UACE Physics paper 1 2007 Guide **Time 2½ marks**

Instructions the candidates:

Answer **five** questions, including at least **one**, but **not more than two** from each sections **A, Band 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	$9.81ms^{-2}$
Electron charge, e	$1.6 x10^{-19}C$
Electron mass	$9.11 \times 10^{-31}kg$
Mass of the earth	$5.97 \times 10^{24}kg$
Plank's constant, h	$6.6 \times 10^{-34}Js$
Stefan's-Boltzmann's constant, σ	$5.67 \times 10^{-8}Wm^{-2}K^{-1}$
Radius of the earth	6.4 x 106m
Radius of the sun	$7 \times 10^{8}m$
Radius of the earth's orbit about the sun	$1.5 \times 10^{11}m$
Speed of light in the vacuum, c	$3.0 \times 108ms^{-1}$
Thermal conductivity of copper	$390Wm^{-1}K^{-1}$
Thermal conductivity of aluminium	$210Wm^{-1}K^{-1}$
Specific heat capacity of water	$4.200Jkg^{-1}K^{-1}$
Universal gravitational constant	$6.67 \times 10^{-11}Nm^{2}Kg^{-2}$
Avogadro's number, N_A	$6.02 \times 10^{23}mol^{-1}$
Surface tension of water	$7.0 \times 10^{-2}Nm^{-1}$
Density of water	$1000kgm^{-3}$
Gas constant, R	$8.31Jmol^{-1}K^{-1}$
Charge to mass ratio, e/m	$1.8 \times 10^{11}Ckg^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 \times 10^{9}F^{-1}m$
Faraday's constant, F	$9.65 \times 10^{4}Cmol^{-1}$

SECTION A

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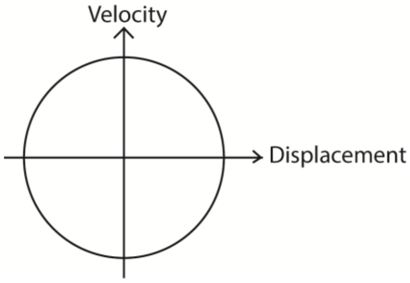
1. (a) Define simple harmonic motion (SHM). (01mark)

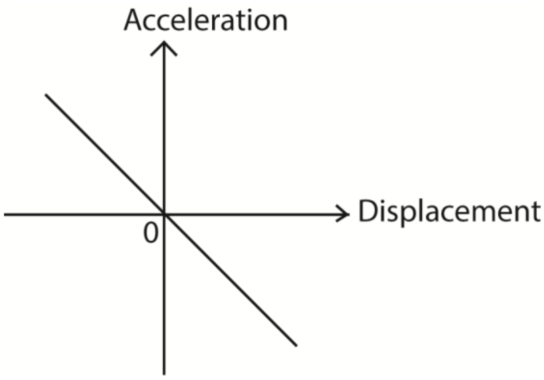
It is periodic motion in which the acceleration of the body along the path of the body is directed towards a fixed point in the line of motion and is proportional to the displacement of the body from a fixed point

(b) Sketch a graph of:

(i) velocity against displacement for a body executing SHM. (03marks)

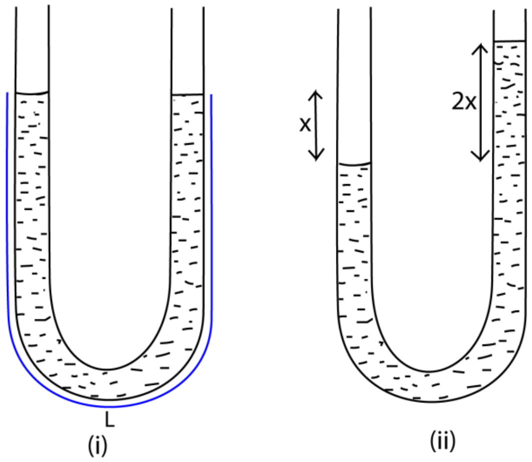


(ii) Acceleration against displacement, for a body executing SHM



(c) A glass U-tube containing a liquid is tilted slightly and then released.

(i) Show that the liquid oscillates with simple harmonic motion. (04mark)



A liquid of density ρ contained in a U-tube of cross section area A and column L, if the liquid is displaced slightly through a distance x from equilibrium position

The restoring force of the liquid = 2xAρg

Using Newton's 2nd law,

$$ma = -2xA\rho g$$

$$a = -\frac{2xA\rho g}{m} \quad \text{but, } m = AL\rho$$

$$a = -\frac{2xg}{L}$$

But $a = -\omega^2 x$

$$\omega = \sqrt{\frac{2g}{L}}$$

$$T = \frac{2\pi}{\omega}$$

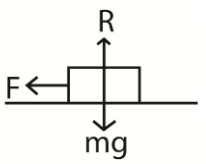
$$T = 2\pi\sqrt{\frac{L}{2g}}$$

Frequency, $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{2g}{L}}$

(ii) Explain why the oscillations ultimately come to rest. (03marks)

Resistive forces lead to loss of energy, causing a gradual decrease in amplitude and eventually oscillation die out

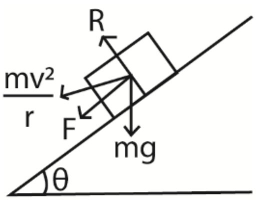
(d) Explain why maximum speed of a car on a banked road is higher than on an unbanked road. (04marks)



Along a circular path on a horizontal road, the frictional force provides the centripetal force

i.e. centripetal force = $\frac{mv_1^2}{r} = \mu R$

On a banked road, the centripetal force is provided by the component of normal reaction, R, and the component of friction



Centripetal force = $\frac{mv_2^2}{r} = F\cos\theta + R\sin\theta$

But $F = \mu R$

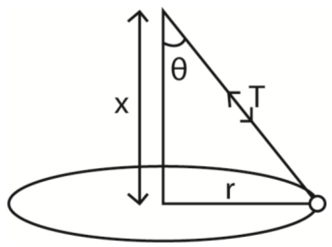
Centripetal force = $\frac{mv_2^2}{r} = \mu R\cos\theta + R\sin\theta$

For $0^0 < \theta < 90^0$, $\mu\cos\theta + \sin\theta > \mu$

Therefore, $v_2 > v_1$

(e) A small bob of mass 0.2kg is suspended by an inextensible string of length 0.8m. The bob is then rotated in a horizontal circle of radius 0.4m. Find

(i) linear speed of the bob (03marks)



$x^2 = 0.8^2 – 0.4^2$

x = 0.692m

Tsinθ = $\frac{mv^2}{r}$ ………………………….. (i)

Tcosθ = mg

Eqn. (i) and Eqn (ii)

tanθ = $\frac{v^2}{rg}$

v^2 = rgtanθ

v = $\sqrt{0.4 \ x\ 9.81\ x\ \frac{0.4}{0.692}}$ = 1.51ms^{-1}

(ii) tension in the string. (02marks)

T = $\frac{mg}{\cos\theta}$ = $0.2\ x\ 9.81\ x\ \frac{0.8}{0.692}$ = 2.29N

2. (a) State Kepler's laws of planetary motion. (03marks)

- Planets describe ellipses about the sun as one focus
- The imaginary line joining the sum and planet sweeps out equal areas in equal time intervals
- The square of the periodic time of revolution of planets about the sun are proportional to the cubes of their mean distance from the sun

(b) (i) A satellite moves in a circular orbit of radius, R, about a planet of mass, M, with period T. Show that $R^3 = \frac{GMT^2}{4\pi^2}$, where G is the universal gravitational constant. (04marks)

Force of attraction, F = $\frac{GMm}{R^2}$ where m is the mass of the satellite.

Centripetal force = mω^2R where ω= $\frac{2\pi}{T}$

⇨ $\frac{GMm}{R^2} = m\left(\frac{2\pi}{T}\right)^2 R$

$R^3 = \frac{GMT^2}{4\pi^2}$

(ii) The period of the moon around the earth is 27.3 days. If the distance of the moon from the Earth is 3.83 x 105km, calculate the acceleration due to gravity at the surface of the Earth. (04marks)

$\frac{GM}{R^3} = \frac{4\pi^2}{T^2}$

Near the earth's surface, $\frac{GMm}{r_e^2} = mg$

⇨ GM = $gr_e^2 = \frac{4\pi^2R^3}{T^2}$

$g = \frac{4\pi^2R^3}{T^2r_e^2}$ = $\frac{4\pi^2(3.83\ x\ 10^8)^3}{(27.3\ x\ 24\ x\ 60\ x\ 60)^2(6.4\ x\ 10^6)^2}$ = 9.73ms^{-2}

(i) Explain why any resistance to forward motion of an artificial satellite results into an increase in its speed. (04marks)

If the satellite encountered a resistance in orbit;

Total energy = M.E = $\frac{-GM_e m_s}{2R}$ decreases. Its orbit radius R decreases to R'

K.E = $\frac{1}{2}m_s v^2 = \frac{-GM_e m_s}{2R'}$

This means that the final kinetic energy and velocity increases.

(c) (i) What is meant by weightlessness? (02marks)

Weightlessness is a condition of zero reaction, the body has the same acceleration as the acceleration due to gravity.

(ii) Why does acceleration due to gravity vary with location on the surface of the earth? (03marks)

The earth is elliptical with equatorial radius bigger than the polar radius. At the equator, the body is less attracted towards the earth than at the pole. Therefore gravity at the equator is less than the gravity at the poles. The earth rotates about the polar axis. A body at the pole is practically stationary while the body towards the equator experiences a centripetal force.

Mω2R = mg –mg'

∴g' =g – ω^2R

3. (a) (i) State the laws of solid friction. (03marks)

- The frictional force between two surfaces opposes their relative motion.
- The frictional force is independent of the area of contact of the given surfaces when the normal reaction is constant,
- The limiting frictional force is proportional to the normal reaction for the case of static friction. The frictional force is proportional to the normal reaction for the case of kinetic (dynamic) friction, and is independent of the relative velocity of the surfaces.

(ii) Using molecular theory, explain the laws stated in (a)(i) (03marks)

- Actual area of contact between solid surfaces is very small. Therefore pressure at points of contact is very high; projections emerge to produce adhesion or welding. The force which oppose motion is obtained (Law I)
- The actual area of contact is the sum of the areas of tiny projections that adhere to each other and are nearly independent of the surface areas of contact.(law II)
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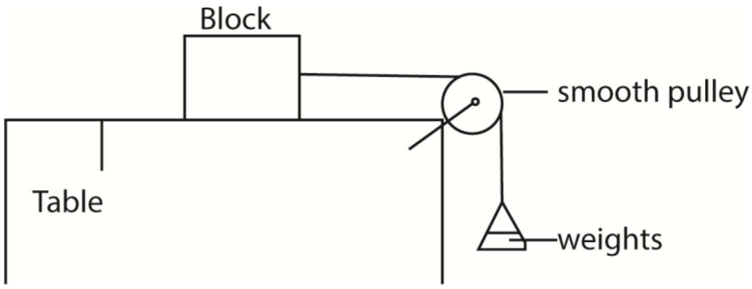
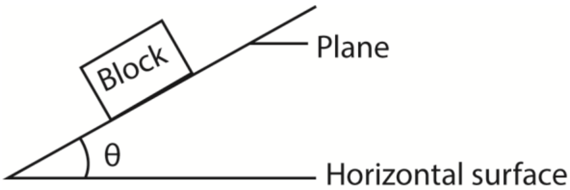
- Increase in weight increases the actual area of contact and hence greater limiting frictional force.

(b) Describe an experiment to determine the coefficient of static friction for an interface between a rectangular block of wood and plane surface. (04marks)



- 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 on to the scale pan until the block just starts to move. The total weight of the scale pan and weights added is obtained, W_f.
- The coefficient of static friction, $\mu = \frac{W_f}{mg}$

Alternative method



- A block is placed on horizontal plane. The plane is tilted gently until the block just start to slide
- The angle of tilt θ is measured
- The coefficient of static friction, $\mu = \tan\theta$

(c) (i) State the difference between conservative and non-conservative forces, give one example each. (03marks)

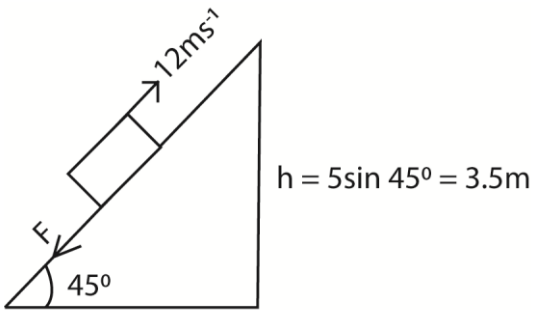
For conservative forces, the work done by force in a closed loop is zero e.g. gravitational force, magnetic force and electrostatic force

For non-conservative forces, work done by force in a closed loop is not zero. E.g. frictional force.

(ii) State the work-energy theorem. (01mark)

Work done by the resultant force on the body is equal in kinetic energy of the body

(iii) A block of mass 6.0kg is projected with a velocity of $12ms^{-1}$ up a rough plane inclined at 45^0 to horizontal. If it travels 5.0m up the plane, find the friction force. (04marks)



Initial kinetic energy = work done against resistance force.

$\therefore \frac{1}{2}mv^2 = mgsin\, 45^0 + F\, x\, s$

$\frac{1}{2}\, x\, 6\, x\, 12^2 = 6\, x\, 9.81\, x \sin 45^0 + F\, x\, 5$

F = 44.8N

(d) Explain the effect of temperature on the viscosity of a liquid.

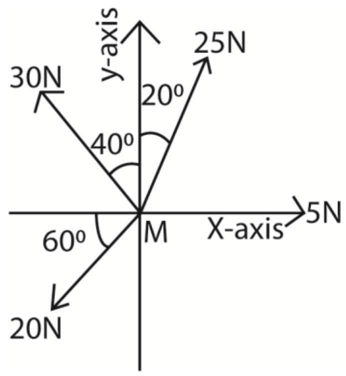
An increase in temperature of a liquid leads to an increase in molecular separation which weakens the intermolecular forces of attraction thereby reducing viscosity.

4. (a) (i) Define vector and scalar quantities and give one example of each. (03marks)

A vector quantity has both magnitude and direction e.g. velocity, displacement, force, acceleration due to gravity

A scalar quantity has only magnitude e.g. mass, volume, speed

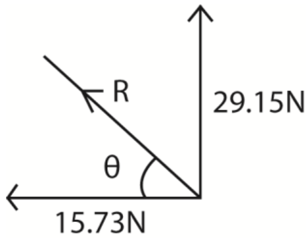
(ii)



A body, M, of mass 6kg s acted on by forces of 5N, 20N, 25N and 30N as shown in the figure above. Find the acceleration of M (05marks)

Resolving horizontally: 5 + 25cos 70^0 – 30cos 50^0 – 20cos60^0 = -15.73N

Resolving vertically: 30sin50^0 + 25sin70^0 – 20sin60^0 = 29.15N



R = $\sqrt{29.15^2 + 15.73^2}$ = 33.12N

θ = $tan^{-1}\left(\frac{29.15}{15.73}\right)$ = 61.7^0

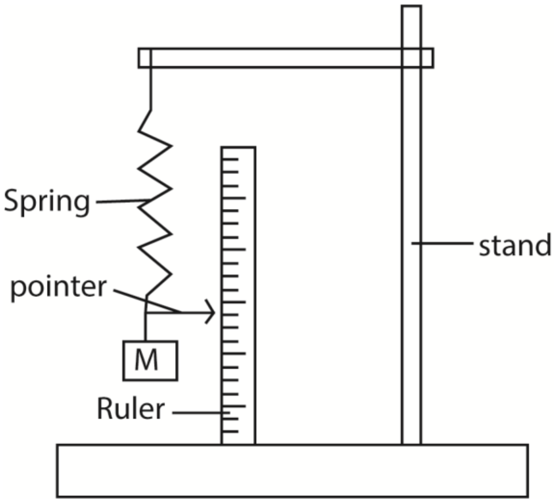
From F = ma

a = $\frac{33.12}{6} = 5.52ms^{-1}$

(b) (i) What is meant by acceleration due to gravity? (01mark)

Acceleration due to gravity is the force of attraction due to gravity exerted on 1kg mass. Or is the rate of change of velocity of a body moving freely under gravity.

(ii) Describe how you would use a spiral spring, a retort stand with a clamp, a pointer, seven 50g masses, a meter rule and a stop clock to determine the acceleration due to gravity. (06marks)



- Suspend a spiral spring from the clamp of a retort stand.
- Attach the pointer to the free end of the spring such that it is horizontal.
- Read and record the initial pointer position on a meter rule supported vertically.
- Suspend a 50g mass from the spring and record the new position of the pointer and calculate the extension, x, of the spring
- Displace the 50g mass through a small vertical distance and release it.
- Measure the time for a reasonable number of oscillations
- Calculate the period T of oscillations. Repeat the procedure for different value of masses.
- Plot a graph of T^2 against x, and find the slope, S, of the graph
- Calculate g from g = $\frac{4\pi^2}{S}$

(iii) State any two sources of error in the experiment in (b)(ii) above. (01marks)

- Reading positions of the pointer
- Determining period T

(iv) A body of mass 1kg moving with simple harmonic motion has speeds of $5ms^{-1}$ and $3ms^{-1}$ when it is at distances of 0.10m and 0.2m respectively from equilibrium point. Find the amplitude of the motion. (04marks)

$v^2 = \omega^2(A^2 - x^2)$

$5^2 = \omega^2(A^2 - 0.1^2)$ ……………………… (i)

$5^2 = \omega^2(A^2 - 0.2^2)$ ……………………… (ii)

From (i) and (ii)

A = 0.24m

SECTION B

5. (a) (i) Define a thermometric property and give two examples (02marks)

Thermometric property is a physical measurable property that varies linearly and continuously with temperature and is constant at constant temperature.

Examples

- Volume of constant mass of a gas at constant pressure
- Pressure of a gas at constant volume
- Electrical resistance of a platinum wire
- e.m.f of a thermocouple

(ii) When is the temperature of 0K attained? (02marks)

Ok is when molecules of a substance slow down and attain their minimum total energy

(b)(i) With reference to constant-volume gas thermometer, define temperature on the Celsius scale (02marks)

$\theta = \frac{P_\theta - P_0}{P_{100} - P_0}$ where θ is unknown temperature, P_θ is the pressure at unknown temperature, P_0 is the pressure at ice point and P_{100} is the pressure at steam point.

(ii) State two advantages and two disadvantages of the constant-volume gas thermometer. (02marks)

Advantages

- it has a wide range
- very accurate

Disadvantages

- it does not give direct reading
- cannot measure rapidly changing temperatures.

(c) (i) Define triple point of water (01mark)

Triple point of water is the temperature and pressure at which saturated water vapour, pure water and ice coexist in equilibrium.

(ii) Describe how you would measure the temperature of a body on the thermodynamic scale using a thermocouple. (03marks)

The e.m.f, E_{Tr} is obtained when a hot junction is placed in water at triple point. E.m.f, E_T is obtained at unknown temperature T.

$T = \frac{E_T}{E_{Tr}} \; x \; 273.16K$

(d) The resistance, R_θ of platinum varies with the temperature 0^0C as measured by the constant-volume gas thermometer according to the equation

$R_\theta = 50.0 + 0.17\theta + 3.0 \times 10^{-4}\theta^2$

(i) Calculate the temperature on the platinum scale corresponding to 60^0C on the gas scale. (06marks)

$R_0 = 50\Omega$

$R_{60} = 50 + 0.17 \times 60 + 3.0 \times 10^{-4} x 60^2 = 61.28\Omega$

$R_{100} = 50 + 0.17 \times 100 + 3.0 \times 10^{-4} x\ 100^2 = 70.00\Omega$

$\theta = \frac{R_\theta - R_0}{R_{100} - R_0} \; x \; 100^0C$

$= \frac{61.28-50}{70-50} \; x \; 100$

$= 56.4^0C$

(ii) Account for the difference between the two values and state the temperatures at which they agree. (02marks)

Difference thermometric properties vary differently with temperature.

6. (a) (i) Define latent heat (01mark)

Latent heat is the amount of heat required to change a unit mass of a substance from one state to another at constant temperature.

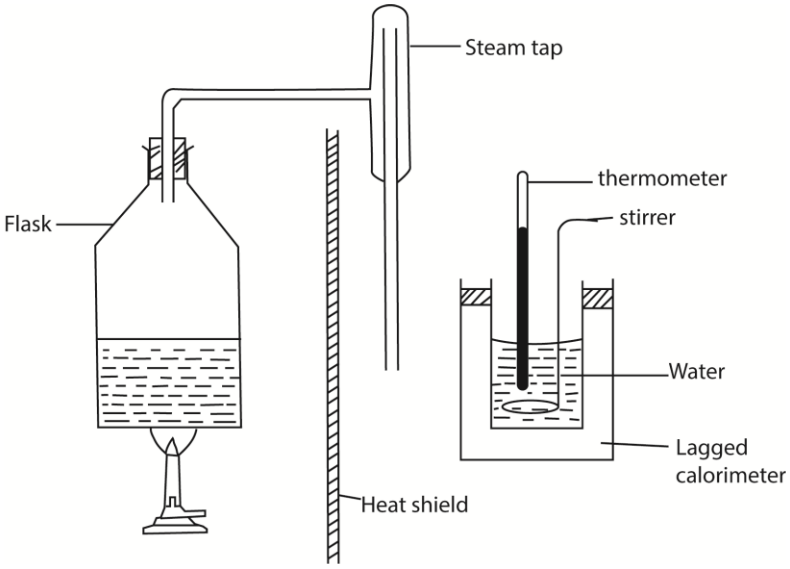
(ii) Explain the significance of latent heat in regulation of body temperature (03marks)

On a hot day, the body sweats. Evaporation occurs at the surface of the body leading to the cooling of the body since the evaporating water draws heat from the body.

(b) (i) Using kinetic theory, explain boiling of a liquid (03mark)

Molecules of a liquid through moving randomly have attractive forces between them. When a liquid is heated, the molecules move faster and forces of attraction weakened until they are overcome at the boiling temperature. At this point, saturated vapour pressure (SVP) of liquids is equal to external pressure. Liquid molecules with enough energy escape from the bulk to the atmosphere.

(ii) Describe how you would determine the specific latent heat of vaporization of water by the method of the mixtures (05marks)



- The initial temperature θ_0 and mass, m of water in the calorimeter are measured
- Steam from boiling water is passed into water in a calorimeter and after a reasonable temperature rise, flow of steam is stopped and final temperature, θ_f is recorded.
- Mass m_2 of water in the calorimeter is then taken
- The mass of steam condensed, $m_s = (m_2 - m)$

  Given that the heat capacity of the calorimeter= C

  Heat gained by steam = heat gained by water and calorimeter

  $m_s c_v + m_s c(100 - \theta_f) = (m_2 - m)c(\theta_f - \theta_0) + C(\theta_f - \theta_0)$

  c_v = specific latent heat of vaporization

c= specific heat capacity of water

(iii) Explain why latent heat of vaporization is always greater than that of fusion. (02marks)

In evaporation energy is needed to break intermolecular forces of attraction ad to expand against atmospheric pressure while in fusion, energy is needed to weaken molecular attraction only.

(c) In an experiment to determine the specific latent heat of vaporization of a liquid using the continuous flow calorimeter, the following results were obtained.

Voltage, V/V	Current, I/A	Mass collected in 300s/g
7.4	2.6	5.8
10.0	3.6	11.3

Calculate the power of the heater required to evaporate 3.0g of water in 2 minutes (06marks)

$I_1V_1 = m_1l + h$ ……………………………….(i)

$I_2V_2 = m_2l + h$ ……………………………….(ii)

From (i) and (ii)

$l = \frac{I_2V_2 - I_1V_1}{m_2 - m_1} = \frac{10 \ x\ 3.6 - 7.4 \ x\ 2.6}{(11.3 \ x\ 10^{-3} - 5.8 \ x\ 10^{-3})/300} = 9.14 \ x\ 10^5 Jkg^{-1}$

$m_3 = \frac{3.0 \ x\ 10^{-3}}{2 \ x\ 60} = 2.5 \ x\ 10^{-5} kgs^{-1}$

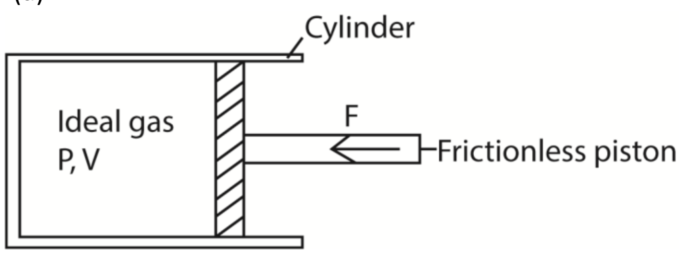
$l = \frac{I_2V_2 - I_3V_3}{m_2 - m_3}$

$9.14 \ x\ 10^5 n = (10 \ x\ 3.6 - I_3V_3) \div \left(\frac{11.3 \ x\ 10^{-3}}{300} - 2.5 \ x\ 10^{-5}\right)$

$11.59 = 36 - I_3V_3$

Power = $I_3V_3 = 36 - 11.59 = 24.41W$

7. (a)



A fixed mass of an ideal gas is confined in a cylinder by frictionless piston of cross section area A. the piston is in equilibrium under the action of force, F as shown in the figure above. Show that the work done, W, by the gas when it expands from V_1 to V_2 is given by

$W = \int_{V_1}^{V_2} PdV$ (03marks)

Suppose the gas expands by dv so that the piston moves out through a small distance dx.

Work done by the gas, dW = Fdx

= PAdx

= Pdv

Total work done during expansion from v_1 to v_2 is given by

$$W = \int_{v_1}^{v_2} Pdv$$

(b) State the first law of thermodynamics and use it to distinguish between Isothermal and adiabatic changes in a gas. (05marks)

$\Delta Q = \Delta U + \Delta W = nC_v\Delta T + \Delta W$

During isothermal expansion, $\Delta T = 0$. Therefore all the energy supplied is equal to the work done by the gas during expansion.

In adiabatic expansion, no heat enters or leaves the gas. Therefore $\Delta Q = 0$ and $\Delta U = -\Delta W$.

In adiabatic expansion, work s done at the expense of its internal energy. Therefore the gas cools.

(c) The temperature of 1mole of helium gas at a pressure of 1.0 x 10^5Pa increases from 20^0C to 100^0C when the gas is compressed adiabatically.

Find the final pressure of the gas. (Take γ =1.67) (04 marks)

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

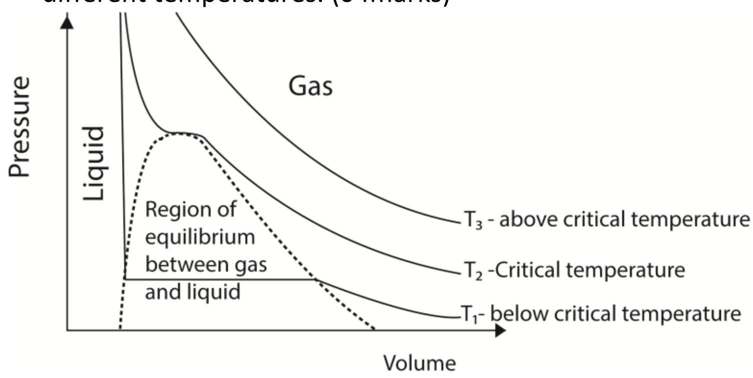
$but\ V = \frac{nRT}{P} \Rightarrow \frac{P_1T_1^{\gamma}}{P_1} = \frac{P_2T_2^{\gamma}}{P_2}$

$\Rightarrow \frac{T_1^{\gamma}}{P_1^{\gamma-1}} = \frac{T_2^{\gamma}}{P_2^{\gamma-1}}$

$\frac{(293)^{1.67}}{(1.0\ x\ 10^5)^{0.67}} = \frac{(373)^{1.67}}{(P)^{0.67}}$

$P = 1.87\ x\ 10^5 Pa$

(d) With the aid of a P-V diagram, explain what happens when a real gas is compressed at different temperatures. (04marks)



- Above the critical temperature a gas obeys Boyle's law.
- Below the critical temperature a gas exist as unsaturated vapour at low pressure when the pressure is increase it condenses until all the gas is turned into a liquid.

(e) The root-mean square speed of the molecules of a gas is 44.72ms^{-1}. Find the temperature of the gas if its density is 9.0 x 10^{-2}kgm^{-3} and the volume is 42.0m^3. (04marks)

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

⇨ $\frac{RT}{V} = \frac{1}{3}\rho\overline{c^2}$

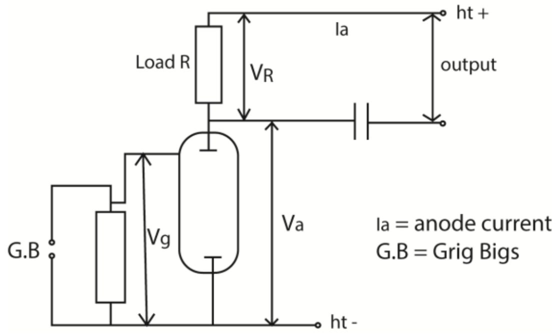
T = $\frac{1}{3}\rho\overline{c^2} x\ \frac{V}{R} = \frac{1}{3}\ x\ 9.0\ x\ 10^{-2} x\ (44.72)^2\ x\ \frac{42}{8.31}$ = 303.2K

SECTION C

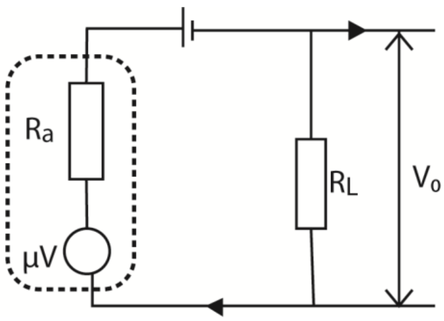
8. (a) Describe briefly the mechanism of thermionic emission (03marks)

High temperature raises the kinetic energy of free electrons in metallic lattice and make electrons to escape from the surface of the metal against the attraction of positive ions

(b) (i) Draw a labelled circuit to show a triode being used as a single-stage voltage amplifier. (03maks)



(ii) With the aid of an equivalent circuit of a triode as an amplifier, obtain an expression for voltage gain (04marks)



If Vi is input voltage, μ amplification factor,

⇨ e.m.f = μV_i

Output voltage = $I_a R_L$

Ia = $\frac{\mu V_i}{R_a + R_L}$

Thus $V_0 = \frac{\mu V_i R_L}{R_a + R_L}$

Voltage gain = $\frac{V_0}{V_i} = \frac{\mu V_i}{R_a + R_L}$

(iii) A triode with mutual conductance of 3.0×10^{-3} AV^{-1} and anode resistance of $1 \times 10^4 \Omega$, is used as a single-stage amplifier. If the load resistance is $3 \times 10^4 \Omega$, calculate the voltage gain of the amplifier. (05marks)

From $\mu = R_a g_m = 3.0 \times 10^{-2} \times 1 \times 10^4 = 30$

From $A = \frac{V_0}{V_i} = \frac{\mu V_i}{R_a + R_L}$

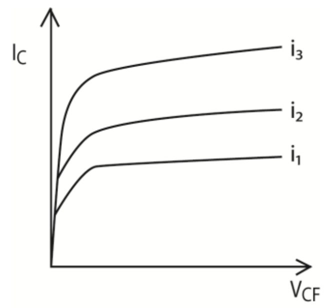
$= \frac{30 \times 3 \times 10^4}{1 \times 10^4 + 3 \times 10^4}$

= 22.5

(c) (i) Describe the structure of a junction transistor. (02marks)

A transistor consist of 3 layers of P- and n- semiconductors called respectively emitter, base and collector. The base is thinner. It can be PnP type or nPn transistor.

(ii) Sketch and describe the collector-current against collector-emitter voltage characteristic of a junction transistor. (03marks)

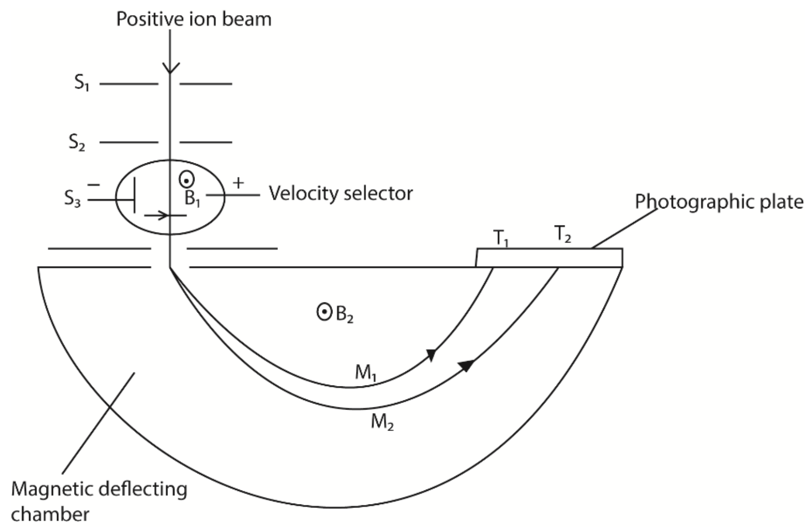


For small values of V, Ic increases linearly with V but strongly dependent on i.

9. (a) What are isotopes? (01mark)

Isotopes are atoms of the same element with the same atomic number but different atomic mass.

(b) With the aid of a diagram, describe the operation of Bainbridge spectrometer in determining the specific charge of ions. (06marks)



T_1 and T_2 are tracers on photographic plate, S_1, S_2 and S_3 are slits

Mode of Action

- Positive ions are produced in a discharge tube and admitted as a beam through slits S_1 and S_2.
- The beam then passes between insulated plates P, Q, connected to a battery, which create an electric field of intensity E.

- A uniform magnetic field B_1, perpendicular to E is applied over the region of the plates and all ions, charge e with the same velocity, v given by $B_1ev = Ee$ will then pass undeflected through the plates and through a slit S_3.
- The selected ions are deflected in a circular path of radius r by a uniform perpendicular magnetic field B_2 and an image is produced on a photographic plate as shown.
  In this case
  $\frac{mv^2}{r} = B_2ev$
  $\therefore \frac{m}{e} = \frac{rB_2}{v}$

  But for the ions selected v = $\frac{E}{B_1}$ from above
  Specific charge, $\frac{e}{m} = \frac{E}{rB_2B_1}$

(c) Explain the purpose of each of the following in a Geiger-Muller tube

(i) a thin mica window

To allow easy entry of ionizing particles in the GMT

(ii) Argon gas at low pressure

Argon form ions when it is struck by ionizing particle.

Low pressured reduces resistance to ion movement to respective electrodes.

(iii) Halogen gas mixed with argon gas

Form quenching agent to prevent secondary ionization.

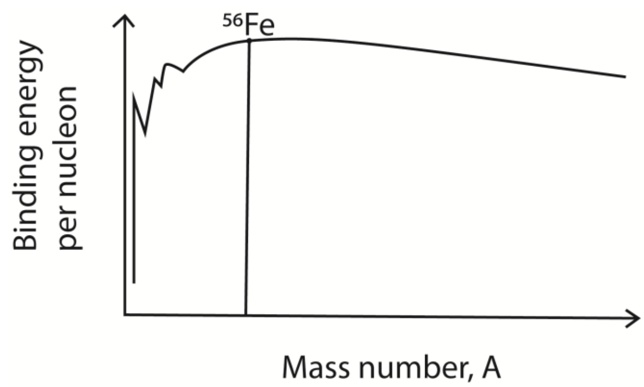
(iv) An anode in the form of a wire (04marks)

Anode in form of a wire increases strength of electric field intensity

(d) (i) What is meant by binding energy per nucleon of a nucleus? (01mark)

Binding energy per nucleon is the ratio of the energy required to split a nucleus into the individual nucleons to the number of nucleon in the nucleus.

(ii) Sketch a graph of binding energy per nucleon against mass number for naturally occurring nuclides (01marks)



(iii) State one similarity between nuclear fusion and nuclear fission. (01mark)

Both release energy

(e) (i) At a certain time, an α-particle detector registers a count rate of $32s^{-1}$. Exactly 10days later, the count rate dropped to $8s^{-1}$. Find the decay constant. (04marks)

$A = A_0e^{-\lambda t}$

$8 = 32e^{-10\lambda}$

$\lambda = 0.1386$ per day

(ii) State two industrial uses and two health hazards of radioactivity. (04marks)

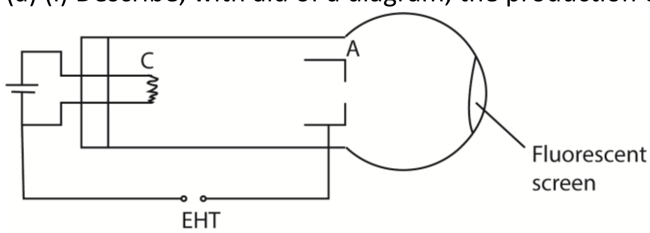
Industrial uses

- Estimate the rate of wear in machinery
- Automatic control of thickness of paper, plastic or metal sheeting
- Investigating the flow of liquids in chemical plants or underground water and sewage pipeline.

Hazards

- May cause skin burn
- Cancers
- Gene mutation

10. (a) (i) Describe, with aid of a diagram, the production of cathode rays



- Cathode C produces electrons by thermionic emission.
- Electrons are accelerated by p.d between cathode and anode

(ii) State and justify two properties of cathode rays (02marks)

- carry negative charge because they are attracted towards a positive potential

- move in straight line because the cast a shadow when intercepted by Maltase cross

(b) Explain each of the following terms as applied to photoelectric emission:

(i) stopping potential (01marks)

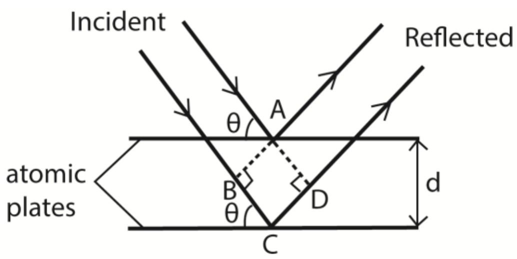
Stopping potential is a minimum potential that reduces photocurrent to zero.

(ii) threshold frequency (01mark)

It is the frequency of radiation below which no electron emission takes place.

(c) Explain X- ray diffraction by crystals and derive Bragg's law (06marks)

- A parallel beam of monochromatic X-rays incident on a crystal is reflected from successive atomic planes and super-imposed, forming an interference pattern.



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For constructive interference to occur, the path difference is equal to the whole number of wavelength

Thus BC + CD = nλ

⇨ dsinθ + dsinθ = nλ

or 2dsinθ = nλ where n = 1, 2, 3, 4 …

(d) The potential difference between the cathode and anode of an X-ray tube is 5.0 x 10^{-4}V. If only 0.4% of the kinetic energy of the electrons is converted into X-rays and the rest is dissipated as heat in the target at a rate of 600W, find the

(i) current that flows (03marks)

99% of energy is converted to heat.

Power converted to heat = 0.99IV = 600W

⇨ 0.99 x I x 5.0 x 10^{-4} = 600

I = 1.21 x 10^{6}A

(ii) speed of the electrons striking the target. (03marks)

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

u = $\sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \, x \, 1.6 \, x \, 10^{-19} x \, 5 \, x \, 10^{-4}}{9.11 \, x \, 10^{-34}}}$ = 1.33 x 10^{4}ms^{-1}

Compiled by Dr. Bbosa Science