a) (i) State the laws of **photoelectric emission**. (04 marks)

(ii) Explain briefly one application of photoelectric effect. (04 marks)

(b) In a photoelectric set up, a point source of light of power 3.2×10^{-3} W emits mono-energetic photons of energy 5.0 eV. The source is located at a distance of 0.8 m from the centre of a stationary metallic sphere of work function 3.0 eV and of radius 8.0×10^{-3} m. The efficiency of photoelectron emission is one in every 10^6 incident photons. Calculate the

(i) number of photoelectrons emitted per second. (04 marks)

(ii) maximum kinetic energy in joules, of the photo electrons. (02 marks)

(c) (i) State **Bragg's law** of X-ray diffraction. (01 mark)

(ii) Show that density ρ, of a crystal can be given

$$\rho = \frac{M\sin^3\theta}{125N_A(n\lambda)^3}$$

where θ is the glancing angle, n is the order of diffraction, λ is the x-ray wavelength and M is the molecular weight of the crystal. (05 marks)

10. (a) With reference to a Geiger-Muller tube, define the following:

(i) quenching agent. (01 mark)

(ii) back ground count rate. (01 mark)

(b) (i) With the aid of a labelled diagram, describe the operation of a Geiger- Muller (GM) tube. (06 marks)

(ii) Explain how the half- life of a short lived radioactive source can be obtained by use of a Geiger- Muller tube. (04 marks)

(c) A radioactive isotope $^{32}_{15}P$ which has a half- life of 14.3 days, disintegrates to form a stable product. A sample of the isotope is prepared with an initial activity of 2.0 x 106 s^{-1}. Calculate the

(i) number of ^{32}P atoms initially present. (03 marks)

(ii) activity after 30 days. (03 marks)

(iii) number ^{32}P atoms after 30 days. (02 marks)

(*Assume* $N = N_0e^{-\lambda t}$)

END