P 510/1
PHYSICS

Paper 1

UGANDA ADVANCED CERTIFICATE OF EDUCATION

PHYSICS

S.6 PAPER 1 - 2014

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

*Attempt **five** questions in all.*

Non-programmable scientific electronic calculators may be used.

Assume where necessary.

Acceleration due to gravity, g = $9.81\ ms^{-2}$

Mass of the earth	=	5.97×10^{24} kg
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} $Wm^{-2} K^{-4}$
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}ms^{-1}$
Specific heat capacity of water	=	4,200J kg^{-1} K^{-1}
Universal gravitational constant, G	=	6.67×10^{-11}N m^2 kg^{-2}
Density of water	=	1000 kgm^{-3}
Gas constant, R	=	8.31 J $mol^{-1}K^{-1}$

SECTION A

3. (a) (i) State the law of conservation of energy. (1)

(ii) A particle is projected at an acute angle to the horizontal. Assuming no air resistance show that the mechanical energy of the particle is conserved throughout its motion (5)

(b) A particle, hanging from a spring at rest, extends the spring by e. Show that if the particle is given a small vertical displacement and then released, it executes simple harmonic motion and find the period. (5)

(c) A mass of 500 g is released from rest so that it falls vertically through a distance of 10 cm onto a scale pan of negligible mass hung from a spring of force constant 100 N. Find

(i) the position of the scale pan when it first comes to instantaneous rest. (5)

(ii) the amplitude of the subsequent motion of the particle (2)

(iii) the period of the motion. (2)

2. (a) Define the terms: ***elastic limit*** and ***Young's modulus.*** (2)

(b) Explain the energy transformations that occur when a wire is stretched

(i) elastically (3)

(ii) plastically (2)

(c) A rod of mild steel of uniform cross sectional area 0.0030 m^2 and length 1.0 m is stretched steadily until it breaks.

(i) Sketch a graph to show the relationship between the force and the extension.

Explain the shape of the graph. (4)

(ii) When the applied force on the rod is 120 kN the strain is 4.0×10^{-4}.

Calculate Young's modulus for steel. (3)

(iii) The rod is found to break at a stretching force of 240 kN.

Explain why the stress at the section of the rod where the break occurs is likely to be much greater than 80000 kN m^{-2} . (2)

(iv) Just before the rod breaks, its extension is about 4 cm.

Estimate the work done in stretching the rod by this amount. Suggest why the calculated value of the work done is likely to be less than the actual value. (4)

3. (a) (i) State Newton's law of gravitation. (1)

(ii) Deduce the dimensions of the Universal gravitational constant (2)

(b) Assume that a planet moves with uniform speed in a circular orbit of radius r about the sun. The periodic time of the planet is T. Show that the quantity (r^3/T^2) is independent of the mass of the planet. (4)

(c) An artificial satellite is launched in a circular orbit round the equator at a height of 3.60×10^7 m above the surface of the Earth.

(i) Determine from first principles the speed with which the satellite must be launched to maintain it in the orbit. (5)

(ii) Determine the periodic time of the satellite (3)

(iii) What deduction can be made from the result obtained in (ii) above with reference to the satellite? (2)

(iv) If another satellite moves in a circular orbit concentric with that of the above satellite, at a height of 1.48×10^7 m above the surface of the Earth, what is the periodic time of this second satellite. (3)

4. (a) Distinguish between ***scalar*** and ***vector*** quantities. Give **two** examples of each.(3)

(b) (i) Define the terms ***time of flight*** and ***range*** as applied to projectile motion. (2)

(ii) A projectile is fired in air with a speed u at an angle θ to the horizontal. Find the time of flight of the projectile. (2)

(c) State the conditions for the equilibrium of a rigid body under the action of coplanar forces. (2)

(d) A mass of 5.0 kg is suspended from the end A of a uniform beam of mass 1.0 kg and length 1.0 m. The B of the beam is hinged in the wall. The beam is kept horizontal by a rope attached to the mid-point of the beam and to a point C, in the wall at a height 0.75 m above B. Calculate

(i) the tension in the rope (6)

(ii) the force exerted by the hinge on the beam. (5)

8. (a) (i) Distinguish between thermionic emission and photoelectric emission. (3)

(ii) Apart from them carrying negative charge, state four other properties of cathode rays. (2)

(b) Describe an experiment to show that cathode rays indeed carry negative charge. (4)

(c) A beam of electrons moving with a velocity v enters normally a strong magnetic field, which is uniform and of induction B. If each electron has a mass m and charge e, stating the assumptions made,

(i) derive an expression for the distance d covered by an electron while moving in the field. (3)

(ii) write down the relationship between d and B (1)

(d) A charged oil drop falls under gravity in air with a velocity of $4.90 \times 10^{-4}\ ms^{-1}$ between two parallel plates 5 mm apart. When a p.d of 4500 V is connected between the plates, the drop rises steadily with a velocity of $1.10 \times 10^{-4}\ ms^{-1}$.

Assuming that the effect of buoyancy on the drop is negligible, calculate

(i) the radius of the oil drop. (3)

(ii) the number of electrons on the drop (4)

(Density of oil = $900\ kg\ m^{-3}$; coefficient of viscosity of air $=1.81 \times 10^{-5}\ Nm^{-2}s$)

1.(a) State the laws of solid friction (3)

(b) (i) Describe an experiment to determine the co-efficient of friction between two surfaces (4)

(ii) A particle of mass m is projected up a rough plane of angle ø with a speed u. it reaches a maximum and slides back. Prove that when it again attains its original speed u, it will be a distance

$$\frac{u^2\mu\sec\phi}{g(\tan^2\phi - \mu^2)}$$

down the plane from the point of projection, given that μ, the co-efficient of friction is less than tanø. (6)

(c) (i) Define **co-efficient of viscosity** and **laminar flow** (2)

(ii) Given that the volume of a liquid issuing per second from a pipe depends on the co-efficient of viscosity η, the radius of the pipe a and the pressure gradient, show that

$$\text{Volume per second} = \frac{kpa^4}{\eta l}$$ (5)

5. (a) (i) State Boyle's law. (1)

(ii) Describe an experiment to verify Boyle's law. (6)

(b) (i) Explain why the pressure of a fixed mass of gas in a closed rigid container decreases when the temperature of the container falls. (2)

(ii) State the conditions for an isothermal change (2)

(c) (i) Derive the equation of state. (4)

(ii) A ball of volume 4 litres at a temperature of 20°C contains nitrogen at a pressure of

1.5×10^5 Pa. After some more nitrogen had been pumped in, the volume of the ball became 4.5 litres, the temperature 30^oC and the pressure 5.5×10^5 Pa. What mass of nitrogen was pumped in? [Molar mass of nitrogen = 28 g] (5)

4. (a) (i) Define surface tension and show that it is equal to the work done per unit area in increasing the liquid surface under isothermal conditions. (3)

(ii) Find the work required to break up a drop of water of radius 0.5 cm into drops of water each of radius 1 mm. [Surface tension of water is 2.27×10^{-2} Nm^{-1}] (4)

(b) Describe an experiment to measure surface tension of a liquid by the capillary tube method. (6)

(c) (i) Derive an expression for the excess pressure in a soap bubble of radius r if the soap solution has surface tension γ. (3)

(ii) The pressure inside an air bubble formed 40 cm below the water surface is

1.063×10^5 Pa. If the surface tension of water is 2.27×10^{-2} Nm^{-1} find the radius of the bubble. [Atmospheric pressure = 1.013×10^5 Pa] (4)

4. (a) (i) Define the *two principal molar heat capacities of a gas*. (02)

(ii) State, *which one is greater*, and *explain why* this is so. (02)

(iii) Show that the *difference between the molar heat capacities* is equal to the *molar gas constant*. (05)

(b) State the *conditions for an adiabatic process*. (02)

(c) A gas at a pressure of **1.2×10^6 Pa** and temperature **$90\ ^0C$** expands *adiabatically to twice its original volume* and then is *compressed isothermally to its original volume.* [Take ratio of the principal molar heat capacities, **γ = 1.40**.]

(i) *Sketch and label* the two stages on a *P-V diagram.* (02)

(ii) Find the *final pressure* and *temperature* of the gas. (07)

7. (a) State Prevost's theory of exchange with reference to heat radiation. (1)

(b) Explain why metals are better conductors of heat compared to wood. (4)

(c) A is a composite slab made up of two layers of thickness d_1 and d_2 with thermal conductivities k_1 and k_2 respectively. B is a slab of thickness $d_1 + d_2$ with thermal conductivity k. One face of each of the slabs is maintained by heating at a temperature θ_1 and the other end at θ_2. If the rate of conduction per unit area through the two slabs is the same, find k in terms $k_{1,}$ k_2, d_1 and d_2.
(6)

(d) The heat radiation received by the earth from the sun is 1.4×10^3 Wm^{-2}. Assuming this 90% of what the sun emits as a black body, estimate the temperature of the sun. (4)

(e) With the aid of a labeled diagram, describe the construction and mode of operation of the optical pyrometer. (5)

5 (a) (i) Define thermal conductivity. (1)

(ii) Explain the mechanism of heat transfer in metals. (3)

(iii) Describe an experiment to determine the thermal conductivity of a metal. (6)

(b) (i) What is a black body? (1)

(ii) Draw sketch graphs to show the variation of relative intensity of black body radiation with wavelength for different temperatures. (2)

(iii) Explain the appearance of a metal ball placed in a dark room when its temperature is progressively raised from room temperature to just below melting.

(3)

(c) A heating element in form of a cylinder **30 cm** long and **1.5 cm** in diameter has an output of **1.8 kW**. If its radiation is **85%** that of a black body, find its temperature.

(4)

6. (a) What assumptions are necessary in the derivation of the Kinetic theory expression for the pressure of an Ideal gas ? (4)

(b) A beam of **2×10^{22}** Nitrogen atoms, each of mass 2**$.32 \times 10^{-26}$ kg** is incident normally on a wall of a cubical container of edge **5. 0cm**. The beam is reflected through **180^{0}**. If the mean speed of the atoms is **$500\ ms^{-1}$**, find the pressure exerted by the Nitrogen gas.

(4)

(c) (i) State Dalton's law of partial pressures. (1)

(ii)Two containers **A** and **B** of volume **3×10^3 cm^3** and **6×10^3 cm^3** respectively contain helium gas at a pressure of **1.0×10^3 Pa** and temperature **300 K**. Container **A** is heated to **373K** while container **B** is cooled to **273 K**. Find the final pressure of the Helium gas. (5)

(d) (i) Use the kinetic theory of gases to explain the effect of increasing temperature on saturation vapour pressure. (3)

(ii)Sketch a pressure versus volume curve for a real gas undergoing compression below its critical temperature. Explain the main features of the curve. (3)

7. (a) (i) Define specific latent heat of fusion. (1)

(ii) Describe an experiment to determine the specific latent heat of fusion of water. (5)

(b) (i) Explain why the molar heat capacity of an ideal gas at constant pressure differs from that at constant volume. (3)

(ii) Derive an expression for the difference of the above molar heat capacities. (4)

(c) (i) State the conditions necessary for a reversible adiabatic process. (2)

(ii) A gas initially occupying a volume of **1.0 litre** at a temperature of **47^0C** and a pressure of **1.40×10^5 Pa** expands isothermally to a volume of **2.0 litres**. It is then compressed adiabatically to its original volume. If γ = **1.4** find the final temperature and pressure. (5)

7. (a) (i) The specific heat capacity of copper is **400J kg^{-1} K^{-1}**. Explain the meaning of the statement. (1)

(ii) State the factors that determine the rate of cooling of a body. (2)

(iii) Explain why a small body cools faster than a bigger one of the same material and shape. (4)

(b) With the aid of a well labeled diagram, describe an electrical method of determining the specific latent heat of vaporization of water, stating the precautions taken to minimize heat losses (7)

(c) Two taps, one delivering water at a temperature of **25^oC** at a rate of **0.3 g s^{-1}** and the other delivering water at a temperature of **15^oC** at a rate of **0.4 g s^{-1}**, are directed to a well-lagged copper calorimeter of mass **50 g** containing ice at **0^oC** while stirring. After **5** minutes the contents of the calorimeter are found to have attained a temperature of **5^oC**. Find the mass of ice originally in the calorimeter.

Specific latent heat of fusion of ice = 3.36×10^5 Jkg^{-1} (6)

SECTION C

8. (a) (i) Sketch the **I-V characteristic** for gaseous conduction and explain the main features of the curve. (4)

(ii) Explain why this is not a good method for producing cathode rays. (2)

(b) (i) What is meant by **thermionic emission**? (1)

(ii) Describe an experiment to show that cathode rays travel in straight lines. (4)

(c) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates. Show that the path of the beam between the plates is a parabola. (4)

(d) A charged oil drop of mass **6×10^{-15} kg** falls vertically in air with a steady velocity between two parallel vertical plates **5 mm** apart. When a p.d of **3000 V** is applied between the plates, the drop now falls with a steady velocity at an angle **58.5^{o}** to the vertical. Calculate the charge **Q** on the drop. (Neglect the up thrust on it)

(5)

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PHYSICS

Paper 1

UGANDA ADVANCED CERTIFICATE OF EDUCATION

END OF TERM 1 – 2014

PHYSICS

S.6 PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt ***five*** *questions in all, choosing at least one from each of the sections A, B and C.*

Assume where necessary.

Acceleration due to gravity, g = 9.81 ms^{-2}

Mass of the earth	=	5.97×10^{24} kg
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} $Wm^{-2} K^{-4}$
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Speed of light in a vacuum, c	=	$3.0 \times 10^{8} ms^{-1}$
Specific heat capacity of water	=	4,200J $kg^{-1} K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} N\, m^{2}\, kg^{-2}$
Density of water	=	1000 kgm^{-3}
Gas constant, R	=	8.31 J $mol^{-1}K^{-1}$

SECTION A

1(a) Define the following:

(i) Tensile stress (1)

(ii) Tensile strain (1)

(iii) Young's modulus (1)

(b) (i) Sketch the stress-strain curve for a copper wire and explain the characteristic features of the curve. (4)

(ii) How does the curve in b(i) compare with that of a material like glass? (2)

(c) Derive an expression for the energy stored in a unit volume of a stretched elastic material, expressing your answer in terms of Young's modulus and the strain of the material. (4)

(d) A cylindrical copper rod of length 0.5 m and diameter 2 cm is fixed between two rigid supports at a temperature of 20^0C. The temperature of the rod is raised to 70^0C. Calculate

(i) the force exerted on the rigid supports, at this temperature. (4)

(ii) the energy stored in the rod at 70^0C (3)

Young's modulus for copper = 1.2×10^{11} Nm^{-2} (Mean coefficient of linear expansion of copper between 20^0C and 70^0C is 1.7×10^{-5} K^{-1})

2(a) Define simple harmonic motion. (1)

(b) A particle moves so that its displacement x after time t is given by

$$x = r \sin 2\pi t$$

(i) Show that the particle executes simple harmonic motion (3)

(ii) Using the same axes sketch graphs of displacement against time, velocity against time and acceleration against time. (3)

(c) A uniform cylinder of height h floats vertically in water with ¾ of its height submerged. Show that if the cylinder is given a small vertical displacement and then released, it executes simple harmonic motion of period $\pi \sqrt{\left(\frac{3h}{g}\right)}$

(6)

(d) A cube of mass 100 g rests on a light scale pan that is supported on a vertical spring of constant 24.5 Nm^{-1} . The pan is then set to oscillate vertically. Find the maximum amplitude for the cube to remain in contact with the pan throughout the motion. (3)

(e) (i) Distinguish between free and damped oscillations and sketch a displacement-time graph for each.. (4)

3(a) (i) State stokes' law of viscosity (1)

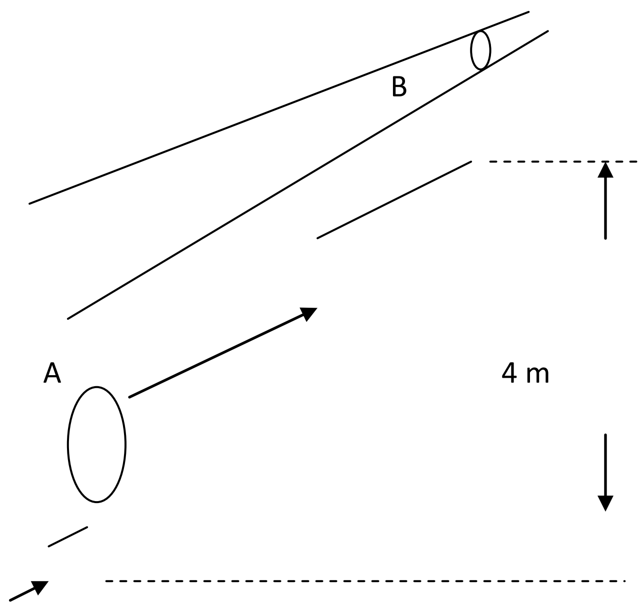
(ii) A ball of density σ and radius r is released to fall through a liquid of density ρ and viscosity, η. Derive an expression for its terminal velocity during its motion. (3)

(iii) Two identical rain drops are observed to fall with a terminal velocity of 0.2 ms^{-1} If the two coalesce into one drop, what will be the new terminal velocity? (4)

(b) (i) State Bernoulli's principle (2)

(ii) Explain one application of Bernoulli's principle (3)

(c) The diagram below shows a pipe delivering water



The cross-sectional area at section A is 30 cm^2 and the velocity there is 4 ms^{-1} while the cross-sectional area at B is 15 cm^2. Find:

(i) the volume of water flowing per second (2)

(ii) the static pressure at B if the atmospheric pressure is 1 x 10^5 Nm^{-2}. (5)

4(a) (i) Show that in uniform circular motion the accelerating force is towards the centre of the circle and derive an expression for the acceleration. (4)

(ii) State two differences between uniform circular motion and simple harmonic motion. (2)

(ii) Explain briefly the action of a centrifuge. (3)

(iii) A cyclist is to turn a corner of a horizontal circular track of radius r where the coefficient of friction between the tyres and the track surface if μ. For no skidding his velocity, v, must fulfill the condition that

$$v < \sqrt{\mu r g} \quad (3)$$

(b) (i) Define gravitational potential. (1)

(ii) Find an expression for the total energy of a satellite of mass m circling the earth of mass M in an orbit of radius R. (3)

(iii) Explain the effect of friction between such a satellite and the atmosphere in which it moves. (4)

SECTION B

5(a) Describe an experiment to verify Newton's law of cooling. (5)

(b) (i) Distinguish between ***a real*** and ***an ideal*** gas. (3)

(ii) Derive the expression:

$P = \frac{1}{3}\rho\overline{c^2}$ for the pressure of an ideal gas of density ρ and mean square speed $\overline{c^2}$. (6)

(c) (i) Explain why the pressure of a fixed mass of gas in a closed container increases when temperature of the container is raised. (2)

(ii) Nitrogen gas is trapped in a container by a movable piston. If the temperature of the gas is raised from 0°C to 50°C at constant pressure of 4.0×10^5 Pa and the total heat added is 3.0×10^4 J, calculate the work done by the gas.

[The molar heat capacity of nitrogen at constant pressure is 29.1 J mol^{-1} K^{-1}; C_p/C_v = 1.4] (4)

6(a) (i) What is meant by the term temperature? (1)

(ii) Give two characteristics of a material to be chosen as a thermometric substance

(2)

(iii) Name six thermometric properties that can be used to measure temperature. (3)

(b) Define a Celsius scale based on a fixed mass of gas at constant volume. (2)

(c) (i) Explain briefly why thermometers based on different thermometric properties give different values for the same temperature. (1)

(ii) A thermometer is constructed with a liquid that expands according to the relation

$$V_t = V_0(1 + \alpha t + \beta t^2)$$

where V_t = volume of liquid at temperature t^0C, V_0 = volume of liquid at 0^0C

α and β are constants such that $\alpha = 1000\beta$.

What will the liquid thermometer read when the gas thermometer reads 200^0C? (5)

(d) (i) What is a thermo-junction? (2)

(ii) Sketch a graph of the emf of a thermocouple for the range before and after the neutral temperature. (2)

(iii) State two advantages and two disadvantages of thermocouple thermometers over other types. (2)

7 (a) With the aid of diagram, discuss briefly variations of temperature gradient for a steel bar when the bar is;

(i) unlagged (2)

(ii) lagged (2)

(b) (i) In the determination of thermal conductivity of a poor conductor such as cork, the substance is made thin and fairly of large cross-sectional area. Explain why this is so. (2)

(ii) Describe how the thermal conductivity of cork can be determined. (5)

(c) An aluminium pan of diameter 20.0cm and thickness 2.0mm is filled with water and heated such that the water boils producing steam at a rate of $5.0gs^{-1}$ at steady state conditions.

(i) Calculate the temperature of the external surface of the pan (4)

(ii) State the assumption made (1)

(d) (i) State Stefan's law of black body radiation. (1)

(ii)As a piece of charcoal is steadily heated up, it appears reddish in colour before turning whitish. Explain this observation. (3)

SECTION C

8(a) (i) Sketch the *I-V characteristic* for gaseous conduction. (2)

(ii) Explain the main features of the curve. (3)

(b) A beam of electrons moving with a velocity **v**, enters normally a strong magnetic field, which is uniform and of induction **B**. If each electron has a mass **m** and charge **e**, assuming that the electrons suffer a deviation of 180^0 by the time they leave the magnetic field,

(i) derive an expression for the distance **d,** covered by an electron while moving in the field. (3)

(ii) write down the relationship between **d** and **B**. (1)

(c) (i) Draw a labeled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

(d) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates.

Show that the path of the beam between the plates is a parabola. (5)

9(a) A high p.d is applied across two electrodes in air contained in a closed glass tube. Describe, with the aid of labeled diagrams, what will be observed when the pressure in the tube is progressively reduced down to very low pressures. (5)

(b) (i) List **four** main properties of cathode rays. (2)

(ii) Describe an experiment to show that cathode rays carry a negative charge. (4)

(c) (i) In the Millikan's oil-drop experiment, why is there a need to surround the chamber with a constant temperature bath? (2)

(ii) Explain how Millikan's experiment proves that charge is quantized. (2)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius **6×10^{-6} m** was found to fall under gravity at a terminal velocity of **0.004 cm s^{-1}** and to rise at **0.012 cm s^{-1}** when a field of **2×10^{5} Vm^{-1}** was suitably applied. Given that the viscosity of the medium was **2.122×10^{-5} Nsm^{-2}**, determine the number of electrons on the drop.

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P 510/1
PHYSICS

Paper 1

BEGINNING OF TERM TWO EXAMS – 2017

S.6 PHYSICS

Paper 1

2 hours 30 minutes.

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Attempt ***five*** *questions in all, choosing at least one from each of the sections A, B and C.*
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Gas constant, R	=	$8.31\ J\ mol^{-1}K^{-1}$

SECTION A

1(a) Define the following:

(i) Tensile stress (1)

(ii) Tensile strain (1)

(iii) Young's modulus (1)

(b) (i) Sketch the stress-strain curve for a copper wire and explain the characteristic features of the curve. (4)

(ii) How does the curve in b(i) compare with that of a material like glass? (2)

(c) Derive an expression for the energy stored in a unit volume of a stretched elastic material, expressing your answer in terms of Young's modulus and the strain of the material. (4)

(d) A cylindrical copper rod of length 0.5 m and diameter 2 cm is fixed between two rigid supports at a temperature of 20^0C. The temperature of the rod is raised to 70^0C. Calculate

(i) the force exerted on the rigid supports, at this temperature. (4)

(ii) the energy stored in the rod at 70^0C (3)

Young's modulus for copper = 1.2×10^{11} Nm^{-2} (Mean coefficient of linear expansion of copper between 20^0C and 70^0C is 1.7×10^{-5} K^{-1})

2(a) Define simple harmonic motion. (1)

(b) A particle moves so that its displacement x after time t is given by

$$x = r \sin 2\pi t$$

(i) Show that the particle executes simple harmonic motion (3)

(ii) Using the same axes sketch graphs of displacement against time, velocity against time and acceleration against time. (3)

(c) A uniform cylinder of height h floats vertically in water with ¾ of its height submerged. Show that if the cylinder is given a small vertical displacement and then released, it executes simple harmonic motion of period $\pi\sqrt{\left(\frac{3h}{g}\right)}$

(6)

(d) A cube of mass 100 g rests on a light scale pan that is supported on a vertical spring of constant 24.5 Nm^{-1}. The pan is then set to oscillate vertically. Find the maximum amplitude for the cube to remain in contact with the pan throughout the motion. (3)

(e) (i) Distinguish between free and damped oscillations and sketch a displacement-time graph for each.. (4)

3(a) (i) State stokes' law of viscosity (1)

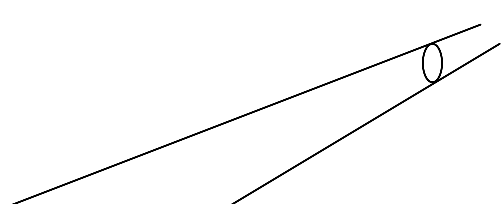
(ii) A ball of density σ and radius r is released to fall through a liquid of density ρ and viscosity, η. Derive an expression for its terminal velocity during its motion. (3)

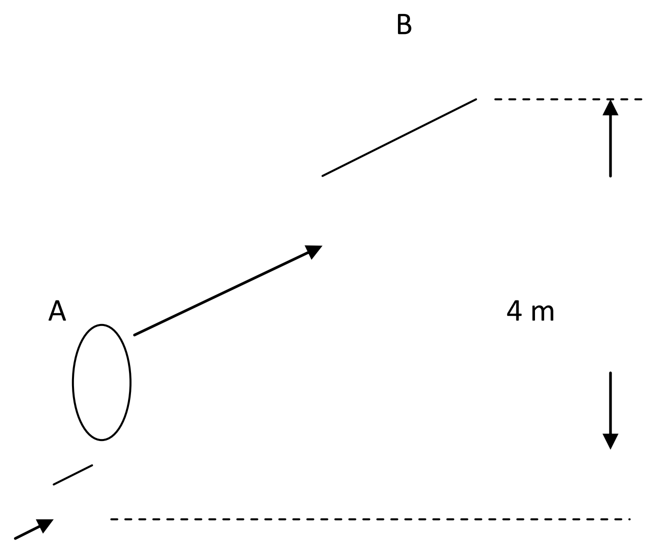
(iii) Two identical rain drops are observed to fall with a terminal velocity of 0.2 ms^{-1} If the two coalesce into one drop, what will be the new terminal velocity? (4)

(b) (i) State Bernoulli's principle (2)

(ii) Explain one application of Bernoulli's principle (3)

(c) The diagram below shows a pipe delivering water





The cross-sectional area at section A is 30 cm^2 and the velocity there is 4 ms^{-1} while the cross-sectional area at B is 15 cm^2. Find:

(i) the volume of water flowing per second (2)

(ii) the static pressure at B if the atmospheric pressure is 1×10^5 Nm^{-2}. (5)

4(a) (i) Show that in uniform circular motion the accelerating force is towards the centre of the circle and derive an expression for the acceleration. (4)

(ii) State two differences between uniform circular motion and simple harmonic motion. (2)

(ii) Explain briefly the action of a centrifuge. (3)

(iii) A cyclist is to turn a corner of a horizontal circular track of radius r where the coefficient of friction between the tyres and the track surface if μ. For no skidding his velocity, v, must fulfill the condition that

$$v < \sqrt{\mu r g} \qquad (3)$$

(b) (i) Define gravitational potential. (1)

(ii) Find an expression for the total energy of a satellite of mass m circling the earth of mass M in an orbit of radius R. (3)

(iii) Explain the effect of friction between such a satellite and the atmosphere in which it moves. (4)

SECTION B

5(a) Describe an experiment to verify Newton's law of cooling. (5)

(b) (i) Distinguish between ***a real*** and ***an ideal*** gas. (3)

(ii) Derive the expression:

$P = \frac{1}{3}\rho\overline{c^2}$ for the pressure of an ideal gas of density ρ and mean square speed $\overline{c^2}$. (6)

(c) (i) Explain why the pressure of a fixed mass of gas in a closed container increases when temperature of the container is raised. (2)

(ii) Nitrogen gas is trapped in a container by a movable piston. If the temperature of the gas is raised from 0^0C to 50^0C at constant pressure of 4.0×10^5 Pa and the total heat added is 3.0×10^4 J, calculate the work done by the gas.

[The molar heat capacity of nitrogen at constant pressure is 29.1 J mol^{-1} K^{-1}; $C_p/C_v = 1.4$] (4)

6(a) (i) What is meant by the term temperature? (1)

(ii) Give two characteristics of a material to be chosen as a thermometric substance

(2)

(iii) Name six thermometric properties that can be used to measure temperature. (3)

(b) Define a Celsius scale based on a fixed mass of gas at constant volume. (2)

(c) (i) Explain briefly why thermometers based on different thermometric properties give different values for the same temperature. (1)

(ii) A thermometer is constructed with a liquid that expands according to the relation

$$V_t = V_0(1 + \alpha t + \beta t^2)$$

where V_t = volume of liquid at temperature t^0C, V_0 = volume of liquid at 0^0C

α and β are constants such that $\alpha = 1000\beta$.

What will the liquid thermometer read when the gas thermometer reads 200^0C? (5)

(d) (i) What is a thermo-junction? (2)

(ii) Sketch a graph of the emf of a thermocouple for the range before and after the neutral temperature. (2)

(iii) State two advantages and two disadvantages of thermocouple thermometers over other types. (2)

7 (a) With the aid of diagram, discuss briefly variations of temperature gradient for a steel bar when the bar is;

(i) unlagged (2)

(ii) lagged (2)

(b) (i) In the determination of thermal conductivity of a poor conductor such as cork, the substance is made thin and fairly of large cross-sectional area. Explain why this is so. (2)

(ii) Describe how the thermal conductivity of cork can be determined. (5)

(c) An aluminium pan of diameter 20.0cm and thickness 2.0mm is filled with water and heated such that the water boils producing steam at a rate of $5.0gs^{-1}$ at steady state conditions.

(i) Calculate the temperature of the external surface of the pan (4)

(ii) State the assumption made (1)

(d) (i) State Stefan's law of black body radiation. (1)

(ii)As a piece of charcoal is steadily heated up, it appears reddish in colour before turning whitish. Explain this observation. (3)

SECTION C

8(a) (i) Sketch the *I-V characteristic* for gaseous conduction. (2)

(ii) Explain the main features of the curve. (3)

(b) A beam of electrons moving with a velocity **v**, enters normally a strong magnetic field, which is uniform and of induction **B**. If each electron has a mass **m** and charge **e**, assuming that the electrons suffer a deviation of 180^0 by the time they leave the magnetic field,

(i) derive an expression for the distance **d,** covered by an electron while moving in the field. (3)

(ii) write down the relationship between **d** and **B**. (1)

(c) (i) Draw a labeled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

(d) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates.

Show that the path of the beam between the plates is a parabola. (5)

9(a) A high p.d is applied across two electrodes in air contained in a closed glass tube. Describe, with the aid of labeled diagrams, what will be observed when the pressure in the tube is progressively reduced down to very low pressures. (5)

(b) (i) List **four** main properties of cathode rays. (2)

(ii) Describe an experiment to show that cathode rays carry a negative charge. (4)

(c) (i) In the Millikan's oil-drop experiment, why is there a need to surround the chamber with a constant temperature bath? (2)

(ii) Explain how Millikan's experiment proves that charge is quantized. (2)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius **6×10^{-6} m** was found to fall under gravity at a terminal velocity of **0.004 cm s^{-1}** and to rise at **0.012 cm s^{-1}** when a field of **2×10^{5} Vm^{-1}** was suitably applied. Given that the viscosity of the medium was **2.122×10^{-5} Nsm^{-2}**, determine the number of electrons on the drop. (5)

END

NAME ……………………………………………………………Personal No. …….Sign ………..

P 510/1

Paper 1

BEGINNING OF TERM TWO EXAMINATIONS, 2017

S.6 PHYSICS

PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

*Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B** and **C**.*

Permittivity of free space ε_o	=	8.85×10^{-12} F m^{-1}
Acceleration due to gravity, g	=	9.81 ms^{-2}
Electronic charge, *e*	=	1.6×10^{-19} C
Mass of the earth	=	5.97×10^{24} kg
Planck's constant, *h*	=	6.6×10^{-34} Js
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} Wm^{-2} K^{-4}
Wien's displacement constant	=	2.9×10^{-3} m K
Radius of Earth's orbit about the sun	=	1.5×10^{11} m
Radius of the sun	=	7.0×10^{8} m
Specific heat capacity of water	=	4.2×10^{3} J kg^{-1} K^{-1}
Specific latent heat of fusion of water	=	3.34×10^{5} J kg^{-1}
Specific heat capacity of copper	=	400 J kg^{-1} K^{-1}
Avogadro's number N_A	=	6.02×10^{23} mol^{-1}
Density of water	=	1000 kg m^{-3}
Gas constant, R	=	8.31 J $mol^{-1}K^{-1}$

Questions attempted					
Marks					

SECTION A

1(a) Write the equations of ***uniformly accelerated*** motion (3 marks)

(b) (i) Briefly distinguish between ***conservative*** and ***non-conservative*** forces. Give two examples in each case. (4 marks)

(ii) State the ***principle of conservation*** of energy. Show that a projectile fired with a speed $u\ ms^{-1}$ at an angle θ to the horizontal obeys this principle throughout its motion. (4 marks)

(c) The engine of a 5-tonne lorry can develop 30kW, and its maximum speed on level road is $90\ km h^{-1}$. Assuming that the friction resistance is constant, calculate the greatest speed at which the lorry can climb a hill of 1 in 25. (4 marks)

(d) (i)Define ***moment*** of a force. (1 mark)

(ii)A wheel of radius $0.84 m$ is pivoted at its centre. A tangential force of $50\ N$ acts on the wheel so that the wheel rotates with uniform velocity. Find the work done by the force to turn the wheel through 20 revolutions. (4 marks)

2(a) (i) Define the term angular velocity. (1mark)

(ii) A car of width c and whose centre of gravity is at a height h above the ground goes round a bend of radius r. Show that it will overturn if its speed exceeds $\sqrt{\frac{c g r}{2 h}}$. (5 marks)

(iii) A bucket of water is swung at constant tangential speed in a vertical circle of radius 0.5 m in such a way that the bucket is upside down when it is at the top of the circle. Find the minimum speed that the bucket may have if the water is to remain in it? (3marks)

(b) State Kepler's laws of gravitation. (3 marks)

(c) (i) Define gravitational field strength. (1mark)

(ii) With aid of a sketch, qualitatively explain the variation of acceleration due to gravity with distance from the centre of the earth. (3marks)

(d) A satellite of mass m is to be launched into an orbit of radius R round the earth of radius r. Show that the minimum launching velocity is given by $v^2 = \frac{g\,r(2R - r)}{R}$.

(4 marks)

3(a) (i)What is meant by the term **dimensions of a physical quantity**? (1 mark)

(b) The volume per second of a liquid ejected from a pipe of radius a under steady flow is given by the expression $\frac{V}{t} = \frac{\pi}{8} p^x \eta^y a^z$, where p is the pressure gradient with dimensions $M L^{-2} T^{-2}$ and $[\eta] = M L^{-1} T^{-1}$. By dimensional analysis, find the values of x, y and z. (5 marks)

(c) (i)Define the terms ***range*** and ***time of flight*** as applied to projectile motion.(2marks)

(ii)A shell is fired from a gun with a velocity U at an angle α to the horizontal.

Show that the vertical distance y covered is given by $y = x\tan\alpha - \frac{gx^2\sec^2\alpha}{2U^2}$.

(4 marks)

(d) A shell is fired with a velocity of 100 ms^{-1} at an angle of 60^0 to the horizontal from a gun placed at the top of a hill of vertical height 800 m above the ground. Find the:

(i)time taken by the shell to hit the enemy on the ground assuming the shell is on target. (4 marks)

(ii) velocity with which the shell hits the target. (4 marks)

4(a) (i)Distinguish between **scalar** and **vector** physical quantities. Give **two** examples of each. (4marks)

(ii)The diagram in figure 1 shows three coplanar forces acting on a particle.

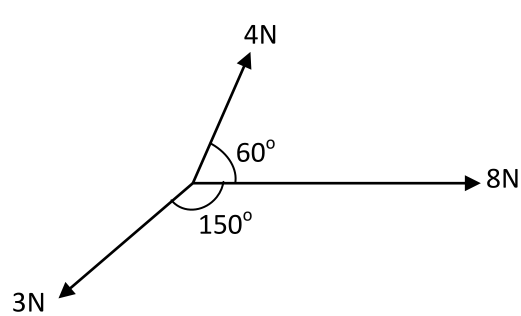


Fig. 1

Find the magnitude, and inclination to the 8N force, of the resultant force. (5marks)

(b) State the laws of solid friction. (3marks)

(c) With aid of a labeled diagram, describe an experiment to determine the coefficient of static friction. (4marks)

(d) Figure 2 shows two particles M and N each of mass 2 kg. M is held at A on an inclined plane and is connected to N by a light inelastic string that passes over a smooth pulley P. The coefficient of friction between particle M and the plane is 0.5.

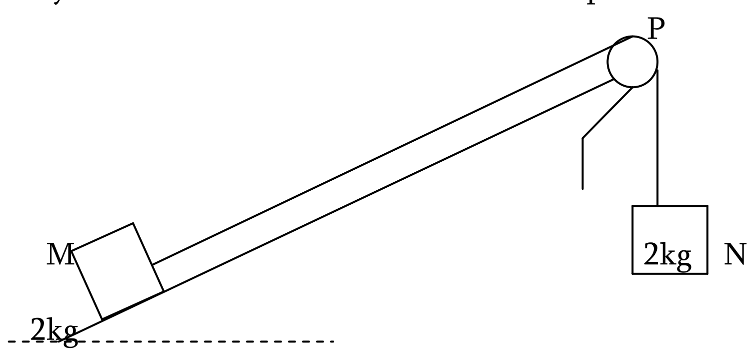


Fig. 2

Find the acceleration of the masses and the tension in the string when M is released from rest. (4marks)

SECTION B

5(a) (i)What is meant by a ***thermometric property*** and ***triple point of water***? (2 marks)

(ii)Describe how you would measure the temperature of a body on the thermodynamic scale using a thermocouple. (3 marks)

(iii)The resistance of a platinum wire at the triple point of water is 5.25Ω. What will be the resistance at $100\,^0C$? (2 marks)

(b) The resistance R_t of a platinum wire varies with the gas temperature $t\,^0C$ according to the equation $R_t = R_0\left(1+\alpha t+\beta t^2\right)$, where R_0 is the resistance at $0\,^0C$ and α and β

are constants. For a platinum resistance wire thermometer, $\alpha = 4.13\times10^{-3}$ and $\beta = -6.4\times10^{-7}$ respectively. Calculate the reading of the platinum thermometer when the gas thermometer reads $1000\ ^0C$. (5 marks)

(c) Define the term **specific latent heat of vapourisation**. (1 mark)

(d) An electrical heater rated at 500 W is immersed in a liquid of mass 2.0 kg contained in a large thermos flask of heat capacity 840 J kg^{-1}at 28^0C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid is $2.5\times10^3\ J\,kg^{-1}K^{-1}$, its specific latent heat of vapourization is $8.54\times10^3\ J\,kg^{-1}$ and its boiling point is $78\,^0C$, estimate the amount of liquid which boils off.

State any assumptions made in your calculation. (7 marks)

6(a) (i)State **Boyle's law**. (1 mark)

(ii)The pressure P of an ideal gas of density ρ and mean square speed $\overline{c^2}$ is given by $P = \frac{1}{3}\rho\,\overline{c^2}$. Use this expression to derive Boyle's law. (3 marks)

(b) Air contains approximately of 20% oxygen and 80% nitrogen. The relative molecular masses of oxygen and nitrogen are 32 and 28 respectively. Calculate the ratio of the:

(i)mean-square speed of oxygen to that of nitrogen. (3 marks)

(ii) partial pressure of oxygen to that of nitrogen in air. (4 marks)

(c) A fixed mass of a gas is contained in a cylinder of volume V_1 and pressure P_1.The gas is allowed to expand to a volume V_2 and pressure P_2. Assuming that the temperature remained constant, show that the work done by the gas is given by $W = -P_1V_1\ln\frac{P_2}{P_1}$.

(3 marks)

(d) A litre of hydrogen gas at a temperature of 27^0C and a pressure 10^5 Nm^{-2} expands isothermally until its volume is doubled and is then adiabatically expanded until the new volume is again doubled. Given that $C_p = 29.2\ J\,mol^{-1}K^{-1}$,

(i)Show the above processes on a P-V diagram, (2 marks) (ii)Calculate the final pressure of the gas. (4 marks)

7(a) (i) Define **thermal conductivity** of a material (1 mark)

(ii)Briefly account for the fact that metals are better conductors of heat than insulators. (3 marks)

(b) A wall of a building consists of two brick layers each of thickness 10.0 cm and between which there is a layer of air 2.0 cm thick.

Find the rate of heat flow through one m^2 of the wall if the inner and outer temperatures of the building are 25^0C and 15^0C respectively. (6 marks)

(c) Describe with the aid of a labeled diagram, how the temperature of a furnace may be measured. (5 marks)

(d) The total power output of the sun is $4.0 \times 10^{26}\,W$. Given that the mass of the sun is $1.97 \times 10^{30}\ kg$ and its density is $1.4 \times 10^{3}\ kg\,m^{-3}$, estimate the temperature of the sun. State any approximations made. (5 marks)

SECTION C

8(a) Define the following terms as used in photo electricity.

(i) work function. (1 mark)

(ii) stopping potential (1mark)

(b) (i)Describe an experiment to determine Planck's constant in a laboratory. (5 marks)

(ii) Write down Einstein's photo-electric equation and explain how it accounts for emission of electrons from a metal surface. (3 marks)

(iii)Electromagnetic radiation of frequency 8.8×10^{14} Hz falls upon a surface whose work function is 2.5eV. Calculate the maximum speed of the photoelectrons released from the surface. (4 marks)

(c)

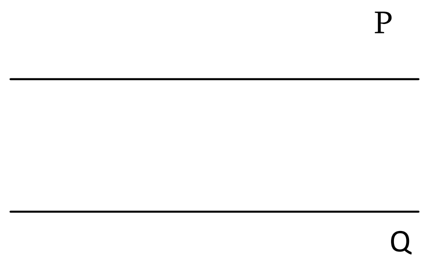


Fig.3

Figure 3, shows two parallel metal plates P and Q each of length 5.0 cm and separated by a distance of 4.0 cm. A p.d. of 12V is applied between P and Q and the space between P and Q is a vacuum. A beam of electrons of speed $u = 1.0 \times 10^{6}$ ms^{-1} is directed midway between P and Q. Calculate the angle at which the beam emerges from the space between P and Q to the initial direction of the beam.

(6 marks)

9(a) (i) Explain how Millikan's experiment for measuring the charge of the electron proves that charge is quantized. (3 marks)

(ii) Oil droplets are introduced into the space between two flat horizontal plates, set **5.0 mm** apart. The plate voltage is the adjusted to exactly **780V** so that one of the droplets is held stationary. Then the voltage is switched off and the selected droplet is observed to fall a measured distance of **1.5 mm in 11.2 s**. Given the density of oil used is **900 kgm^{-3}** and the viscosity of air is **1.8×10^{-5} Nsm^{-2}**, calculate the charge of the droplet. (5 marks)

(b) (i) What are cathode rays? (1 mark)

(ii) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates. Show that the path of the beam between the plates is a parabola. (3 marks)

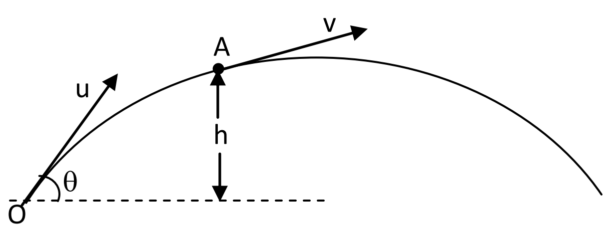
(iii)An electron gun operating at **3×10^3 V** is used to project electrons into the space between two oppositely charged parallel plates of length **10 cm** and separation **5 cm**. Calculate the vertical deflection of the electrons as they emerge from the region between the charged plates when the potential difference is **1.0×10^3 V.** (4 marks)

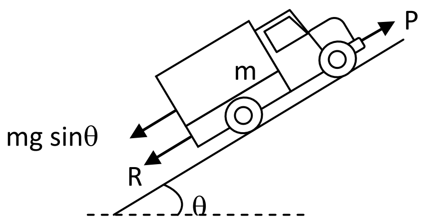
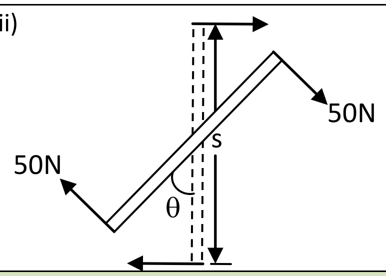
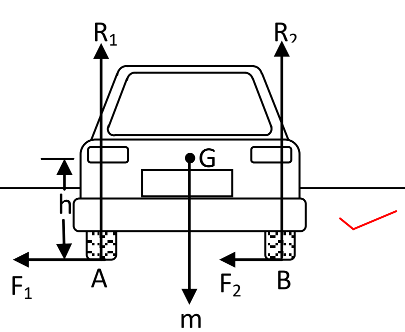
(Use charge to mass ratio of an electron = **1.8×10^{11} Ckg^{-1}**)

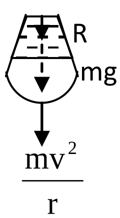
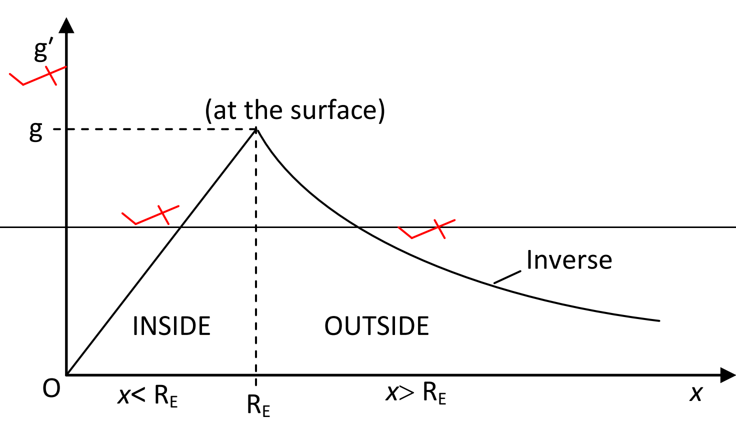
(c) A beam of positive ions is accelerated through a potential difference of **1.0×10^3 V** into a region of uniform magnetic field of flux density **0.2T**. While in the magnetic field, it moves in a circle of radius **2.3 cm**. Derive an expression for the charge to mass ratio of the ions, and calculate its value. (4 marks)

END

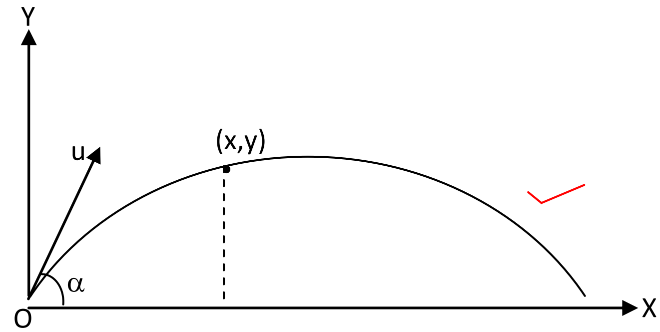
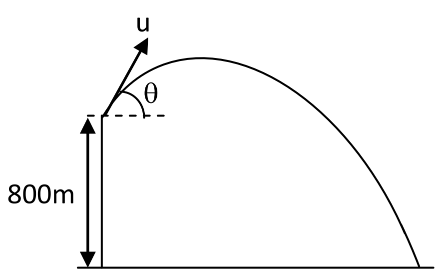
S6 PHY PAPER 1, B.O.T TERM 2 EXAM 2017

Qn	Answer	Marks
1 (a)	$v = u + at$ $s = ut + \frac{1}{2}at$ $v^2 = u^2 + 2as$ where a = acceleration u = initial velocity v = velocity after time t s = displacement after time t *Provided the quantities are defined*	1 1 1
(b)	(i)A conservative force is one whose work done on a body depends only on the initial and final positions of the body. i.e. the work done is independent of the path taken. The work done by a non-conservative force depends on the path taken. Conservative forces – gravity, magnetic force, electrostatic force. *Any two @½* Non-conservative forces – friction, viscous force	1 1 1 1
	(ii) In a closed system the total energy is constant. OR Energy can neither be created or destroyed but can only change form  Let the datum level be through the point of projection, O Then, at O the p.e = 0 and k.e = $\frac{1}{2}mu^2$ $= \frac{1}{2}m(u_x^2 + u_y^2)$ $= \frac{1}{2}mu^2(\cos^2\theta + \sin^2\theta)$ $\therefore$ at O the total m.e = p.e + k.e = $0 + \frac{1}{2}mu^2\cos^2\theta + \frac{1}{2}mu^2\sin^2\theta$	1 ½ ½

	At point A, where the velocity is v at an angle α to the horizontal, the total m.e $= mgh + ½mv^2$ But $v^2 = v^2\cos^2\alpha + v^2\sin^2\alpha$ Now, $v^2\cos^2\alpha = u^2\cos^2\theta$ (no change in horizontal velocity) and $v^2\sin^2\alpha = u^2\sin^2\theta - 2gh$ $\therefore\ v^2 = u^2\cos^2\theta + u^2\sin^2\theta - 2gh$ $\therefore$ at A the total m.e $= mgh + ½m(u^2\cos^2\theta + u^2\sin^2\theta - 2gh)$ $= mgh + ½mu^2 - mgh$ $= ½mu^2$ ...... as at point O	½ ½ ½ ½
(c)	 $\sin\theta = \frac{1}{25}$ At maximum speed acceleration, a = 0 Let P = driving force Then $P - (R + mg\sin\theta) = 0$ $\therefore P = R + mg\sin\theta$ .... (i) On the level road $R = \frac{30 \times 10^3}{v}$ $\therefore\ R = 1200$ N Let v' = maximum velocity on the slope Then $\frac{30 \times 10^3}{v'} = 1200 + 5 \times 10^3 \times 9.81 \times \frac{1}{25}$ $\therefore\ v' =$ **9.49 m s^{-1}**	1 1 1 1
(d)	(i) The moment of a force about a point is the product of the force and the perpendicular distance of its line of action from the point.	1
	(ii)  F = 50 N; s = 0.84 m $\theta = n(2\pi) = 20 \times 2\pi = 40\pi$ radians Work done = Force x distance moved $= F \times \theta s$ $= 50 \times 40\pi \times 0.84$ = **5,278 N**	1 1 1 1
	Total = 20	
2 (a)	(i) ... the rate at which a line joining a point on the body to the centre of the circle sweeps through an angle.	1
	(ii)  Suppose a car of mass is moving with a velocity v round a horizontal circular track of radius. Let R_1 and R_2 be the respective normal	

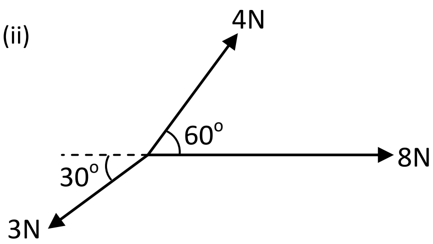
	reactions at the wheels A and B, and F_1 and F_2 the corresponding frictional forces, which provide the centripetal force. Then $F_1 + F_2 = \frac{mv^2}{r}$ .... (1) and $R_1 + R_2 = mg$ .... (2) Taking moments about the centre of gravity, G, we have $(F_1 + F_2)h + \frac{1}{2}cR_1 - \frac{1}{2}cR_2 = 0$ .. (3) Substituting for $(F_1 + F_2)$ in equation (3) $\frac{mv^2}{r}h + \frac{1}{2}cR_1 - \frac{1}{2}cR_2 = 0$ .... (4) Solving for R_1 and R_2 between equations (2) and (4), we get $R_1 = \frac{1}{2}m\left(g - \frac{2v^2h}{cr}\right)$ and $R_2 = \frac{1}{2}m\left(g + \frac{2v^2h}{cr}\right)$ The car will overturn if $R_1 < 0$ $\therefore \frac{1}{2}m\left(g - \frac{2v^2h}{cr}\right) < 0$ $\therefore v > \sqrt{\frac{cgr}{2h}}$	1 ½ ½ ½ ½ ½ ½ ½ ½
	(iii)  For the water to remain in the bucket $R > 0$ $\therefore \frac{mv^2}{r} > mg$ $\therefore v^2 > rg$ $\therefore v > \sqrt{0.5 \times 9.81}$ $\therefore v >$ **2.215 m s^{-1}**	
(b)	1. The planets describe ellipses about the sun as one focus. 2. The line joining the sun and the planet sweeps out equal areas in equal times. 3. The squares of the periods of revolution of the planets are proportional to the cubes of their means distances from the sun.	1 1 1
(c)	(i) Gravitational field strength is the force acting on a mass of 1 kg placed in the gravitational field	1
	(ii)  	½ 1

		½
	At points inside the earth, the acceleration due to gravity is directly proportional to the distance from the centre of the earth. At points above the earth's surface, the acceleration due to gravity varies inversely as the square of the distance from the centre of the earth.	½ ½
(d)	Then, the energy needed, W = increase in potential energy and kinetic energy This is equal to the k.e of the satellite at launch $\therefore \frac{1}{2}mv^2 = \frac{GMm}{r} - \frac{GMm}{R} + \frac{1}{2}mv_o^2$, where v_o is the velocity in the orbit .....(1) But $\frac{mv_o^2}{R} = \frac{GMm}{R^2} \Rightarrow \frac{1}{2}mv_o^2 = \frac{GMm}{2R}$ $\therefore \frac{1}{2}mv^2 = \frac{GMm}{r} - \frac{GMm}{2R}$ .... (2) But $\frac{GM}{r^2} = g \Rightarrow \frac{GM}{r} = gr$ Substituting for $\frac{GM}{r}$ in equation (2) gives $\frac{1}{2}mv^2 = mgr - \frac{mgr^2}{2R}$ $\mathbf{v^2 = \frac{gr(2R-r)}{R}}$	
3 (a)	Dimensions of a physical quantity is the way a physical quantity is related to the fundamental quantities, i.e. mass, length and time.	1
(b)	$[p] = ML^{-2}T^{-2}$, $[\eta] = MT^{-1}L^{-1}$ So $\left[\frac{V}{t}\right] = [p]^x.[\eta]^y.[a]^z$ $\therefore L^3T^{-1} = (ML^{-2}T^{-2})^x.(MT^{-1}L^{-1})^y.L^z$ $\therefore L^3T^{-1} = M^{x+y}.L^{-2x-y+z}.T^{-2x-y}$ Comparing coefficients, we have For L: $-2x - y + z = 3$ .... (1) For M: $x + y = 0$ ..... (2) For T: $-2x - y = -1$ .... (3) From (1) and (3): **z = 4** Eq(2) + Eq(3): $-x = -1$ $\therefore$ **x = 1** And **y = -1**	1 1 1 1 1

(c)	(i) Range is the distance, measured directly, between the point of projection and the point where the projectile lands. Time of flight is the time between the instant of projection and landing.	1 1
	(ii)  Consider the bullet to be at point (x,y) on the trajectory The horizontal distance, x, after time t is given by $x = (u\cos\alpha)t$ $\therefore \quad t = \dfrac{x}{u\cos\alpha}$ The vertical height attained is $y = (u\sin\alpha)t - \frac{1}{2}gt^2$ $\therefore \quad y = x\tan\alpha - \dfrac{gx^2}{2u^2\cos^2\alpha}$ $\therefore \quad y = x\tan\alpha - \dfrac{g\,x^2\sec^2\alpha}{2u^2}$	1 ½ ½ ½ 1 ½
(d)	$U = 100\ \text{m s}^{-1}$, $\theta = 60^\circ$, $h = 800$ m  Using $h = ut\sin\theta - \frac{1}{2}gt^2$ $-800 = 100t\sin60^\circ - \frac{1}{2} \times 9.81t^2$ $4.905t^2 - 50\sqrt{3}\,t - 800 = 0$ $t = 24.35$ s or -6.70 s $\therefore \quad t =$ **24.35 s** $v = \sqrt{v_x^2 + v_y^2}$ $v_x = u\cos\theta = 100\cos60^\circ = 50\ \text{m s}^{-1}$ $v_y = u\sin\theta - gt = 100\sin60^\circ - 9.81 \times 24.35 = -152.27\ \text{m s}^{-1}$ $v = \sqrt{50^2 + (-152.27)^2}$ = **160.27 m s^{-1}** Direction, $\alpha = \tan^{-1}\left(\dfrac{-152.27}{50}\right)$ = **-71.82°** i.e. 71.82° below the horizontal	1 1 1 1 1 1 1 1
4 (a)	(i) A scalar is a quantity which is defined by only magnitude.	1

A vector is a quantity which is defined by both magnitude and direction 1
Scalars: mass, time, work volume, distance, etc. 1
Vectors: pressure, force, acceleration, velocity, impulse, etc. 1

(ii)

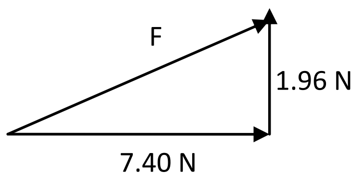


$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 8 \\ 0 \end{pmatrix} + \begin{pmatrix} 4\cos 60^o \\ 4\sin 60^o \end{pmatrix} + \begin{pmatrix} -3\cos 30^o \\ -3\sin 30^o \end{pmatrix}$$ 1, 1

$$= \begin{pmatrix} 7.40 \\ 1.96 \end{pmatrix}$$

1
1

1



Resultant, F $= \sqrt{7.40^2 + 1.96^2}$

$=$ **7.66 N**

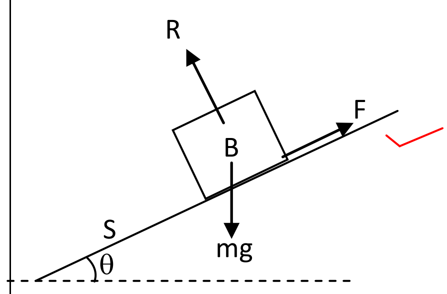
Direction, $\theta = \tan^{-1}\left(\frac{1.96}{7.40}\right)$ = **14.9°** to 8N force

(b) Laws of friction:

- The frictional force between two solid surfaces in contact opposes their relative motion. 1
- The frictional force is independent of the area of contact of given surfaces. 1
- The limiting frictional force is directly proportional to the normal reaction. 1

(c)

Determination of μ between a block and a Surface ½



- The block, B, is placed on the surface, S. ½
- S is gently tilted until B is on the point of slipping down the plane. 1½
- The angle, θ, between the plane and the horizontal is measured. ½

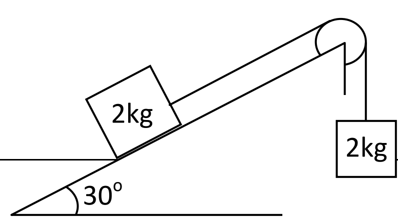
The frictional force, F, is then equal to mgsinθ and the normal reaction R = mgcosθ ½

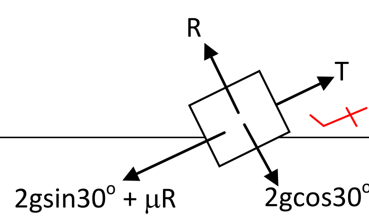
½

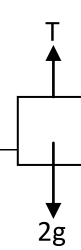
$$\therefore \quad \mu = \frac{F}{R} = \frac{mg \sin\theta}{mg \cos\theta} = \tan\theta$$

NOTE: An alternative experiment that gives the same results shall be accepted.

(d) Let the acceleration of the system be a and the tension in the string be T.





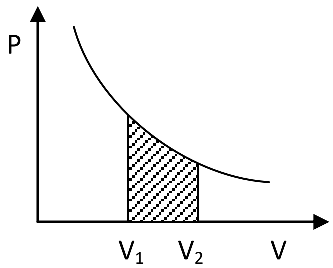


1

	Applying F = ma, we have $2g - T = 2a$ .... (1) and $T - (2g\sin 30^o + \mu R) = 2a$ .... (2) But $R = 2g\cos 30^o$ Eq(1) + eq(2) $2g(1 - \sin 30^o - 0.5\cos 30^o) = 4a$ $\therefore$ $a = ½ \times 9.81(1 - \sin 30^o - 0.5\cos 30^o)$ $= 0.329 \text{ m s}^{-2}$ From (1): $T = 2 \times 9.81 - 2 \times 0.329 =$ **18.96 N**	½ ½ ½ ½ 1
	Total = 20	
5 (a)	(i) A thermometric property is a physical property of a substance whose value changes continuously with temperature. The triple point of water is a unique temperature at which pure water, pure ice and pure water vapour co-exist in equilibrium.	1 1
	(ii) - The emf, E_{tr}, of the thermocouple at the triple point is measured. - The emf, E_θ, of the thermocouple at the triple point is measured. The temperature, θ, is calculated from $\theta = \frac{E_\theta}{E_{tr}} \times 273.16 \text{ K}$	1 1 1
	(iii) $R_{tr} = 5.25\Omega$, $R_\theta = ?$ Now $373 = \frac{R_{100}}{5.25} \times 273.16$ $\therefore$ $R_{100} = \frac{373 \times 5.25}{273.16} =$ **7.17 Ω**	1 1
(b)	$R_t = R_o(1 + \alpha t + \beta t^2)$, $\alpha = 4.13 \times 10^{-3}$, $\beta = -6.4 \times 10^{-7}$ $t = \left(\frac{R_t - R_o}{R_{100} - R_o}\right) \times 100^oC$ $= \left[\frac{R_o(1 + 1000 \times 4.13 \times 10^{-3} - 1000^2 \times 6.4 \times 10^{-7}) - R_o}{R_o(1 + 100 \times 4.13 \times 10^{-3} - 100^2 \times 6.4 \times 10^{-7}) - R_o}\right] \times 100^oC$ $= \frac{4.13 - 0.64}{0.413 - 0.0064} \times 100^oC$ $= \frac{3.49}{0.4066} \times 100^oC =$ **858.34°C**	1 1 1 1 1
(c)	This is the quantity of heat required to convert 1 kg mass of a substance from liquid to vapour at constant temperature.	1
(d)	$\begin{pmatrix}\text{Heat supplied} \\ \text{by heater}\end{pmatrix} = \begin{pmatrix}\text{Heat gained} \\ \text{by flask}\end{pmatrix} + \begin{pmatrix}\text{Heat gained} \\ \text{by liquid}\end{pmatrix} + \begin{pmatrix}\text{Heat taken to} \\ \text{boil liquid}\end{pmatrix}$	1

	$500 \times 10 \times 60 = C_f.\Delta\theta + m_l c_l.\Delta\theta + mL_v$ $300{,}000 = 840(78-28) + 2 \times 2.5 \times 10^3(78-28) + m \times 8.54 \times 10^3$ $300{,}000 = 42{,}000 + 250{,}000 + 8540m$ $\therefore\ m = \mathbf{0.937\ kg}$ Assumptions: - All heat is taken up by the flask and the liquid. - No heat is lost to the surroundings	1 3 1 ½ ½
	Total = 20	
6 (a)	(i) The volume of a fixed mass of gas at constant temperature is inversely proportional to the pressure.	1
	(ii) $p = \frac{1}{3}\rho\overline{c^2}$ Let m = mass of each molecule and N = number of molecules, V = volume of gas Then $p = \frac{1}{3}\frac{Nm}{V}\overline{c^2}$ $\therefore pV = \frac{1}{3}Nm\overline{c^2}$ $\therefore pV = \frac{2}{3}N\left(\frac{1}{2}m\overline{c^2}\right)$ $\therefore pV = \frac{2}{3}N\left(\frac{3}{2}kT\right)$, where k = Boltzmann's constant $\therefore pV = NkT$ Thus, at constant temperature pV = constant	 ½ ½ ½ ½ 1
(b)	Oxygen = 20%; nitrogen = 80% $M_o = 32$, $M_N = 28$ (i) Using $p = \frac{1}{3}\rho\overline{c^2}$ $pV = \frac{1}{3}(Nm)\overline{c^2}$ Now, Nm = M = molecular mass For one mole of oxygen $p_oV = \frac{1}{3}M_o\overline{c_o^2} = RT$ and for one mole of oxygen $p_nV = \frac{1}{3}M_n\overline{c_n^2} = RT$ $\therefore$ at the same temperature, $\overline{c_o^2} : \overline{c_n^2} = \frac{3RT}{32} : \frac{3RT}{28} = 28:32 = 7:8$	 1 1 1
	(ii) Let P_o = partial pressure due to oxygen P_n = partial pressure due to nitrogen n_o = number of oxygen molecules in the mixture n_n = number of nitrogen molecules in the mixture m_o = mass of each oxygen molecule m_n = mass of each nitrogen molecule Then $P_o = \frac{1}{3}\frac{n_o m_o}{V}\overline{c_o^2}$ and $P_n = \frac{1}{3}\frac{n_n m_n}{V}\overline{c_n^2}$ $\therefore \frac{P_o}{P_n} = \frac{n_o m_o}{n_n m_n}.\frac{\overline{c_o^2}}{\overline{c_n^2}} = \frac{20}{80}.\frac{7}{8} = \frac{7}{32}$	 1 2

(c) The total work done in expanding from V_1 to V_2 is



$$W = \int dW = \int_{V_1}^{V_2} PdV$$ 1

For n moles of gas

$$P = \frac{nRT}{V}$$

1

Hence $W = \int_{V_1}^{V_2} PdV = \int_{V_1}^{V_2} nRTdV = nRT\log_e\left(\frac{V_2}{V_1}\right)$

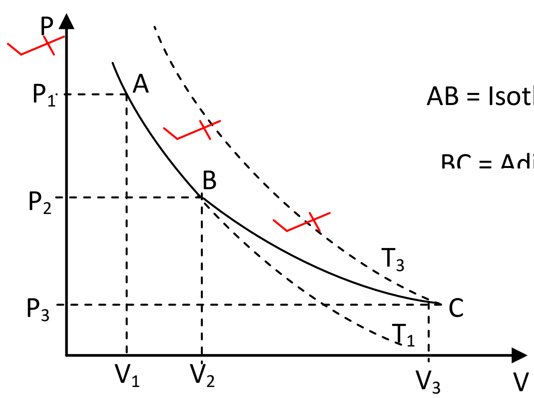
The heat required, $Q = W = nRT\log_e\left(\frac{V_2}{V_1}\right)$

But $P_1V_1 = P_2V_2 = nRT$

$\therefore V_2 = \frac{P_1V_1}{P_2}$

$\therefore W = P_1V_1\log_e\left(\frac{P_1V_1}{P_2}\cdot\frac{1}{V_1}\right) = P_1V_1\log_e\left(\frac{P_1}{P_2}\right) = -P_1V_1\log_e\left(\frac{P_2}{P_1}\right)$ 1

(d) $V_1 = 1$ litre $= 1 \times 10^{-3}m^3$ $T_1 = 27^oC = 300$ K $P_1 = 10^5$ Nm^{-2}
$V_2 = 2 \times 10^{-3}$ m^3 $T_2 = T_1$ $P_2 = ?$
$V_3 = 4 \times 10^{-3}$ m^3 $T_3 = ?$ $P_3 = ?$



½

AB = Isothermal

BC = Adiabatic ½

½

½

Along AB: $P_1V_1 = P_2V_2$ ½

$\therefore P_2 = \frac{10^5 \times 1 \times 10^{-3}}{2 \times 10^{-3}} = 5 \times 10^4$ Nm^{-2} ½

Using $P_2V_2^{\gamma} = P_3V_3^{\gamma}$

$P_3 = 5 \times 10^4\left(\frac{2 \times 10^{-3}}{4 \times 10^{-3}}\right)^{1.40}$ ½

$=$ **18,950 Nm^{-2}** ½

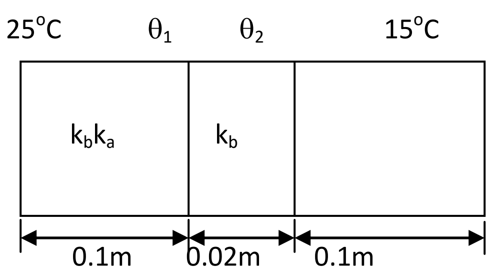
Using $T_2V_2^{\gamma-1} = T_3V_3^{\gamma-1}$

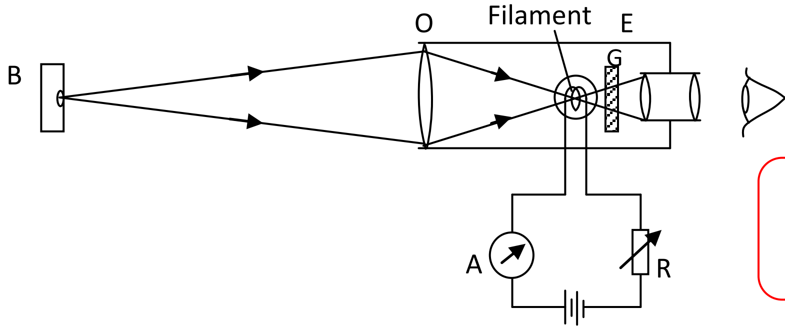
$C_p = 29.2$ J mol^{-1} K^{-1}

$C_v = C_p - R$

$= 29.2 - 8.83$

$= 20.89$ J mol^{-1} K^{-1} 1

	$T_3 = 300\left(\dfrac{2\times10^{-3}}{4\times10^{-3}}\right)^{1.40-1} = \mathbf{227.4\ K}$	1½
	Total = 20	
7 (a)	(i) Thermal conductivity is the heat flow rate in a substance per unit area per unit temperature gradient.	1
	(ii) - In poor conductors heat is conducted by waves produced by lattice vibrations. - This happens, say, when heat is applied to one part of the solid, the kinetic energy of vibration of the molecules there is increased. - Because of the bonds between the molecules, the kinetic energy of vibration of the neighbouring molecules is in turn also increased. So the wave moves on. - In metals conduction is predominantly due to freely moving electrons (in addition to lattice vibration). - When a part of a metal is heated, the free electrons gain thermal energy and their velocities increase. - They distribute this energy by collision with positive ions in the lattice and increase the ions' vibrational energy. - Because electrons are light, they are able to move quickly to the cooler parts of the solid. So this mode of heat transfer is much faster.	 ½ ½ ½ ½ ½ ½
(b)	Assume the heat flow rate through the layers to be same.  $\dfrac{k_b A(25-\theta_1)}{0.1} = \dfrac{k_a A(\theta_1-\theta_2)}{0.02} = \dfrac{k_b A(\theta_2-15)}{0.1}$ $\therefore \dfrac{0.7(25-\theta_1)}{0.1} = \dfrac{0.024(\theta_1-\theta_2)}{0.02} = \dfrac{0.7(\theta_2-15)}{0.1}$ $\therefore \dfrac{0.7(25-\theta_1)}{0.1} = \dfrac{0.7(\theta_2-15)}{0.1}$ $\therefore \quad 25 - \theta_1 = \theta_2 - 15$ $\therefore \theta_1 + \theta_2 = 40$ .... (1) Also $7(25 - \theta_1) = 1.2(\theta - \theta_2)$ $\therefore \quad 8.2\theta_1 - 1.2\theta_2 = 175$ .... (2) From (1): $\theta_1 = 40 - \theta_2$ Substituting for θ_1 into (2): $8.2(40 - \theta_2) - 1.2\theta_2 = 175$	½ 1 ½ ½ ½ ½ ½

	$\therefore \quad 9.4\theta_2 = 153$ $\therefore \theta_2 = 16.3^oC$ $\therefore$ Heat flow rate per m^2 $\dfrac{0.7(16.3-15)}{0.1}$ = **9.1 Wm^{-2}**	1 1
(c)	A pyrometer is used. What is shown below is an optical pyrometer  *Correct labeling of any 4 main parts @½* - It consists of a telescope, OE, and a lamp having a tungsten filament. G is a red filter through which light from the body, B, whose temperature is required passes. - The eyepiece, E, is focused upon the filament. - The furnace, B, is then focused by the objective lens O so that its image lies in the plane of the filament. - The temperature of the filament is adjusted using rheostat R until it "disappears" in the background of the radiation from B. Now, the ammeter, A, which measures the current, has been calibrated directly in degrees, and gives the temperature of the furnace.	2
(d)	Power output = 4.0×10^{26} W $m_s = 1.97 \times 10^{30}$; $\rho_s = 1.4 \times 10^3$kg m^{-3} Assuming that the sun is spherical Volume, V = $\dfrac{m}{\rho} = \frac{4}{3}\pi r_s^3$ $\therefore \quad 3 \times \dfrac{1.97 \times 10^{30}}{1.4 \times 10^3} = 4\pi r_s^3$ $\therefore r_s = \sqrt[3]{3.359 \times 10^{26}}$ = 6.952×10^8 m Assume that the sun radiates as a black body Then power radiated by the sun = 4.0×10^{26} W = $\sigma A T_s^4$ $\therefore \quad 4\pi r_s^2 \sigma T_s^4 = 4 \times 10^{26}$ $\therefore T_s^4 = \dfrac{4 \times 10^{26}}{4\pi \times (6.952 \times 10^8)^2 \times 5.67 \times 10^{-8}}$ $\therefore T_s = \sqrt[4]{1.162 \times 10^{15}}$ = **5,838 K**	1 1 1 1 1
Total = 20		

P 510/1
PHYSICS

Paper 1

UGANDA ADVANCED CERTIFICATE OF EXAMINATIONS

PHYSICS

S.6 PAPER 1 - 2014

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

*Attempt **five** questions in all.*

Non-programmable scientific electronic calculators may be used.

Assume where necessary.

Acceleration due to gravity, g	=	9.81 ms^{-2}
Mass of the earth	=	5.97×10^{24} kg
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} Wm^{-2} K^{-4}
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, *c*	=	$3.0 \times 10^{8}ms^{-1}$
Specific heat capacity of water	=	4,200J kg^{-1} K^{-1}
Universal gravitational constant, G	=	6.67×10^{-11}N m^2 kg^{-2}
Density of water	=	1000 kgm^{-3}
Gas constant, R	=	8.31 J $mol^{-1}K^{-1}$

SECTION A

1. (a) State Kepler's laws of planetary motion. (3)

(b) Derive the expression for the centripetal force on mass **m** moving with uniform speed **v** in a circular path of radius **r**. (4)

(c) Explain why:

(i) the earth has atmosphere. (2)

(ii) a cyclist has to lean over towards the centre of a bend in order to turn well. (2)

(d) A satellite of mass **120 kg** moves in a circular orbit around the earth with a period of **7.7×10^7 s**.

(i) Find its height above the earth. (5)

(ii) Calculate the mechanical energy of the satellite. (4)

2. (a) What is meant by ***simple harmonic motion***? (1)

(b) A cylindrical vessel of cross-sectional area **A** contains air of volume **V**, at pressure **P**, trapped by a frictionless piston of mass **M**. The piston is pushed down and then released.

(i) If the piston oscillates with simple harmonic motion, show that its frequency, **f,** is given by

$$f = \frac{A}{2\pi}\sqrt{\frac{P}{MV}}$$ (6)

(ii) Show that the expression for ***f***, in b(i) is dimensionally correct. (2)

(c) A mass of **0.1kg** suspended from a spring of force constant **24.5 Nm^{-1}** is pulled vertically downwards through a distance of **5.0 cm** and released. Find the

(i) period of oscillation. (2)

(ii) position of the mass **0.3 seconds** after release. (4)

(d) Sketch the following graphs for a body performing simple harmonic motion:

(i) Velocity against displacement (1)

(ii) Displacement against time. (1)

(e) With the aid of sketch graphs, distinguish between free and damped oscillations. (3)

3. (a) (i) Distinguish between ***kinetic energy*** and ***potential energy*** and show that a mass m, moving with a velocity, v, has kinetic energy given by $\frac{1}{2}\, m\, v^2$ (5)

(ii) What is meant by the term ***conservative force***? (1)

(iii) Show that for a particle moving in the gravitational field the total mechanical energy is conserved. (4)

(b) (i) Define the ***moment of a force***. (1)

(ii) The inner end of a concentrically coiled spring is fixed to the axle of a wheel of radius **0.5 m**. When two tangential parallel forces, each of **6N** acting in opposite directions, are applied to the wheel to form a couple, the wheel turns through an angle of **120^0**. Find the energy stored in the spring. (3)

(c) The engine of a **5-tonne** lorry can develop **30kW**, and its maximum speed on level road is **90 km h** $^{-1}$. Assuming that the friction resistance is constant, calculate the greatest speed at which the lorry can climb a hill of **1 in 25**. (4)

(d) Explain rocket propulsion. (3)

SECTION B

4. (a) (i)Explain why the difference between the principal heat capacities of a solid is negligible. (2)

(ii) Derive an expression for the difference in molar heat capacities of a gas. (4)

(b) (i)Explain why the sound propagation in air is considered to be an adiabatic process. (2)

(ii) A fixed mass of gas at a pressure P_1 and volume V_1 expands isothermally to a pressure P_2 and volume V_2. Derive an expression for the work done by the gas. (4)

(c) A gas of volume **2 litres** at a temperature of **27^{0}C** and pressure of **1.5 x 10 ^{5} Pa** is heated at constant pressure until its volume doubles. It is then cooled at constant volume back to its original temperature before finally being compressed isothermally to its original volume.

Draw a p-V diagram of the whole cycle and find the net work done by the gas. (5)

(d) The pressure **P** of an ideal gas of density **ρ**, is given by $\mathbf{P = \frac{1}{3}\rho \overline{c^2}}$, where $\mathbf{\overline{c^2}}$ is the mean-square speed of its molecules. Use this expression to derive Avogadro's hypothesis. (3)

5. (a) Explain why

(i) at low pressures a real gas approximates to a perfect gas. (2)

(ii) evaporation causes cooling. (2)

(b) (i) State two properties of a saturated vapour. (2)

(ii) Air is trapped between a piston and a liquid in a cylinder. The piston is slowly pulled outwards at constant temperature and this continues even after all the liquid has evaporated. Sketch a graph of pressure against volume for the contents of the cylinder and explain its features. (3)

(iii) Describe an experiment to show that saturated vapour pressure varies with temperature. (6)

(c) Air saturated with water vapour and contained in a rigid cylinder, at **100^0C** and **2.0×10^5 Pa** pressure is cooled to **20^0C**. Neglecting the expansivity of the cylinder calculate the final pressure in the cylinder, if the saturated vapour pressure of water at **$20\ ^0C$** is **2.3×10^3 Pa**. [Atmospheric pressure = **1.013×10^5 Pa**] (5)

6. (a) Define thermal conductivity of a material. (1)

(b) (i) Using molecular theory of matter, explain the mechanism of heat energy transfer in insulators. (3)

(ii) Briefly account for the fact that metals are better conductors of heat than insulators. (3)

(c) A pan of diameter **20.0 cm** and thickness **2.0 mm** is filled with water and heated such that the water boils producing steam at a rate of **$5.0 g\ s^{-1}$** at steady state conditions.

(i) calculate the temperature of the external surface of the pan. (4)

(ii) State the assumptions made. (2)

(Specific latent heat of vaporisation of water is **$2.26 \times 10^6 J\ kg^{-1}$** while conductivity of the material of the pan is **$380\ Wm^{-1} K^{-1}$**)

(d) (i) What is meant by black body radiation ? (1)

(ii) The total power output of the sun is **4.0×10^{26} W**. Given that the mass of the sun is **1.97×10^{30} kg** and its density is ***1.4×10^{3} kg m^{-3}***, estimate the temperature of the sun. State any assumptions made.

(Stefan's constant, σ = **5.67×10^{-8} Wm^{-1}K^{-1}**) (6)

END

BEGINNING-OF-TERM TEST

February 2012

S6 PHYSICS

Paper 1

2 ½ hours

NAME ……………………………………………………… Stream…… … H'se………

Signature ………………………………………………

Answer **ALL** questions.

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Mass of the earth	=	5.97×10^{24} kg
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	=	7.0×10^{8}m

Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Specific heat capacity of water	=	4,200J kg^{-1} K^{-1}
Universal gravitational constant, G	=	6.67×10^{-11}N m^{-2} kg^{-2}
Density of water	=	1000 kgm^{-3}
Gas constant , R	=	8.31 J $mol^{-1}K^{-1}$

Question	**1**	**2**	**3**	**4**	**5**	**TOTAL**
Marks						

SECTION A

1(a) (i) State the principle of *conservation of mechanical energy*. (01)

(ii) A particle is projected at an acute angle, **θ**, to the horizontal. Assuming no air resistance, *show that the mechanical energy* of the particle is *conserved* throughout its motion. (04)

(b) A ball of mass **0.5 kg** is allowed to drop from rest, from a point a distance of **5.0 m** above a horizontal concrete floor. When the ball first hits the floor, it rebounds to a height of **3.0m**.

(i) What is the *speed of the ball just after the first collision* with the floor? (04)

(ii) If the collision lasts **0.01 s**, find the *average force* which the floor exerts on the ball. (04)

(c) A bullet of mass **10 g** is fired at short range into a block of wood of mass **990 g** resting on a smooth horizontal surface and attached to a spring of force constant **100 Nm^{-1}**. The bullet remains embedded in the block while the spring is compressed by a distance of **5.0 cm**. Find the *elastic potential energy* of the compressed spring, and the *speed of the bullet* just before collision with the block. (05)

(d) Explain, *giving two examples*, the meaning of a 'conservative force' (02)

2.(a) (i) State the *laws of solid friction*. (03)

(ii) Explain, *using the molecular theory*, the laws stated in (i) above. (03)

(b) Describe how the *coefficient of static friction* for an interface between a rectangular block of wood and a plane surface can be determined. (04)

(c) State the *conditions for the equilibrium* of a rigid body under the action of coplanar forces. (02)

(d) A mass of **5.0 kg** is suspended from the end **A** of a uniform beam of mass **1.0 kg** and length **1.0 m**. The end **B** of the beam is hinged in the wall. The beam is kept horizontal by a rope attached to the mid-point of the beam and to a point **C**, in the wall at a height **0.75 m** above **B**. Calculate:

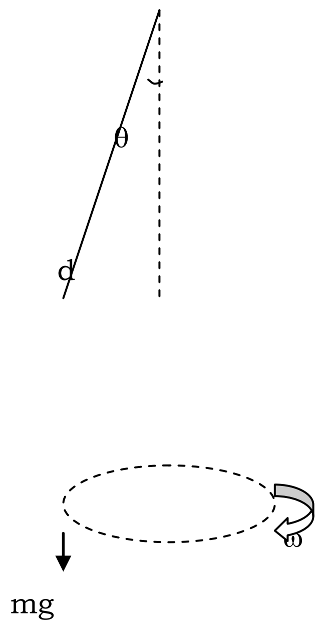
(i) the *tension* in the rope. (05)

(ii) the *force exerted by the hinge* on the beam. (03)

3.(a) (i) Define *angular velocity*. (01)

(ii) Derive an expression for the *force* $\boldsymbol{F}$, on a particle of *mass* $\boldsymbol{m}$, moving with *angular velocity* $\boldsymbol{\omega}$, in a circle of *radius* $\boldsymbol{r}$. (04)

(b)



A pendulum bob is set rotating so that it describes a horizontal circle with *angular velocity* ω as shown in the figure above. If the mass of the bob is **m** and the length of the string is **d**, find in terms of **m**, **d** the expression for:

(i) the *tension in the string* in terms of **m**, **d** and **ω** (03)

(ii) the *tangential velocity* of the bob. (03)

(c) A body of mass, **m,** is attached to the end of a string of length, **a**. The other end of the string is fixed. The string is initially held taut and horizontal and the body is then released.

Find the *velocity of the body and the tension in the string* when the string reaches the *vertical position.* (03)

(d) (i) Derive an expression for the *speed* with which a car can negotiate a bend on *a banked track* without skidding. (03)

(ii) Explain why a *racing car can travel faster* on a banked track than on a flat track of the same radius of curvature. (03)

SECTION B.

4. (a) (i) Define the *two principal molar heat capacities of a gas*. (02)

(ii) State, *which one is greater*, and *explain why* this is so. (02)

(iii) Show that the *difference between the molar heat capacities* is equal to the *molar gas constant*. (05)

(b) State the *conditions for an adiabatic process*. (02)

(c) A gas at a pressure of $\mathbf{1.2 \times 10^6}$ **Pa** and temperature $\mathbf{90\ ^0C}$ expands *adiabatically to twice its original volume* and then is *compressed isothermally to its original volume.* [Take ratio of the principal molar heat capacities, $\boldsymbol{\gamma = 1.40}$.]

(i) *Sketch and label* the two stages on a *P-V diagram.* (02)

(ii) Find the *final pressure* and *temperature* of the gas. (07)

5 (a) (i) Define *thermal conductivity*. (01)

(ii) Explain the *mechanism of heat conduction in metals*. (03)

(iii) Describe an experiment to determine the *thermal conductivity* of a metal. (06)

(b) (i) What is a *black body*? (01)

(ii) Draw *sketch graphs* to show the variation of *relative intensity of black body radiation with wavelength for different temperatures*. (02)

(iii) Explain the *appearance of a metal ball* placed in a dark room when its temperature is *progressively raised from room temperature to just below melting.* (03)

(c) The heat radiation *per second per* m^2 received by the earth from the sun is **1.4×10^3 Wm^{-2}**. Assuming this is **90%** of what the sun emits as a black body; *estimate the temperature of the sun*. (04)

END

S.6 PAPER 1 TEST – (Mechanics and Modern)

1(a) (i) Define surface tension in terms of surface energy. (1)

(ii) Calculate the work done against surface tension forces in blowing a soap bubble of diameter 15 mm. Take the surface tension of the soap solution as 3.0×10^{-2} Nm^{-1} (3)

(iii) Lycopodium powder is sprinkled over the surface of water in a dish. A small drop of soap solution is then introduced at the centre of the surface.

Explain what is observed on the surface. (3)

(b) Describe an experiment to investigate the effect of temperature on surface tension of a liquid. (6)

(c) (i) Derive an expression for the capillary rise of a liquid of density ρ, surface tension γ, and angle of contact θ, in a tube of radius, r. (3)

(ii)The internal diameter of the tube of a mercury barometer is 3.00mm. Find the corrected reading of the barometer after allowing for the error due to surface tension, if the observed reading is 76.56 cm. [Surface tension of mercury = 4.80×10^{-1} Nm^{-1}; angle of contact of mercury with glass is 140^0; density of mercury is 13600 kgm^{-3}] (4)

2(a) What is meant by the following terms:

(i) nuclear number. (1)

(ii) binding energy. (1)

(b) Calculate the energy released by 1.0 g of a sample during the decay of ${}^{220}_{86}Rn$ nucleus into ${}^{216}_{84}Po$ nucleus and an alpha particle. (4)

Mass of 220 Rn = 219.964176 u

Mass of 216 Po = 215.955794 u

Mass of 4 He = 4.001566 u

1 u = 931 MeV and Avogadro's number = 6.02×10^{23}

(c) (i)With the aid of a labeled diagram, describe how the diffusion cloud chamber can be used to detect ionizing radiation from a radioactive source.

(5)

(ii) Draw and explain the nature of tracks expected in c(i) above if the source emits α-particles. (2)

(d) (i) Explain how you would use the decay curve for a radioactive material to determine its half life. (2)

(ii) A radioactive source contains 1.0 µg of plutonium of mass number 239. If the source emits 2300 alpha particles per second, calculate the half-life of Plutonium.

[Assume the decay law $N = N_0 e^{-\lambda t}$] (5)

END

1 (a) (i) Define pressure. (1)

(ii) Derive the expression for the pressure at a point a depth, **h** from the surface of a liquid of density, ρ. (3)

(b) A block of mass **0.10 kg** is suspended from a spring balance. When the block is immersed in water of density **1000 kgm^{-3}**, the spring balance reads **0.63 N**. When the block is immersed in a liquid of unknown density, the spring reads **0.70 N**. Find:

(i) the density of the solid. (4)

(ii) the density of the liquid. (3)

(c)(i) State Bernoulli's principle. (1)

(i)Explain qualitatively the origin of the lift force on an aero-plane at take off. (3)

(ii)An aero-plane has a wing area of **40 m^2**. At take off, the speed of air above and below the wings are **120 ms^{-1}** and **100 ms^{-1}** respectively. Find the lift on the aero-plane, if the density of air is **1.3 kgm^{-3}**. (5)

2. (a) Derive the pressure $P = \frac{1}{3}\rho\overline{c^2}$ for the pressure, **P**, of an ideal gas of density ρ and mean square speed $\overline{c^2}$. State any assumptions made. (7)

(b) A gas is confined in a container of volume **0.1 m^3** at a pressure of **1.0 x 10^5 Nm^{-2}** and a temperature of **300 K**. If the gas is assumed to be ideal, calculate the density of the gas (The relative molecular mass of the gas is **32**). (5)

(c) Explain how cooking at a pressure of **76 cm** of mercury and a temperature of **100 ^{0}C**, may be achieved on top of high mountains. (3)

(d)The masses of Hydrogen and Oxygen atoms are **1.66 x 10^{-27} kg** and **2.66 x 10^{-26} kg**. What is the ratio of the root-mean –square speed of Hydrogen to that of Oxygen molecules at the same temperature? (3)

(e)Indicate the different states of a real gas at different temperatures on a pressure versus volume sketch graph. (2)

END

S.6 PAPER 1 TEST – October, 2014

1(a) (i) State the difference between isothermal and adiabatic expansion of a gas. (2)

(ii) Using the same axes ans point, sketch graphs of pressure versus volume for a fixed mass of a gas undergoing isothermal and adiabatic changes. (3)

(b) Show that the work done, W, by a gas which expands reversibly from V_0 to V_1 is given by $\int_{V_0}^{V_1} P\ dV$. (4)

(c) (i) State the differences between real and ideal gases. (2)

(ii) Draw a labeled diagram showing P – V isothermals for a real gas above and below the critical temperature. (3)

(d) Ten moles of a gas, initially at 27^0C are heated at constant pressure of 1.01×10^5 Pa and the volume increased from 250 litres to 375 litres. Calculate the increase in internal energy. [Assume $C_p = 28.5\ Jmol^{-1}K^{-1}$, $R = 8.314\ Jmol^{-1}K^{-1}$] (6)

2(a) (i) What is meant by thermionic emission? (1)

(ii) Sketch the Current – Potential difference characteristics of a thermionic diode for two different operating temperatures and explain their main features. (5)

(iii) Describe one application of a diode. (2)

(b) (i) What features of an X-ray tube make it suitable for continuous production of X-rays? (3)

(ii) Sketch a graph of intensity versus frequency of radiation produced in an X-ray tube and explain its features. (5)

(c) A monochromatic X-ray beam of wavelength 1.0×10^{-10} m is incident on a set of planes in a crystal of spacing 2.8×10^{-10} m. What is the maximum order possible with these X-rays? (4)

3(a) Define the following terms:

(i) centripetal acceleration. (1)
(ii) angular velocity. (1)

(b) (i) What is meant by banking of a track? (1)

(ii) Derive an expression for the angle of banking, θ, for a car of mass, m, moving at a speed, v, round a banked track of radius, r. (4)

(c) A bob of mass, m, is tied to an inelastic thread of length, l, and whirled with constant speed in a vertical circle.

(i) With the aid of a sketch diagram, explain the variation of tension in the string along the circle. (5)

(ii) If the string breaks at one point along the circle, state the most likely position and explain the subsequent motion of the bob. (2)

(d) A body of mass 15 kg is moved from the earth's surface to a point 1.8×10^6 m above the earth. If the radius of the earth is 6.4×10^6 m and its mass is 6.0×10^{24} kg, calculate the work done in taking the body to that point. [use $G = 6.67 \times 10^{-11}$ Nm^2kg^{-2}] (6)

END

Instruction: Attempt at least two questions in one hour.

P510/1
PHYSICS

Paper 1

AUGUST 2015

UACE MOCKS 2015

PHYSICS

PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary.

Permittivity of free space ε_o	=	8.85×10^{-12} Fm^{-1}
Acceleration due to gravity, g	=	9.8 ms^{-2}
Electron charge, *e*	=	1.6×10^{-19} C
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} Wm^{-2} K^{-4}
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{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}$
Specific heat capacity of water	=	4,200J kg^{-1} K^{-1}
Universal gravitational constant, G	=	6.67×10^{-11}N m^{-2} kg^{-2}
Avogadro's number N_A	=	6.02×10^{23} mol^{-1}
Density of water	=	1000 kgm^{-3}
Gas constant , R	=	8.31 J $mol^{-1}K^{-1}$
Charge to mass ratio, $^e/m$	=	1.8×10^{11} C kg^{-1}
The constant $\frac{1}{4\pi\varepsilon_o}$	=	9.0×10^{9} F^{-1}m

SECTION A

1. (a) (i) Define the coefficient of surface tension. (1)

(ii) Lycopodium powder is sprinkled over the surface of water in a dish. A small drop of soap solution is then introduced at the centre of the surface.

Explain what is observed on the surface. (3)

(b) Describe an experiment to investigate the effect of temperature on surface tension of a liquid. (6)

(c) (i) State Bernoulli's principle. (1)

(ii) Explain how the principle is applied in a filter pump. (3)

(d) Water flows steadily along a uniform tube of cross-section 30 cm^2. The static pressure is 1.25×10^5 Pa and the total pressure is 1.30×10^5 Pa. Find

(i) the flow velocity (4)

(ii) the mass flow rate. (2)

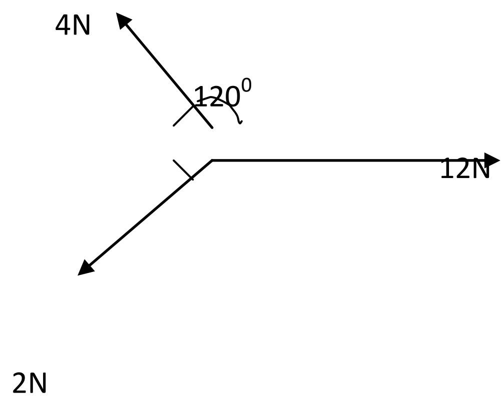
2. (a) Define the following

(i) a couple (1)

(ii) work (1)

(b) Show that when a couple rotates a body the work done is equal to the product of the torque and the angle in radians turned through. (4)

(c) The diagram below shows three coplanar forces acting on a particle.

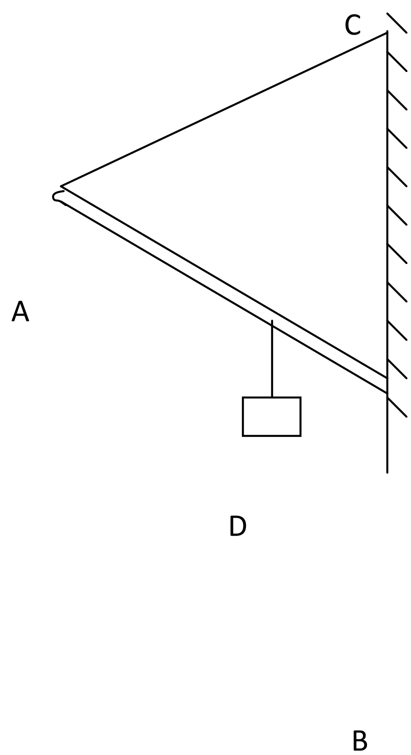


Find the magnitude, and inclination to the 12N force, of an additional force that will bring about equilibrium. (6)

(d) The figure below shows a uniform rigid plank AB of weight 100 N and length, 5 m freely hinged at end B in a vertical wall. A light rope is fixed between end A and a point C 5 m vertically above B so that AB makes an angle of 30^o with the horizontal. A box of weight 200 N is hung from point D on the plank 2 m from end B. Find

(i) the tension in the rope. (3)

(ii) the reaction at the hinge. (5)



3. (a) (i) Derive an expression for the tangential speed of a particle describing a circle of radius r at an angular velocity ω. (3)

(ii) A coin is placed on a horizontal turntable at a point 5 cm from the centre of the turntable. If the coefficient of friction between the coin and the turntable is 0.5, find the maximum frequency of the turntable for the coin to remain at the same point. (3)

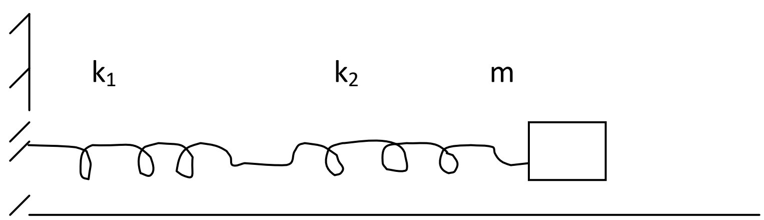
(b) (i) Define gravitational potential. (1)

(ii) Find an expression for the total energy of a satellite of mass m circling the earth of mass M in an orbit of radius R. (3)

(iii) Explain the effect of friction between such a satellite and the atmosphere in which it moves. (4)

(c) (i) Define simple harmonic motion. (1)

(ii) The figure below shows two springs of respective constants k_1 and k_2 joined in series. A mass m resting on a smooth horizontal surface is fixed to one end of the combination.



The other end of the combination is fixed so that the springs are horizontal. If m is now pulled a short distance along the surface and then released, show that it executes simple harmonic motion and find the period. (5)

4. (a) (i) What is meant by a conservative force? (1)

(ii) Show that if a body is moving in the gravitational field the mechanical energy is conserved. (4)

(b) A light helical spring gives a displacement of 4 cm for a load of 400 g. Such a spring supports a light pan. A mass of 100 g is dropped from a height of 4 cm on to the pan. Find

(i) the maximum displacement produced (4)

(ii) the speed with which the pan-mass combination returns to the initial position of the pan. (3)

(c) (i) What is meant by uniform acceleration? (1)

(ii) A particle is projected vertically upwards from the top of a tree. Sketch a displacement-time and a velocity-time graph for the motion up to the time the particle hits the ground. (2)

(d) A car, which is slowing down steadily, passes a point A with a speed of 72 km h^{-1} at the instant a motorcyclist at A is starting off in the same direction. If the motorcyclist maintains a steady acceleration of 2.5 ms^{-2} and catches up with the car at point B when the car's speed is 18 km h^{-1}, find

(i) the time taken to move from A to B (3)

(ii) the distance AB (2)

SECTION B

5 (a) (i) Define thermal conductivity (1)

(ii) Explain the mechanism of heat transfer in metals (3)

(iii) Describe an experiment to determine the thermal conductivity of a metal. (6)

(b) (i) What is a black body? (1)

(ii) Draw sketch graphs to show the variation of relative intensity of black body radiation with wavelength for different temperatures. (2)

(iii) Explain the appearance of a metal ball placed in a dark room when its temperature is progressively raised from room temperature to just below melting.

(3)

(c) A heating element in form of a cylinder 30 cm long and 1.5 cm in diameter has an output of 1.8 kW. If its radiation is 85% that of a black body, find its temperature.

(4)

6. (a) Explain why

(i) at low pressures a real gas approximates to a perfect gas. (2)

(ii) evaporation causes cooling. (2)

(b) (i) State two properties of a saturated vapour. (2)

(ii) Air is trapped between a piston and a liquid in a cylinder. The piston is slowly pulled outwards at constant temperature and this continues even after all the liquid has evaporated.

Sketch a graph of pressure against volume for the contents of the cylinder and explain its features. (3)

(iii) Describe an experiment to show that saturated vapour pressure varies with temperature. (6)

(c) Air saturated with water vapour and contained in a rigid cylinder, at $100^{o}C$ and

2.0×10^{5} Pa pressure, is cooled to $20^{o}C$. Neglecting the expansivity of the cylinder calculate the final pressure in the cylinder, if the saturated vapour pressure of water at $20^{o}C$ is 2.3×10^{3} Pa.

[Atmospheric pressure = 1.013×10^{5} Pa] (5)

7. (a) (i) Define specific latent heat of fusion. (1)

(ii) Describe an experiment to determine the specific latent heat of fusion of water (5)

(b) (i) Explain why the molar heat capacity of an ideal gas at constant pressure differs from that at constant volume. (3)

(ii) Derive an expression for the difference of the above molar heat capacities. (4)

(c) (i) State the conditions necessary for a reversible adiabatic process. (2)

(ii) A gas initially occupying a volume of 1.0 litre at a temperature of $47^{o}C$ and a pressure of 1.40×10^{5} Pa expands isothermally to a volume of 2.0 litres. It is then compressed adiabatically to its original volume. If $\gamma = 1.4$ find the final temperature and pressure. (5)

SECTION C

8. (a) (i) Distinguish between X-rays and cathode rays. (2)

(ii) In an X-ray tube explain the features adopted for the structure and materials of the anode. (4)

(b) (i) State Bragg's law. (1)

(ii) What is the condition for obtaining many orders of X-ray diffraction. (1)

(iii) A monochromatic beam of X-rays of wavelength 1.187×10^{-10} m is incident on a set of parallel atomic planes of spacing 3.00×10^{-10} m. Determine the maximum order of diffraction. (3)

(c) (i)In photo-electricity, what is meant by the work function? (1)

(ii) Describe how you could determine Planck's constant in a school laboratory. (5)

(iii) When monochromatic light of frequency 6.0×10^{14} Hz falls on a metal surface the stopping potential is 0.6 V while when the same surface is struck by light of frequency 1.0 x 10^{15} Hz the stopping potential becomes 2.2 V.

Determine the work function of the metal. (3)

9. (a) (i) Distinguish between radioactivity and nuclear fission. (2)

(ii) Why are neutrons preferred to charged particles for inducing nuclear reactions. (2)

(b) Describe how a Geiger-Muller tube works. (6)

(c) 1.2g of a substance forms a point source of γ-rays. Only 1 in 10^{12} of its atoms are radioactive and the half-life is 100 days. A Geiger-Muller tube facing the source at a distance of 10 cm gives a count rate of 11 s^{-1}. If the window of the tube has an area of 7 cm^2 find

(i) the number of radioactive atoms present (5)

(ii) the mass number of the substance (2)

(d) Determine whether the nucleus $^{210}_{84}Po$ is stable or it may undergo disintegration to produce $^{206}_{82}Pb$ and an α-particle. (3)

Mass of ^{210}Po = 209.937u

Mass of ^{206}Pb = 205.929u

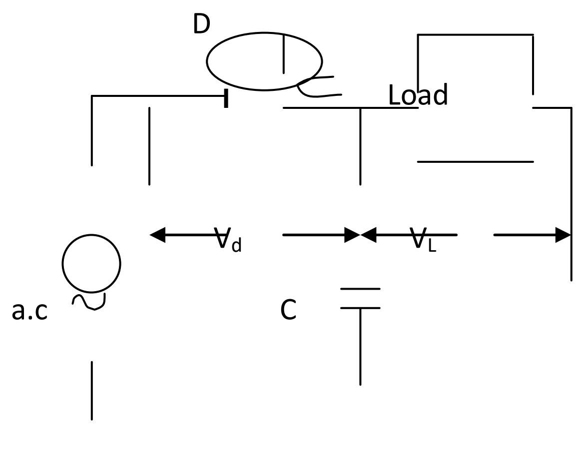
Mass of ^{4}He = 4.002u

10. (a) (i) Sketch the I-V characteristic for gaseous conduction. (2)

(ii) Explain the main feature of the curve. (3)

(b) A valve diode D was connected to rectify a.c supply to a load as shown below.

C is a capacitor.



(i) State the purpose served by the capacitor C. (1)

(ii) Explain the effect on the p.d's V_d and V_L of introducing a little mercury vapour in the vacuum of D. (3)

(c) (i) Draw a labelled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius 6×10^{-6} m was found to fall under gravity at a terminal velocity of 0.004 cm s^{-1} and to rise at 0.012 cm s^{-1} when a field of 2×10^{5} Vm^{-1} was suitably applied. Given that the viscosity of the medium was 2.122×10^{-5} Nsm^{-2} determine the number of electrons on the drop.
(5)

END

Name ……………………………………………………Personal No……….

Signature ………………………………………..

UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK ONE (1), 2016

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Electron charge, *e*	=	$1.6\ x10^{-19}$ C
Stefan's Boltzmann's constant, σ	=	$5.7x10^{-8}\ Wm^{-2}\ K^{-4}$
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	$1.5\ x10^{11}$m
Speed of light in a vacuum, *c*	=	$3.0 \times 10^{8}ms^{-1}$
Specific heat capacity of water	=	$4,200J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67\ x10^{-11}N\ m^{-2}\ kg^{-2}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of water	=	$1000\ kgm^{-3}$
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^{e}/m$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $^{1}/_{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}m$

SECTION A

1. (a) Write the equations of ***uniformly accelerated*** motion (3 marks)

(b) i) Briefly distinguish between ***conservative*** and ***non-conservative*** forces. Give two examples in each case. (4 marks)

(ii) State the ***principle of conservation*** of energy. Show that a projectile fired with a speed $u\ ms^{-1}$ at an angle θ to the horizontal obeys this principle throughout its motion. (4 marks)

(c) The engine of a 5-tonne lorry can develop 30kW, and its maximum speed on level road is $90\ kmh^{-1}$. Assuming that the friction resistance is constant, calculate the greatest speed at which the lorry can climb a hill of 1 in 25. (4 marks)

(d) (i) Define ***moment*** of a force. (1 mark)

(ii) A wheel of radius $0.84m$ is pivoted at its centre. A tangential force of $50\ N$ acts on the wheel so that the wheel rotates with uniform velocity. Find the work done by the force to turn the wheel through 20 revolutions. (4 marks)

2. (a) (i) Define the term angular velocity. (1mark)

(ii) A car of width c and whose centre of gravity is at a height h above the ground goes round a bend of radius r. Show that it will overturn if its speed exceeds $\sqrt{\frac{cgr}{2h}}$. (5 marks)

(iii) A bucket of water is swung at constant tangential speed in a vertical circle of radius 0.5 m in such a way that the bucket is upside down when it is at the top of the circle. Find the minimum speed that the bucket may have if the water is to remain in it? (3marks)

(b) State Kepler's laws of gravitation. (3 marks)

(c) (i) Define gravitational field strength. (1mark)

(ii) With aid of a sketch, qualitatively explain the variation of acceleration due to gravity with distance from the centre of the earth. (3marks)

(d) A satellite of mass m is to be launched into an orbit of radius R round the earth of radius r. Show that the minimum launching velocity is given by $v^2 = \frac{gr(2R-r)}{R}$.

(4 marks)

3 (a)(i) What is meant by the term **dimensions of a physical quantity**? (1 mark)

(b) The volume per second of a liquid ejected from a pipe of radius a under steady flow is given by the expression $\frac{V}{t} = \frac{\pi}{8} p^x \eta^y a^z$, where p is the pressure gradient with dimensions $M L^{-2} T^{-2}$ and $[\eta] = M\ L^{-1} T^{-1}$. By dimensional analysis, find the values of x, y and z. (5 marks)

(c) (i) Define the terms ***range*** and ***time of flight*** as applied to projectile motion. (2marks)

(ii) A shell is fired from a gun with a velocity U at an angle α to the horizontal. Show that the vertical distance y covered is given by $y = x\tan\alpha - \frac{gx^2 \sec^2\alpha}{2U^2}$.

(4 marks)

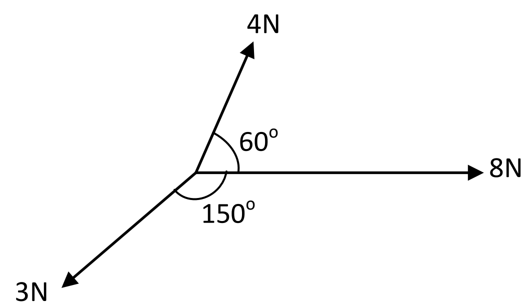
(d) A shell is fired with a velocity of 100 ms^{-1} at an angle of 60^0 to the horizontal from a gun placed at the top of a hill of vertical height 800 m above the ground. Find the:

(i) time taken by the shell to hit the enemy on the ground assuming the shell is on target. (4 marks)

(ii) velocity with which the shell hits the target. (4 marks)

4. (a)(i) Distinguish between **scalar** and **vector** physical quantities. Give **two** examples of each. (4marks)

(ii) The diagram below shows three coplanar forces acting on a particle.

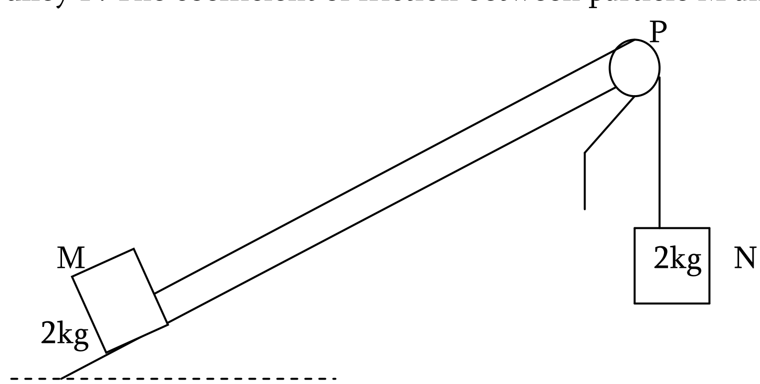


Find the magnitude, and inclination to the 8N force, of the resultant force. (5marks)

(b) State the laws of friction. (3marks)

(c) With aid of a labeled diagram, describe an experiment to determine the coefficient of static friction. (4marks)

(d) The figure below shows two particles M and N each of mass 2 kg. M is held at A on an inclined plane and is connected to N by a light inelastic string that passes over a smooth pulley P. The coefficient of friction between particle M and the plane is 0.5.



Find the acceleration of the masses and the tension in the string when M is released from rest. (4marks)

SECTION B

5. (a) (i)What is meant by a ***thermometric property*** and ***triple point of water***? (2 marks)

(ii)Describe how you would measure the temperature of a body on the thermodynamic scale using a thermocouple. (3 marks)

(iii)The resistance of a platinum wire at the triple point of water is 5.25Ω. What will be the resistance at $100\,^0C$? (2 marks)

(b) The resistance R_t of a platinum wire varies with the gas temperature $t\,^0C$ according to the equation $R_t = R_0\left(1+\alpha t+\beta t^2\right)$, where R_0 is the resistance at $0\,^0C$ and α and β are constants. For a platinum resistance wire thermometer, $\alpha = 4.13\times10^{-3}$ and $\beta = -6.4\times10^{-7}$ respectively. Calculate the reading of the platinum thermometer when the gas thermometer reads $1000\,^0C$. (5 marks)

(c) Define the term **specific latent heat of vapourisation**. (1 mark)

(d) An electrical heater rated at 500 W is immersed in a liquid of mass 2.0 kg contained in a large thermos flask of heat capacity 840 J kg^{-1}at 28^0C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid is $2.5\times10^3\ J\,kg^{-1}\,K^{-1}$, its specific latent heat of vapourization is $8.54\times10^3\ J\,kg^{-1}$ and its boiling point is $78\,^0C$, estimate the amount of liquid which boils off.

State any assumptions made in your calculation. (7 marks)

6(a) (i) State **Boyle's law**. (1 mark)

(ii)The pressure P of an ideal gas of density ρ and mean square speed $\overline{c^2}$ is given by $P = \frac{1}{3}\rho\,\overline{c^2}$. Use this expression to derive Boyle's law. (3 marks)

(b) Air contains approximately of 20% oxygen and 80% nitrogen. The relative molecular masses of oxygen and nitrogen are 32 and 28 respectively. Calculate the ratio of the:

(i) mean-square speed of oxygen to that of nitrogen. (3 marks)

(ii) partial pressure of oxygen to that of nitrogen in air. (4 marks)

(c) A fixed mass of a gas is contained in a cylinder of volume V_1 and pressure P_1. The gas is allowed to expand to a volume V_2 and pressure P_2. Assuming that the temperature remained constant, show that the work done by the gas is given by $W = -P_1V_1 \ln\frac{P_2}{P_1}$. (3 marks)

(d) A litre of hydrogen gas at a temperature of 27^0C and a pressure 10^5 Nm^{-2} expands isothermally until its volume is doubled and is then adiabatically expanded until the new volume is again doubled. Given that $C_p = 29.2\ J\,mol^{-1}K^{-1}$,

(i) Show the above processes on a P-V diagram, (2 marks)

(ii) Calculate the final pressure of the gas. (4 marks)

7(a) (i) Define **thermal conductivity** of a material (1 mark)

(ii) Briefly account for the fact that metals are better conductors of heat than insulators. (3 marks)

(b) A wall of a building consists of two brick layers each of thickness 10.0 cm and between which there is a layer of air 2.0 cm thick. Find the rate of heat flow through one m^2 of the wall if the inner and outer temperatures of the building are 25^0C and 15^0C respectively. (6 marks)

(c) Describe with the aid of a labeled diagram, how the temperature of a furnace may be measured. (5 marks)

(d) The total power output of the sun is $4.0\times10^{26}\,W$. Given that the mass of the sun is $1.97\times10^{30}\ kg$ and its density is $1.4\times10^{3}\ kg\,m^{-3}$, estimate the temperature of the sun. State any approximations made. (5 marks)

SECTION C

8(a) (i) Sketch the I-V characteristic for gaseous conduction. (2 marks)

(ii) Explain the main features of the characteristic. (3 marks)

(b) (i) What is meant by thermionic emission? (1 mark)

(ii) Describe an experiment to show that cathode rays convey negative charge.

(4 marks)

(c) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates.

Show that the path of the beam between the plates is a parabola. (4 marks)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius 6×10^{-6} m was found to fall under gravity at a terminal velocity of 0.004 cm s^{-1} and to rise at 0.012 cm s^{-1} when a field of 2×10^{5} Vm^{-1} was suitably applied. Given that the viscosity of the medium was 2.122×10^{-5} Nsm^{-2} determine the number of electrons on the drop. (5 marks)

9(a) (i) Distinguish between X-rays and cathode rays. (2 marks)

(ii) In an X-ray tube explain the features adopted for the structure and materials of the anode. (4 marks)

(b) (i) State Bragg's law. (1 marks)

(ii) What is the condition for obtaining many orders of X-ray diffraction. (1 marks)

(iii) A monochromatic beam of X-rays of wavelength 1.187×10^{-10} m is incident on a set of parallel atomic planes of spacing 3.00×10^{-10} m. Determine the maximum order of diffraction. (3 marks)

(c) (i) In photo-electricity, what is meant by the work function? (1 mark)

(ii) Describe how you could determine Planck's constant in a school laboratory.

(5marks)

(iii) When monochromatic light of frequency 6.0×10^{14} Hz falls on a metal surface the stopping potential is 0.6 V while when the same surface is struck by light of frequency 1.0×10^{15} Hz the stopping potential becomes 2.2 V.

Determine the work function of the metal. (3 marks)

10(a) (i) Distinguish between **radioactivity** and **nuclear fission**. (2 marks)

(ii) Define **binding energy** of a nucleus (1 mark)

(b) (i) What is half life of a radioactive substance? (1 mark)

(ii) Derive the relationship between half life and the decay constant of a radioactive substance. (3 marks)

(c) With the aid of a diagram describe how a Geiger-Muller tube detects ionizing particles. (6 marks)

(d) At a certain time, an α-detector registered a count rate of 104 min^{-1}. Exactly 12 days later, the count rate dropped to 13 min^{-1}. Find the decay constant. (4 marks)

(e) Explain how each of the following would affect the rate of decay in (d)

(i) temperature rise (1 mark)

(ii) mass of the radioactive substance (1 mark)

(iii) exposed surface area of the radioactive substance (1mark)

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UGANDA ADVANCED CERTIFICATE OF EDUCATION

BEGINNING OF TERM 3, 2014

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt five questions, including at least one, but not more than two from each of the sections A, B, and C.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Electron charge, e	=	1.6×10^{-19} C
Stefan's Boltzmann's constant, σ	=	$5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$
Specific heat capacity of copper	=	$400\ J\ kg^{-1}\ K^{-1}$
Specific latent heat of fusion of ice	=	$3.36 \times 10^{5}\ J\ kg^{-1}$
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, c	=	$3.0 \times 10^{8} ms^{-1}$
Specific heat capacity of water	=	$4{,}200 J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} N\ m^{2}\ kg^{-2}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of water	=	$1000\ kgm^{-3}$
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^{e}/_{m}$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $^{1}/_{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}m$
Permittivity of free space, ε_o	=	$8.85 \times 10^{-12}\ Fm^{-1}$
Mass of the electron	=	9.11×10^{-31} kg

SECTION A

1(a) (i) Define a **couple.** (1)

(ii) A pair of forces of magnitude **F**, act on a wheel and rotates it through an angle **θ**, show that the work done by the forces is equal to the product of torque and the angle of rotation? (3)

(b)

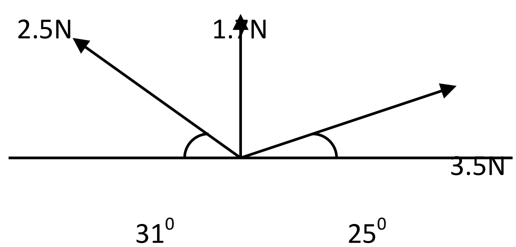

Fig. 1

The forces of **3.5N**, **2.5N** and **1.7N** act at a point as shown in figure 1. Find the resultant force. (6)

(c) A motorist traveling at a constant speed of **50 kmhr** $^{-1}$ passes a motorcyclist just starting off in the same direction. If the motor cyclist maintains a constant acceleration of **2.8 ms** $^{-2}$,

calculate;

(i) the time taken by the motor cyclist to catch up with the motorist. (4)

(ii) the speed with which the motor cyclist overtakes the motorist. (2)

(d) Explain why the tension in a cable of a lift is different when the lift is ascending from when it is descending. (4)

2(a) State **Newton's law** of motion (3)

(b) Use Newton's laws of motion to show that linear momentum is conserved when two parties collide directly. (5)

(c) Three balls A, B and C of masses $\boldsymbol{M_1}$, $\boldsymbol{M_2}$, and $\boldsymbol{M_3}$ respectively lie in a straight line on a smooth surface. The balls are initially at rest. Ball A is projected with a velocity, $\boldsymbol{V_1}$ towards B, makes an elastic collision with B. If B moves and makes a perfectly inelastic collision with C, Show that both B and C move with a velocity

$$V_3 = \frac{2\,M_1\,M_2 V_1}{(M_1 + M_2)\,(M_2 + M_3)} \qquad (5)$$

(d) A bullet of mass **10g** traveling horizontally at **100 ms** $^{-1}$ embeds itself in the centre of a block of wood of mass **900g** which is suspended by a light vertical string **1m** in length.

(i) Determine the vertical height through which the combination rises. (4)

(ii) Calculate the loss in kinetic energy of the bullet. (3)

3(a) (i) Define **pressure.** (1)

(ii) Derive the expression for the pressure at a point a depth **h** from the surface of a liquid of density **ρ.** (3)

(b) A block of mass **0.10 kg** is suspended from a spring balance. When the block is immersed in water of density **1.0×10^{3} kgm^{-3}**, the spring balance reads **0.63N**. When the block is immersed in a liquid of unknown density, the spring balance reads **0.70N.** Find;

(i) the density of the solid. (4)

(ii) the density of the liquid. (3)

(c) What is meant by the following terms as applied to fluids?

(i) terminal velocity. (1)

(ii) coefficient of viscosity. (1)

(iii) streamline flow. (1)

(d) Explain qualitatively the origin of the lift force on an aero -plane at take-off. (3)

(e) Briefly explain, using the kinetic theory of matter, the effect of temperature on viscosities of fluids. (3)

4(a) (i) Define ***simple harmonic motion.*** (1)

(ii) Give ***four*** characteristics of simple harmonic motion. (2)

(iii) Give two examples of oscillatory motion which approximates to simple harmonic motion. (1)

(b) Two springs of force constants K_1 and K_2 are suspended from a horizontal support. A mass m, hangs from the mower ends of the springs as shown in Figure 2.

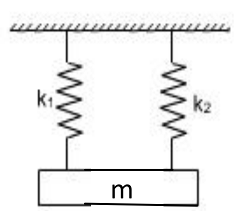

Fig. 2

If both springs have negligible mass, show that when m is displaced from its equilibrium position, it describes simple harmonic motion. Hence deduce the expression for the frequency of the oscillations. (6)

(c) The figure 3 shows two springs S_1 and S_2 in series fixed between a wall and a particle of mass 0.3 kg which is resting on a smooth horizontal plane.

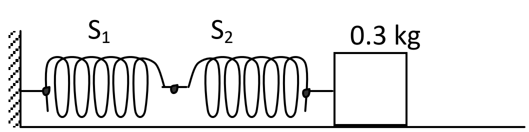

Fig. 3

The force constants of S_1 and S_2 are 20 Nm^{-1} and 30 Nm^{-1} respectively. The mass is pulled horizontally through a distance of 4 cm from its rest position and then released. Find;

(i) the maximum tension in the springs. (3)

(ii) the frequency of oscillation. (2)

(iii) the displacement of the particle from the equilibrium position 0.4 s after release. (4)

SECTION B

5(a) (i) What is a **thermometric property**? (1)

(ii) Give **two** examples of thermometric properties (1)

(iii) Describe how the platinum resistance thermometer can be used to measure absolute temperature. (6)

(b) (i) Define **specific heat capacity.** (1)

(ii) Cold water at **10^0C** and hot water at **85^0C** are run into a bath tub at a rate of

V m^3 per minute and **3×10^{-2} m^3** per minute respectively. At the point of

filling the tub, the temperature of the mixture was **35^0C**.

Calculate the time taken to fill the tank if its capacity is $1.5m^3$ (6)

(c) State **three** advantages of the continuous flow method over the method of mixtures in the determination of specific heat capacity of a liquid. (3)

(d) Explain why water is preferred for use in the cooling systems of engines to other liquids. (2)

6(a) (i) Define specific latent heat of vaporization. (1)

(ii) State the factors that determine the rate of cooling of a body. (2)

(iii) Explain why a small body cools faster than a bigger one of the same material and shape. (4)

(b) With the aid of a well labeled diagram, describe a method of determining the specific latent heat of vaporisation of water based on mixtures. (7)

(c) Two taps, one delivering water at a temperature of **25 ^{0}C** at a rate of **0.3gs $^{-1}$** and the other delivering water at a temperature of **15 ^{0}C** at a rate of **0.4gs $^{-1}$**, are directed to a well lagged copper calorimeter of mass **50g** containing ice at **0 ^{0}C** while stirring. After **5 minutes** the contents of the calorimeter are found to have attained a temperature of **5 ^{0}C.** Find the mass of ice originally in the calorimeter. (6)

7(a) (i) What is meant by an ideal gas? (1)

(ii) State three differences between a real and an ideal gas. (3)

(iii) What is meant by kinetic theory of matter? (2)

(iv) Describe briefly an experiment which one can carry out in support of the kinetic theory of matter. (4)

(b) Derive the expression $P = \frac{1}{3}\rho\, \overline{c^2}$ for the pressure of an ideal gas of density, ρ and mean-square- speed, $\overline{c^2}$. (5)

(c) An ideal gas of volume **100 cm³** at s.t.p expands adiabatically until its pressure drops to a quarter its original value. Find the new volume and temperature if the ratio of the principal specific heat capacities is 1.4. (5)

SECTION C

8(a) (i) State Rutherford's model of the atom. (2)

(ii) Explain **two** main failures of Rutherford's model of the atom. (3)

(b) (i) Explain how Millikan's experiment for measuring the charge of the electron proves that charge is quantized. (4)

(c) In the measurement of electron charge by Millikan's apparatus, a potential difference of **1.6 kV** is applied between two horizontal plates **14 mm** apart. With the potential difference switched off, an oil drop is observed to fall with constant velocity of $\mathbf{4.0\times 10^{-4}\,ms^{-1}}$. When the potential difference is switched on, the drop rises with constant velocity of $\mathbf{8.0\times 10^{-5}\,ms^{-1}}$. If the mass of the oil drop is $\mathbf{1.0\times 10^{-14}\,kg}$, find the number of electron charges on the drop.(Assume air resistance is proportional to the velocity of the oil drop and neglect the up thrust due to air)

(7)

(d) Explain qualitatively, the use of the time-base in a cathode –ray oscilloscope. (4)

9(a) (i) Distinguish between radioactivity and nuclear fission. (2)

(ii) Why are neutrons preferred to charged particles for inducing nuclear reactions.

(2)

(b) Describe how a Geiger-Muller tube works in the detection of ionizing radiation. (6)

(c) 1.2g of a substance form a point source of γ-rays. Only 1 in 10^{12} of its atoms are radioactive and the half-life is 100 days. A Geiger-Muller tube facing the source at a distance of 10 cm gives a count rate of 11 s^{-1}. If the window of the tube has an area of 7 cm^2, find;

(i) the number of radioactive atoms present. (5)

(ii) the mass number of the substance. (2)

(d) Determine whether the nucleus $^{210}_{84}Po$ is stable or it may undergo disintegration to produce ${}^{206}_{82}Pb$ and an α-particle. (3)

Mass of ^{210}Po = 209.937u

Mass of ^{206}Pb = 205.929u

Mass of ^{4}He = 4.002u

10(a) (i) What are Positive rays? (1)

(ii) State four properties of Positive rays. (2)

(b) With the aid of a diagram, describe the operation of the Bainbridge spectrometer in determining the specific charge of ions. (5)

(c) Show that when an alpha particle of mass, m, and initial velocity, V, collides head-on with an atom of atomic number, Z, the closest distance of approach to the nucleus is

$$a_0 = \frac{Z e^2}{\pi \varepsilon_0 m V^2}$$

Where, e is the electronic charge and ε_o is the permittivity of free space. (4)

(d) (i) Derive Bragg's law of X-ray diffraction. (4)

(ii) Calculate the atomic spacing of sodium chloride if the relative atomic mass of sodium is 23.0 and that of chlorine is 35.5. [Density of sodium chloride is 2180 kgm^{-3}] (4)

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UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK ONE (1), 2014

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Electron charge, e	=	$1.6\ x10^{-19}$ C
Stefan's Boltzmann's constant, σ	=	$5.7x10^{-8}\ Wm^{-2}\ K^{-4}$
Radius of the earth	=	$6.4\ x\ 10^{6}m$

Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, *c*	=	3.0×10^{8}ms^{-1}
Specific heat capacity of water	=	4,200J kg^{-1} K^{-1}
Universal gravitational constant, G	=	6.67×10^{-11}N m^{-2} kg^{-2}
Avogadro's number N_A	=	6.02×10^{23} mol^{-1}
Density of water	=	1000 kgm^{-3}
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^{e}/m$	=	1.8×10^{11} C kg^{-1}
The constant $^{1}/_{4\pi\varepsilon_o}$	=	9.0×10^{9} F^{-1}m

SECTION A

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

(ii) Explain what is meant by the angle of friction. (2)

(b) Describe an experiment you would perform to determine the coefficient of static friction between a sphere and a given plane surface. (4)

(c) Figure 1 shows a body in form of a uniform cube of weight 200 N resting with one of its edges B on a horizontal floor and edge A against a vertical wall.

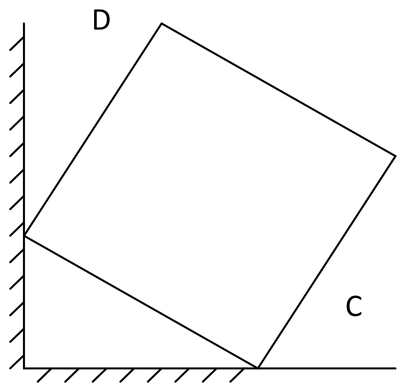


Fig. 1

When a boy of weight 100 N sits on edge D, the cube rests in limiting equilibrium with face AB making an angle of 30^0 with the horizontal. Given that the coefficient of static friction is the same at every point of contact find

(i) the coefficient of static friction. (7)

(ii) the reactions at the wall and the floor. (4)

2. (a) (i) Define ***coefficient of viscosity*** of a liquid. (1)

(ii) A ball of density σ and radius r is released to fall through a liquid of density ρ and viscosity, η. Derive an expression for its terminal velocity during its motion. (3)

(iii) Describe a simple experiment to demonstrate stream line and turbulent flow in a liquid. (4)

(b) (i) State Bernoulli's principle. (2)

(ii) Explain one application of Bernoulli's principle. (3)

(c) (i) Given that the surface tension of a soap solution is 2.7×10^{-2} Nm^{-1}, calculate the work done in forming 10 soap bubbles each of diameter 1.6 cm. (3)

(ii) Two soap bubbles, one of radius x and the other of larger radius y, get attached to each other. Find an expression for the radius of the common interface in terms of x and y. (4)

3. (a) (i) State Newton's law of gravitation. (1)

(ii) Deduce the dimensions of the Universal gravitational constant. (2)

(b) Assume that a planet moves with uniform speed in a circular orbit of radius r about the sun. The periodic time of the planet is T. Show that the quantity (r^3/T^2) is independent of the mass of the planet. (4)

(c) An artificial satellite is launched in a circular orbit round the equator at a height of 3.60×10^7 m above the surface of the Earth.

(i) Determine, from first principles, the speed with which the satellite must be launched to maintain it in the orbit. (5)

(ii) Determine the periodic time of the satellite. (3)

(iii) What deduction can be made from the result obtained in (ii) above with reference to the satellite? (2)

(iv) If another satellite moves in a circular orbit concentric with that of the above satellite, at a height of 1.48×10^7 m above the surface of the Earth, what is the periodic time of this second satellite? (3)

4. (a) Write the equations of uniformly accelerated motion. (3)

(b) A reckless driver traveling at 40 ms^{-1} and accelerating at 0.2 ms^{-2} overtakes a police car at the instant when the police car starts up in pursuit. If the police car maintains a uniform acceleration of $1ms^{-2}$, calculate;

(i) how long the police car takes to catch up with the car. (3)

(ii) the distance the police car travels before catching up with the car. (2)

(c) (i) Briefly distinguish between conservative and non-conservative forces. Give an example of each. (4)

(ii) State the principle of conservation of energy. Show that a projectile fired upwards obeys this principle throughout its downward motion. (4)

(d) The engine of a 5-tonne lorry can develop 30kW, and its maximum speed on level road is 90 kmh^{-1}. Assuming that the friction resistance is constant, calculate the greatest speed at which the lorry can climb a hill of 1 in 25

(4)

SECTION B

5. (a) With the aid of a diagram, describe how you would detect infra-red radiation in a beam of sunlight. (4)

(b) (i) Sketch curves to show how energy is distributed among the various wavelengths of black body radiation for three different temperatures.

(3)

(ii) Explain why cavities in a fire look brighter than the rest of the fire. (2)

(iii) The intensity of radiant energy from a black body is a maximum at a wavelength of 1.5×10^{-6} m. Calculate the temperature of the black body.

(2)

(c) (i) State Stefan's law of black body radiation. (1)

(ii) A strip of platinum foil coated black, is placed on the ground. The area of the strip exposed to the radiation from the sun is 10^{-2} m^2. The radiation from the sun falls normally on the strip to obtain a certain temperature rise. The strip is then shielded from the radiation and a current 1.4 A is maintained through the foil at a potential difference of 4.0 V to obtain the same temperature rise. If only 40% of the intensity of radiation incident on the earth's atmosphere reaches the earth's surface, estimate the surface temperature of the sun. (6)

(iii) If the foil in (ii) were not painted black but was 80% black, what p.d would have to be applied across it to maintain a constant temperature? (2)

6. (a) (i) Define the specific latent heat of vaporisation of a substance. (1)

(ii) Describe an experiment to determine the specific latent heat of vaporisation of water by the electrical method. (5)

(b) (i) Explain why the molar heat capacity of an ideal gas at constant pressure differs from that at constant volume. (3)

(ii) Derive an expression for the difference of the above molar heat capacities. (4)

(c) (i) State the conditions necessary for a reversible adiabatic process. (2)

(ii) A gas initially occupying a volume of 1.0 litre at a temperature of $47^{o}C$ and a pressure of 1.40×10^{5} Pa expands isothermally to a volume of 2.0 litres. It is then compressed adiabatically to its original volume. If $\gamma = 1.4$, find the final temperature and pressure. (5)

7. (a) What assumptions are necessary in the derivation of the Kinetic theory expression for the pressure of an Ideal gas ? (4)

(b) A beam of 2×10^{22} Nitrogen atoms, each of mass 2.32×10^{-26} kg is incident normally on a wall of a cubical container of edge 5.0cm. The beam is reflected through 180^o. If the mean speed of the atoms is $500ms^{-1}$, find the pressure exerted by the Nitrogen gas. (4)

(c) (i) State Dalton's law of partial pressures. (1)

(ii)Two containers A and B of volume 3×10^3 cm^3 and 6×10^3 cm^3 respectively contain helium gas at a pressure of 1.0×10^3 Pa and temperature 300K. Container A is heated to 373K while container B is cooled to 273K. Find the final pressure of the helium gas. (5)

(d) Use the kinetic theory of gases to explain the effect on a saturated vapour pressure of;

(i) raising the temperature at constant volume. (3)

(ii) increasing the volume at constant temperature. (3)

SECTION C

8. (a) Draw a set-up of the apparatus used in the famous Millikan's oil drop experiment and answer the following questions: (2)

(i) Why should a constant temperature bath be necessary? (2)

(ii) State the important measurements that must be carried out in the experiment. (2)

(b) The diagram shows an ultraviolet lamp L placed near a clean but insulated zinc plate P in a dark room. With L switched off, the plate is negatively charged and connected to the cap of an electroscope as shown.

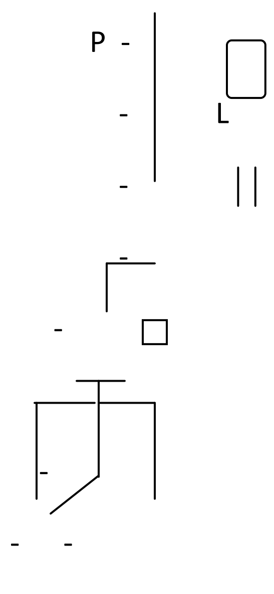


Fig. 2

Explain what is observed when;

(i) the lamp L is switched on. (3)

(ii) the brightness of the lamp is increased. (2)

(c) An X-ray tube works on a d.c potential of 50 kV. Only 0.4% of the energy of the cathode rays is converted into X-radiation and heat is generated in the target at a rate of 600 W. Estimate;

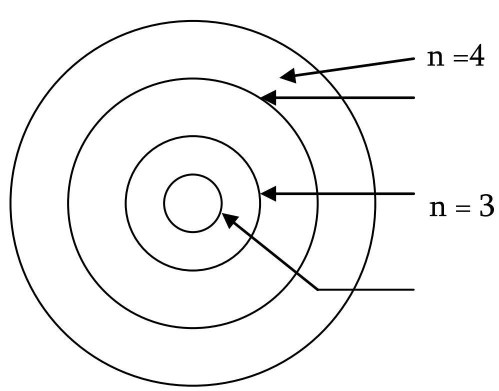
(i) the number of electrons striking the target per second. (3)

(ii) the velocity at which the electrons strike the target. (2)

9. (a) Explain the origin of the **continuous** and **characteristic line** spectra in an X-ray tube. (5)

(b) A monochromatic beam of X-radiation is incident on a set of parallel atomic planes of sodium chloride (NaCl) crystal. A first order diffraction maximum is observed at a glancing angle of 5.4°. When the same X- radiation is incident on a similar set of atomic planes of a potassium chloride (KCl) crystal the second order diffraction maximum is observed at a glancing angle of 10.2°. Compare the spacing between the respective atomic planes for the two crystals. (3)

(c) The diagram below depicts possible electron orbits in the Bohr model for hydrogen. Assume the orbits are circular



n = 2

n = 1

Fig. 3

(i) Show that the total energy of an electron in an orbit of radius r is given by

$$E = \frac{-e^2}{8\pi\varepsilon r}$$ (4)

(ii) If only the orbits allowed for are those whereby

$$mvr = \frac{nh}{2\pi},$$

where m is the electronic mass, v the electron speed, n an integer and h Planck's constant, show that the total energy in (i) above can be expressed as

$$E_n = \frac{-me^4}{8\varepsilon_o^2h^2n^2}$$ (3)

(iii) Calculate the wavelength of the radiation that will be emitted when the electron makes a transition from n = 4 to n = 2 orbits. (5)

10. (a) (i) What is meant by the term '*binding energy of a nucleus*'? (1)

(ii) Calculate the binding energy per nucleon of an α -particle, expressing your result in **MeV**.

Mass of proton = 1.0080u

Mass of a neutron = 1.0087u

Mass of an α - particle = 4.0026u

1u = 931 MeV. (4)

(iii) Sketch a graph of binding energy per nucleon against mass number and use it to explain liberation of energy by nuclear fusion and nuclear fission.

(5)

(b) Derive an expression relating the half life of a radioactive material, $T_{1/2}$ and the decay constant, λ. (3)

(c) When $^{238}_{92}U$ decays, the end product is $^{206}_{82}Pb$. The half life is 1.4 x 10^{17} s.

Suppose a rock sample contains $^{206}_{82}Pb$ and $^{238}_{92}U$ in the ratio 1: 5 by weight. Calculate the:

(i) number of $^{206}_{82}Pb$ atoms in 5.0 g of the rock sample. (3)

(ii) age of the rock. (4)

END

Name ……………………………………………….Center/Index no………………
Signature ……………………………………….. **House** ………………………….

UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK TWO (2), 2014

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt five questions, including at least one, but not more than two from each of the sections A, B, and C.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Electron charge, *e*	=	1.6×10^{-19} C
Stefan's Boltzmann's constant, σ	=	$5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, *c*	=	$3.0 \times 10^{8} ms^{-1}$
Specific heat capacity of water	=	$4{,}200 J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} N\ m^{2}\ kg^{-2}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of water	=	$1000\ kgm^{-3}$
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^{e}/_{m}$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $^{1}/_{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}m$
Permittivity of free space, ε_o	=	$8.85 \times 10^{-12}\ Fm^{-1}$
Mass of the electron	=	9.11×10^{-31} kg

SECTION A

1(a) What is meant by the following terms as applied to materials?

(i) tensile stress (1)

(ii) tensile strain (1)

(iii) elastic limit (1)

(b) Explain the occurrence of work hardening in an otherwise ductile material. (3)

(c) Describe an experiment to determine Young's modulus for a steel wire. (5)

(d) A rod of cross section area **A** and Young's modulus **E** is fixed in rigid supports at its ends. Given that the linear expansivity of the rod is α derive an expression for the force set up in it if the temperature changes by $\delta\theta$. (3)

(e) A metal wire of diameter 2.0×10^{-4} m and length 2 m has its ends fixed at points A and B 1.6 m apart, AB being horizontal. What force should be applied at the mid-point of the wire to pull the point of application to a point 0.65 m below AB? [Young's modulus = 2×10^{11} Nm^{-2}] (6)

2 (a) (i) What are the distinguishing characteristics between *uniform circular motion* and *simple harmonic motion*? (3)

(ii) Derive an expression for the acceleration of a particle describing a circle of radius r with a uniform speed, v. (5)

(b) A particle of mass m is hung on a string of length, l. It is then projected with a horizontal velocity, V.

(i) Show that when the string makes an angle θ with the vertical, during the subsequent motion, the tension in the string is

$$m\{V^2/l - g(2 - 3\cos\theta)\}$$ (4)

(ii) Hence show that if the particle is to describe a complete circle, then

$$V^2 > 5gl$$ (3)

(c) The displacement x of a particle is given by $x = a \sin\omega t$

(i) Derive an expression for its velocity in terms of its displacement, x, the angular velocity, ω, and the amplitude, a. (3)

(ii) Show that the total energy of the particle is constant. (2)

3(a) (i) What is meant by *acceleration due to gravity*? (1)

(ii) Sketch the displacement-time graph for a body thrown vertically up in air. (1)

(iii) What is meant by a trajectory? (1)

(iv) Show, from first principles, that the path followed by a particle projected in air at angle, α, to the horizontal is parabolic. (3)

(b) A projectile is fired horizontally from the top of a cliff, 200 m high. The projectile lands 1000 m from the bottom of the cliff.
Find the:

(i) Initial speed of the projectile. (4)

(ii) Velocity of the projectile just before it hits the ground. (5)

(c) Describe an experiment to determine the acceleration due to gravity using a helical spring of unknown force constant. (5)

4(a) (i) Account for the existence of intermolecular forces. (2)

(ii)Sketch a graph of potential energy against separation of two molecules in a substance and explain the main features of the graph. (4)

(b) (i) Define surface tension. (1)

(ii)Show that the excess pressure, p, in an air bubble inside a liquid over outside pressure is given by

$$p = 2\gamma$$

$$\overline{}$$
$$r$$

where r is the radius of the bubble and γ its surface tension. (3)

(c) (i) State Archimedes principle. (1)

(ii) Show that the Up thrust on a body immersed in a fluid is equal to the weight of the fluid displaced. (4)

(d) A solid weighs 237.5g in air and 12.5g when totally immersed in a liquid of relative density 0.9. Calculate;

(i) the relative density of the solid (2)

(ii) the relative density of a liquid in which the solid would float with one- fifth of its volume exposed above the liquid surface. (3)

SECTION B

5(a) Define *thermo- conductivity* of a material. (1)

(b) (i) Explain, using the molecular theory of matter the mechanism of heat conduction in insulators. (3)

(ii) Briefly account for the fact that metals are better conductors of heat than insulators. (3)

(c) A wall of a building consists of two brick layers each of thickness 10.0 cm and between which there is a layer of air 2.0 cm thick.

Find the rate of heat flow through 1 m^2 of the wall if the inner and outer temperatures of the building are 25^0C and 15^0C respectively.

[Thermal conductivities of brick and air are respectively, 0.7 $Wm^{-1}K^{-1}$ and

0.024 $Wm^{-1}K^{-1}$] (6)

(d) (i) What is meant by a *black body*? (1)

(ii) The average distance of Pluto from the sun is 40 times that of the earth from the sun. If the sun radiates as a black body at 6000K, and is 1.5×10^{11} m from the earth, calculate the surface temperature of Pluto. (6)

6(a) (i) What is meant by cooling correction? (1)

(ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of poor conductor of heat by the method of mixtures.
(5)

(b) (i) Define the term specific heat capacity of a substance. (1)

(ii)An electrical heater rated 500W is immersed in a liquid of mass 2.0 kg contained in a large thermos flask of heat capacity 840J K^{-1} at 28^0C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid is 2.5 x10^3J kg^{-1} K^{-1}, its specific latent heat of vaporization is 8.54 x 10^3J kg^{-1} and its boiling point is 78^0C, estimate the amount of liquid which boils off stating any assumptions made. (7)

(c) (i) With reference to an electrical thermometer, describe the steps involved in setting up a Kelvin scale of temperature. (3)

(ii)The resistance of the element of a platinum resistance thermometer is 4.00Ω at the ice point and 5.46Ω at the steam point. What temperature on the platinum resistance scale would correspond to a resistance of 9.84Ω ?

(3)

7(a) Explain why

(i) at low pressures a real gas approximates to a perfect gas. (2)

(ii) evaporation causes cooling. (2)

(b) (i) State three properties of a saturated vapour. (3)

(ii) Air is trapped between a piston and a liquid in a cylinder. The piston is slowly pulled outwards at constant temperature and this continues even after all the liquid has evaporated. Sketch a graph of pressure against volume for the contents of the cylinder and explain its features. (3)

(iii) Describe an experiment to show that saturated vapour pressure varies with temperature. (6)

(c) The saturated vapour pressure of ether at 0^0C is 185 mmHg and at 20^0C, it is 440 mmHg. The bulb of a constant-volume gas thermometer contains dry air and sufficient ether for saturation. If the observed pressure in the bulb is 1000 mmHg at 20^0C, what will it be at 0^0C? (4)

SECTION C

8(a) Define the following terms as used in photo electricity.

(i) work function. (1)

(ii) stopping potential (1)

(b) (i)Describe an experiment to determine Planck's constant in a laboratory. (5)

(ii) Write down Einstein's photo-electric equation and explain how it accounts for emission of electrons from a metal surface. (3)

(iii)Electromagnetic radiation of frequency 8.8×10^{14} Hz falls upon a surface whose work function is 2.5eV. Calculate the maximum speed of the photoelectrons released from the surface. (4)

(c)

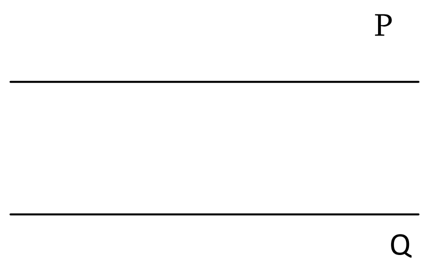


Fig.1

Figure 1, shows two parallel metal plates P and Q each of length 5.0 cm and separated by a distance of 4.0 cm. A p.d. of 12V is applied between P and Q and the space between P and Q is a vacuum. A beam of electrons of speed $u = 1.0 \times 10^{6}\ ms^{-1}$ is directed midway between P and Q. Calculate the angle at which the beam emerges from the space between P and Q to the initial direction of the beam.
(6)

9(a) (i) Distinguish between X-rays and cathode rays. (2)

(ii) Draw a well-labeled diagram of the X-ray tube and outline the principles of production of the X-rays. (6)

(b) (i) State Bragg's law of X-ray diffraction. (1)

(iii) A monochromatic beam of X-rays of wavelength 1.187×10^{-10} m is incident on a set of parallel atomic planes of spacing 3.00×10^{-10} m. Determine the maximum order of diffraction. (3)

(c) Briefly distinguish between X-ray line spectra and optical line spectra. (2)

(d) **Figure 2** below shows some of the energy levels of a mercury atom

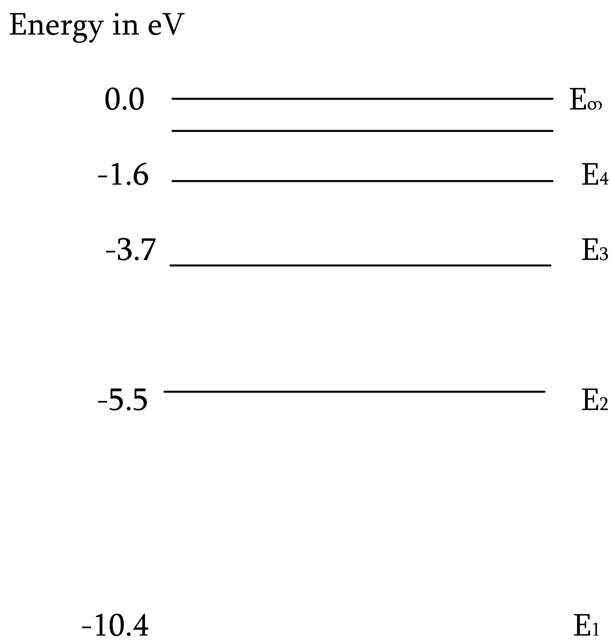


Fig. 2

Determine

(i) the minimum speed of an electron that could just ionize the mercury atom. (3)

(ii) the wavelength of the radiation emitted in an electron transition from E_3 to E_2. (3)

10(a) (i) Sketch and label the I-V characteristic for gaseous conduction. (2)

(ii) Explain the main features of the curve. (3)

(b) A valve diode D was connected to rectify a.c supply to a load as shown in figure 3. C is a capacitor.

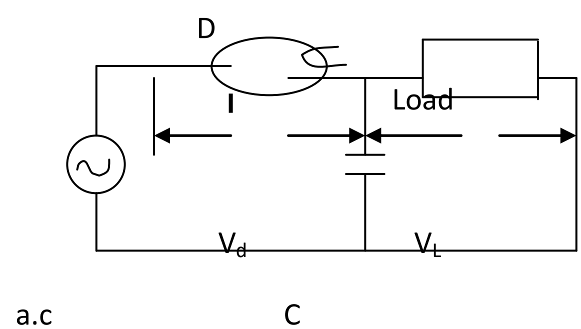


Fig. 3

(i) State the purpose served by the capacitor C. (1)

(ii) Explain the effect on the p.d's V_d and V_L of introducing a little mercury vapour in the vacuum of D. (3)

(c) A sinusoidal voltage of amplitude 0.1V is applied to the grid of triode of amplification factor 12. If the anode resistance of the triode is 15 kΩ, Find;

(i) Voltage will appear across a load of 18 kΩ (3)

(ii) The gain of the stage at this load resistance. (2)

(d) (i) Draw a labeled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

END

S.6 PHYSICS PAPER 1 – TEST 2

1 (a) (i) Define surface tension and show that it is equal to the work done per unit area in increasing the liquid surface under isothermal conditions. (3)

(ii) Find the work required to break up a drop of water of radius **0.5 cm** into drops of water each of radius **1mm**. [Surface tension of water is **2.27×10^{-2} Nm^{-1}**] (4)

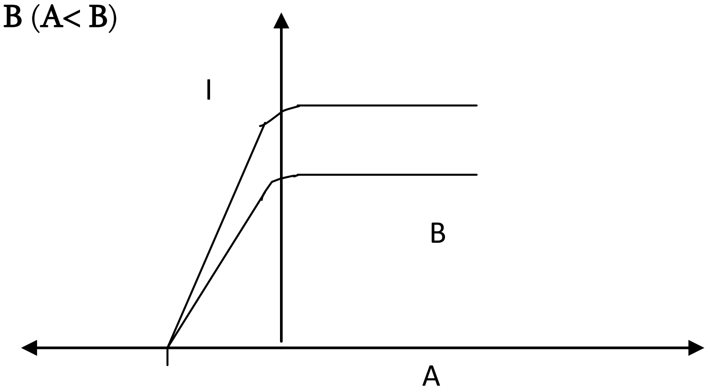
(b) Describe an experiment to measure surface tension of a liquid by the capillary tube method. (6)

(c) (i) Derive an expression for the excess pressure in a soap bubble of radius r if the soap solution has surface tension γ. (3)

(ii) The pressure inside an air bubble formed **40 cm** below the water surface is **1.063×10^5 Pa**. If the surface tension of water is **2.27×10^{-2} Nm^{-1}** find the radius of the bubble. [Atmospheric pressure = **1.013×10^5 Pa**] (4)

2. (a) State the characteristics of photoelectric emission. (4)

(b) The figure below shows graphs of current **I** against p.d **V** applied across a photoelectric cell that receives monochromatic light for two different intensities **A** and **B** (**A**< **B**)



-V V_T +V

(i) Draw a diagram to show the set-up you could use to establish these results. (3)

(ii) State what V_T represents and explain the features of the graphs. (3)

(c) Describe an experiment to determine Planck's constant in a laboratory. (5)

(d) Light of frequency **5.0 x 10^{14} Hz** liberates electrons with maximum energy **2.31 x10^{-19}** J from a certain metallic surface. What is the wavelength of ultra-violet light which liberates electrons of maximum energy **8.93 x 10^{-19}** J from the surface? (5)

END

(ii) A cylinder contains 100 litres of gaseous oxygen at a pressure of 1.217 x 10^7 Pa and temperature 20°C. Assuming oxygen behaves as an ideal gas in this region of pressure and temperature, find the volume of liquid oxygen (density 1140 kg m^{-3}) that may be made by liquefying completely the contents of the cylinder.

[Relative molecular mass of oxygen = 32] (4)

(c) In a continuous flow method for determining the specific heat capacity of a liquid the following data were obtained.

P.d/V	Current/A	Mass of liquid collected in 15 min /kg	Inflow temperature /°C	Outflow temperature /°C
6.0	2.5	0.220	25.0	35.0
7.2	3.0	0.366	25.0	35.0

(i) Draw a labelled diagram of the apparatus needed to obtain such data. (4)

(ii) Calculate the specific heat capacity of the liquid. (3)

(iii) Find the rate at which heat is lost to the surroundings. (2)

(c) Two enemy artillery guns P and Q are 4 km apart. P fires a shell at 200 ms^{-1} while Q fires one at 240 ms^{-1}, each to destroy the enemy gun. If the shells are fired simultaneously and each gun is successfully hit, find

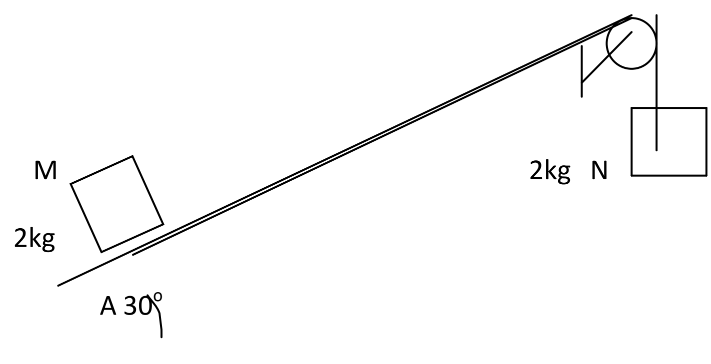
(i) the angle of projection of each shell (3)

(ii) when one is hit, the time that elapses before the other is hit (3)

(iii) the horizontal distance moved by each shell by the time one shell is vertically above the other. (4)

(b) A sphere of mass 2 kg moving with a velocity of 3 ms^{-1} impinges directly on another of mass 1 kg moving at 2 ms^{-1} in the opposite direction. If the coefficient of restitution is 0.5, determine the velocity of each sphere just after impact. (5)

(c) The figure shows two particles M and N each of mass 2 kg. M is held at A on an inclined plane and is connected to N by a light inelastic string that passes over a smooth pulley P.



The coefficient of friction between particle M and the plane is 0.5.

(i) If M is released, find the acceleration of the masses and the tension in the string (6)

(ii) If, during motion, the inclination of the plane is varied, at what inclination to the horizontal will the system begin to move with constant speed? (3)

(b) A mass of 0.1kg suspended from a spring of force constant 24.5 Nm^{-1} is pulled

vertically downwards through a distance of 5.0cm and released. Find the

(i) period of oscillation (2 marks)

(ii) position of the mass 0.3 seconds after release (4 marks)

Name ……………………………………………**Personal no**……………

Signature ………………………………….. **House** …………………………

UGANDA ADVANCED CERTIFICATE OF EDUCATION

BEGINNING OF TERM THREE, 2016

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt five questions, including at least one, but not more than two from each of the sections A, B, and C.

Assume where necessary:

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Stefan's Boltzmann's constant, σ	=	$5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$
Radius of the earth	=	6.4×10^{6}m
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Density of water	=	$1000\ kgm^{-3}$
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Charge to mass ratio, $^{e}/m$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $^{1}/_{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}m$
Permittivity of free space, ε_o	=	$8.85 \times 10^{-12}\ Fm^{-1}$
Mass of the electron	=	9.11×10^{-31} kg

SECTION A

1(a) What is meant by the following terms as applied to materials?

(i) tensile stress (1)

(ii) tensile strain (1)

(iii) elastic limit (1)

(b) Explain the occurrence of work hardening in an otherwise ductile material. (3)

(c) Describe an experiment to determine Young's modulus for a steel wire. (5)

(d) A rod of cross section area **A** and Young's modulus **E** is fixed in rigid supports at its ends. Given that the linear expansivity of the rod is α derive an expression for the force set up in it if the temperature changes by $\delta\theta$. (3)

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(b) A particle of mass m is hung on a string of length, l. It is then projected with a horizontal velocity, V.

(i) Show that when the string makes an angle θ with the vertical, during the subsequent motion, the tension in the string is

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$$p = 2\gamma$$

r

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(i) the relative density of the solid (2)

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SECTION B

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(b) (i) Explain, using the molecular theory of matter the mechanism of heat conduction in insulators. (3)

(ii) Briefly account for the fact that metals are better conductors of heat than insulators. (3)

(c) A wall of a building consists of two brick layers each of thickness 10.0 cm and between which there is a layer of air 2.0 cm thick.

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SECTION C

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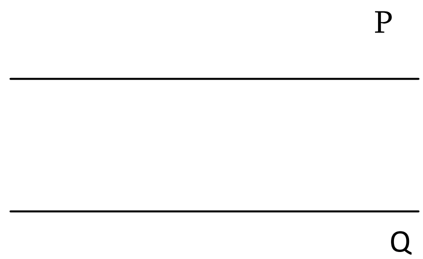


Fig.1

Figure 1, shows two parallel metal plates P and Q each of length 5.0 cm and separated by a distance of 4.0 cm. A p.d. of 12V is applied between P and Q and the space between P and Q is a vacuum. A beam of electrons of speed $u = 1.0 \times 10^{6}\ ms^{-1}$ is directed midway between P and Q. Calculate the angle at which the beam emerges from the space between P and Q to the initial direction of the beam.
(6)

9(a) (i) Distinguish between X-rays and cathode rays. (2)

(ii) Draw a well-labeled diagram of the X-ray tube and outline the principles of production of the X-rays. (6)

(b) (i) State Bragg's law of X-ray diffraction. (1)

(iii) A monochromatic beam of X-rays of wavelength 1.187×10^{-10} m is incident on a set of parallel atomic planes of spacing 3.00×10^{-10} m. Determine the maximum order of diffraction. (3)

(c) Briefly distinguish between X-ray line spectra and optical line spectra. (2)

(d) **Figure 2** below shows some of the energy levels of a mercury atom

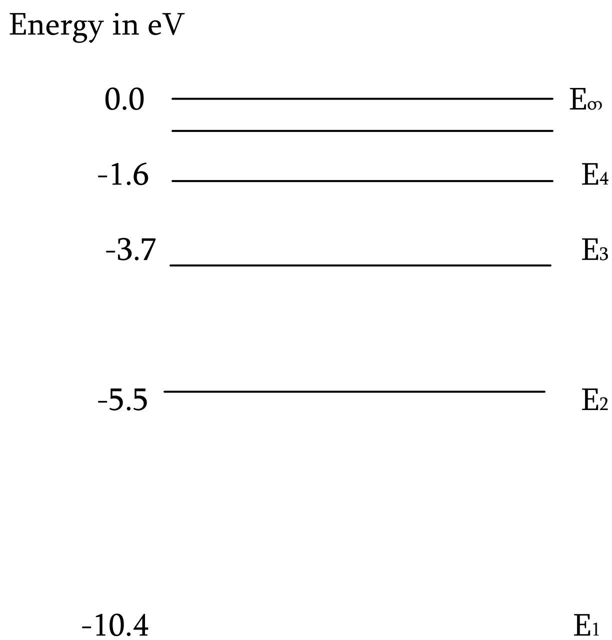


Fig. 2

Determine

(i) the minimum speed of an electron that could just ionize the mercury atom. (3)

(ii) the wavelength of the radiation emitted in an electron transition from E_3 to E_2. (3)

10(a) (i) Sketch and label the I-V characteristic for gaseous conduction. (2)

(ii) Explain the main features of the curve. (3)

(b) A valve diode D was connected to rectify a.c supply to a load as shown in figure 3. C is a capacitor.

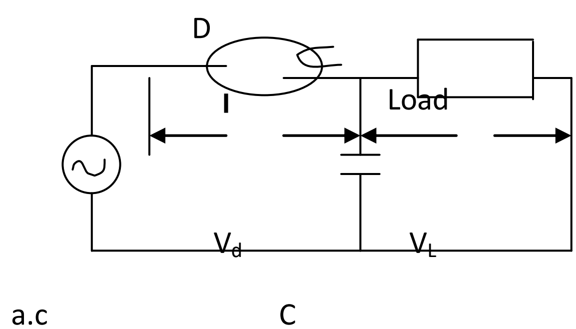


Fig. 3

(i) State the purpose served by the capacitor C. (1)

(ii) Explain the effect on the p.d's V_d and V_L of introducing a little mercury vapour in the vacuum of D. (3)

(c) A sinusoidal voltage of amplitude 0.1V is applied to the grid of triode of amplification factor 12. If the anode resistance of the triode is 15 kΩ, Find;

(i) Voltage will appear across a load of 18 kΩ (3)

(ii) The gain of the stage at this load resistance. (2)

(d) (i) Draw a labeled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

END

BEGINNING-OF-TERM TEST

May 2012

S6 PHYSICS

Paper 1

2 ½ hours

NAME ………………………………………………………… Stream……. … H'se………

Signature ………………………………………………

Answer **FIVE** questions in all, but not more than **Three** from one section.

Acceleration due to gravity, g	=	9.81 ms^{-2}
Mass of the earth	=	5.97 x 10^{24} kg
Stefan's Boltzmann's constant, σ	=	5.67x10^{-8} Wm^{-2} K^{-4}
Radius of the earth	=	6.4 x 10^6m
Radius of the sun	=	7.0 x 10^8m

Radius of Earth's orbit about the sun = 1.5×10^{11}m

Specific heat capacity of water = 4,200J kg^{-1} K^{-1}

Universal gravitational constant, G = 6.67×10^{-11}N m^{-2} kg^{-2}

Density of water = 1000 kgm^{-3}

Gas constant , R = 8.31 J $mol^{-1}K^{-1}$

Question	1	2	3	4	5	TOTAL
Marks						

SECTION A

1. (a) Define the following:

(i) Tensile stress (1)

(ii) Tensile strain (1)

(iii) Young's modulus (1)

(b) (i) Sketch the stress-strain curve for a copper wire and explain the characteristic features of the curve. (4)

(ii) How does the curve in b(i) compare with that of a material like glass? (2)

(c) Derive an expression for the energy stored in a unit volume of a stretched elastic material, expressing your answer in terms of Young's modulus and the strain of the material.
(4)

(d) A cylindrical copper rod of length 0.5 m and diameter 2 cm is fixed between two rigid supports at a temperature of 20°C. The temperature of the rod is raised to 70°C. Calculate

(i) the force exerted on the rigid supports, at this temperature. (4)

(ii) the energy stored in the rod at 70°C (3)

Young's modulus for copper = $1.2 \times 10^{11}\ Nm^{-2}$ (Mean coefficient of linear expansion of copper between 20°C and 70°C is $1.7 \times 10^{-5}\ K^{-1}$)

2. (a) Define simple harmonic motion. (1)

(b) A particle moves so that its displacement x after time t is given by

$$x = r \sin 2\pi t$$

(i) Show that the particle executes simple harmonic motion (3)

(ii) Using the same axes sketch graphs of displacement vs time, velocity vs time and acceleration vs time. (3)

(c) A uniform cylinder of height h floats vertically in water with ¾ of its height submerged. Show that if the cylinder is given a small vertical displacement and then released, it executes simple harmonic motion of period $\pi\sqrt{\left(\frac{3h}{g}\right)}$

(6)

(d) A cube of mass 100 g rests on a light scale pan that is supported on a vertical spring of constant $24.5\ Nm^{-1}$. The pan is then set to oscillate vertically.

Find the maximum amplitude for the cube to remain in contact with the pan throughout the motion. (3)

(e) (i) Distinguish between free and damped oscillations and sketch a displacement-time graph of each.. (4)

3. (a) (i) State stokes' law of viscosity (1)

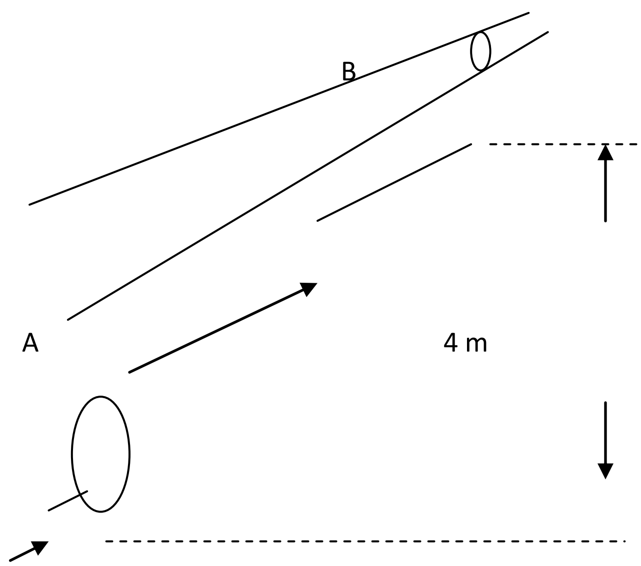
(ii) A ball of density σ and radius r is released to fall through a liquid of density ρ and viscosity η. Derive an expression for its terminal velocity during its motion. (3)

(iii) Two identical rain drops are observed to fall with a terminal velocity of 0.2 ms^{-1} If the two coalesce into one drop, what will be the new terminal velocity? (4)

(b) (i) State Bernoulli's principle (2)

(ii) Explain one application of Bernoulli's principle (3)

(c) The diagram below shows a pipe delivering water



The cross-sectional area at section A is 30 cm^2 and the velocity there is 4 ms^{-1} while the cross-sectional area at B is 15 cm^2.Find

(i) the volume of water flowing per second (2)

(ii) the static pressure at B if the atmospheric pressure is $1 \times 10^5 \text{ Nm}^{-2}$. (5)

4. (a) (i) Show that in uniform circular motion the accelerating force is towards the centre of the circle and derive an expression for the acceleration. (4)

(ii) State two differences between uniform circular motion and simple harmonic motion. (2)

(ii) Explain briefly the action of a centrifuge. (3)

(iii) A cyclist is to turn a corner of a horizontal circular track of radius r where the coefficient of friction between the tyres and the track surface if μ. For no skidding his velocity, v, must fulfill the condition that

$$v < \sqrt{\mu r g} \quad (3)$$

(b) (i) Define gravitational potential. (1)

(ii) Find an expression for the total energy of a satellite of mass m circling the earth of mass M in an orbit of radius R. (3)

(iii) Explain the effect of friction between such a satellite and the atmosphere in which it moves. (4)

SECTION B

5. (a) Describe an experiment to verify Newton's law of cooling. (5)

(b) (i) Distinguish between ***a real*** and ***an ideal*** gas. (3)

(ii) Derive the expression:

$P = \frac{1}{3}\rho\overline{c^2}$ for the pressure of an ideal gas of density ρ and mean square speed $\overline{c^2}$. (6)

(c) (i) Explain why the pressure of a fixed mass of gas in a closed container increases when temperature of the container is raised. (2)

(ii) Nitrogen gas is trapped in a container by a movable piston. If the temperature of the gas is raised from 0^oC to 50^oC at constant pressure of 4.0×10^5 Pa and the total heat added is

3.0×10^4 J, calculate the work done by the gas.

[The molar heat capacity of nitrogen at constant pressure is 29.1 J mol^{-1} K^{-1}; $C_p/C_v = 1.4$] (4)

6. (a) (i) What is meant by a ***reversible process***? (1)

(ii) Explain the conditions for a reversible adiabatic change. (3)

(iii) Explain why a gas heats up when it is compressed adiabatically (3)

(b) The temperature of one mole of oxygen gas at a pressure of 3.0×10^5 Pa falls from 80^oC to 17^oC when the gas expands adiabatically. Find the final pressure of the gas.

[Take $\gamma = 1.40$] (4)

(c) (i) Sketch a P-V curve for a real gas undergoing compression below its critical temperature.
(1)

(ii) Explain the main features of the curve. (3)

(d) When air saturated with water vapour in a rigid cylinder, at 100^oC and

2.0×10^5 Pa pressure, is cooled to 20^oC the pressure drops to 7.98×10^4 Pa. Neglecting the expansivity of the cylinder, calculate the saturated vapour pressure of water at 20^oC. [Atmospheric pressure = 1.013×10^5 Pa] (5)

7. (a) State Prevost's theory of exchange with reference to heat radiation. (1)

(b) Explain why metals are better conductors of heat compared to wood. (4)

(c) A is a composite slab made up of two layers of thickness d_1 and d_2 with thermal conductivities k_1 and k_2 respectively. B is a slab of thickness $d_1 + d_2$ with thermal conductivity k. One face of each of the slabs is maintained by heating at a temperature θ_1 and the other end at θ_2. If the rate of conduction per unit area through the two slabs is the same, find k in terms k_1, k_2, d_1 and d_2.
(6)

(d) The heat radiation received by the earth from the sun is 1.4×10^3 Wm^{-2}. Assuming this 90% of what the sun emits as a black body, estimate the temperature of the sun. (4)

(e) With the aid of a labeled diagram, describe the construction and mode of operation of the optical pyrometer. (5)

SECTION C

8. (a) (i) Sketch the I-V characteristic for gaseous conduction. (2)

(ii) Explain the main features of the characteristic. (3)

(b) (i) What is meant by thermionic emission? (1)

(ii) Describe an experiment to show that cathode rays convey negative charge. (4)

(c) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates.

Show that the path of the beam between the plates is a parabola. (4)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius 6×10^{-6} m was found to fall under gravity at a terminal velocity of 0.004 cm s^{-1} and to rise at 0.012 cm s^{-1} when a field of 2×10^{5} Vm^{-1} was suitably applied. Given that the viscosity of the medium was 2.122×10^{-5} Nsm^{-2} determine the number of electrons on the drop. (5)

END

1. (a) State Newton's laws of motion. (3)

(b) Use Newton's laws of motion to show that linear momentum is conserved when two particles collide directly. (6)

(c) Balls A, B and C of respective masses m_1, m_2 and m_3, lie in a straight line on a smooth surface. The balls are initially at rest. Ball A which is projected with a velocity V_1 towards B, makes an elastic collision with B. If B moves and makes a perfectly inelastic collision with C, show that both B and C move with a velocity

$$V_3 = \frac{2m_1 m_2 V_1}{(m_1 + m_2)(m_2 + m_3)}$$

(5)

(d) The foot of a uniform ladder of weight 200 N is on a horizontal ground, and the top rests against a smooth vertical wall. A man of weight 800 N stands on the ladder one quarter of its length from the bottom. If the inclination of the ladder to the horizontal is 30°, find:

(i) the reaction at the wall (3)

(ii) the total force at the ground. (3)

P510/1
PHYSICS Paper 1

July, 2012

UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK EXAMINATIONS, 2012

PHYSICS

PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary.

Permittivity of free space ε_o = $8.85 \times 10^{-12}\ Fm^{-1}$

Acceleration due to gravity, g = $9.81\ ms^{-2}$

Electron charge, e = 1.6×10^{-19} C

Stefan's Boltzmann's constant, σ = 5.7×10^{-8} $Wm^{-2} K^{-4}$

Radius of the earth = 6.4×10^{6}m

Radius of the sun = 7.0×10^{8}m

Radius of Earth's orbit about the sun = 1.5×10^{11}m

Speed of light in a vacuum, *c* = $3.0 \times 10^{8} ms^{-1}$

Specific heat capacity of water = 4,200J $kg^{-1} K^{-1}$

Universal gravitational constant, G = 6.67×10^{-11} $N m^{2} kg^{-2}$

Avogadro's number N_A = 6.02×10^{23} mol^{-1}

Density of water = 1000 kgm^{-3}

Gas constant , R = 8.31 J $mol^{-1}K^{-1}$

Charge to mass ratio, $^{e}/m$ = 1.8×10^{11} C kg^{-1}

The constant $\frac{1}{4\pi\varepsilon_o}$ = 9.0×10^{9} $F^{-1}m$

SECTION A

1. (a) (i) Define the coefficient of surface tension. (1)

(ii) Lycopodium powder is sprinkled over the surface of water in a dish. A small drop of soap solution is then introduced at the centre of the surface.

Explain what is observed on the surface. (3)

(b) Describe an experiment to investigate the effect of temperature on surface tension of a liquid. (6)

(c) (i) State Bernoulli's principle. (1)

(ii) Explain how Bernoulli principle is applied in a filter pump. (3)

(d) Water flows steadily along a uniform tube of cross-section **30 cm²**. The static pressure is **1.25×10^5 Pa** and the total pressure is **1.30×10^5 Pa**. Find

(i) the flow velocity (4)

(ii) the mass flow rate. (2)

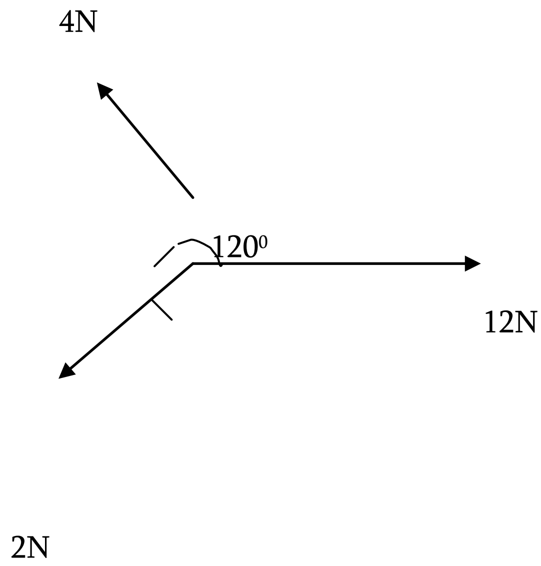
2. (a) Define the following:

(i) A couple. (1)

(ii) Torque. (1)

(b) Show that when a couple rotates a body the work done is equal to the product of the torque and the angle in radians turned through. (4)

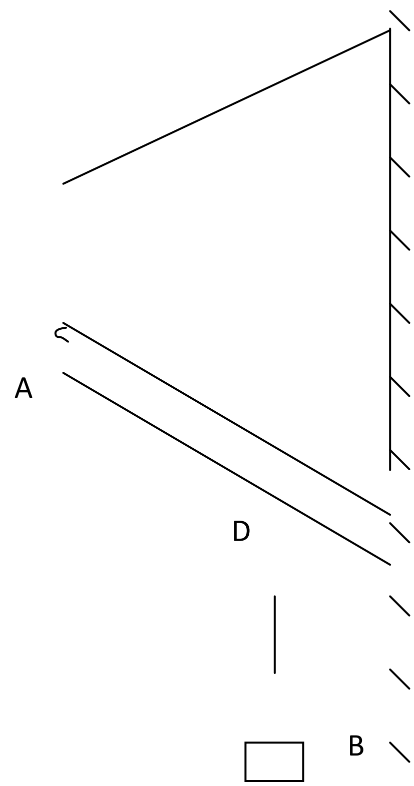
(c) The diagram below shows three coplanar forces acting on a particle.



Find the magnitude, and inclination to the **12N** force, of an additional force that will bring about equilibrium.

(6)

(d) The figure below shows a uniform rigid plank **AB** of weight **100 N** and length **5m** freely hinged at end **B** in a vertical wall. A light rope is fixed between end **A** and a point **C**, **5 m** vertically above **B**, so that **AB** makes an angle of **30°** with the horizontal.



A box of weight **200 N** is hung from point **D** on the plank **2 m** from end **B**. Find;

(i) the tension in the rope. (3)

(ii) the reaction at the hinge. (5)

3. (a) (i) Derive an expression for the tangential speed of a particle describing a circle of radius r, at an angular velocity ω. (3)

(ii) A coin is placed on a horizontal turntable at a point **5 cm** from the centre of the turntable. If the coefficient of friction between the coin and the turntable is **0.5**, find the maximum frequency of the turntable for the coin to remain at the same point. (3)

(b) (i) Define gravitational potential. (1)

(ii) Find an expression for the total energy of a satellite of mass m circling the earth of mass **M** in an orbit of radius **R**. (3)

(iii) Explain the effect of friction between such a satellite and the atmosphere in which it moves. (4)

(c) A particle executing simple harmonic motion vibrates in a straight line. Given that the speeds of the particle are **4 ms^{-1}** and **2 ms^{-1}** when the particle is **3 cm** and **6 cm** respectively from the equilibrium position, calculate the;

(i) amplitude of oscillation. (3)

(ii) frequency of the particle. (3)

4. (a) (i) What is meant by a conservative force? (1)

(ii) Show that if a body is moving in the gravitational field, the mechanical energy is conserved. 4)

(b) A particle is projected with a speed of **30 ms^{-1}** to hit a target at a height of **12 m** above the horizontal through the point of projection and at a distance of **60 m**.

Find:

(i) the angle of projection. (5)

(ii) the time taken to hit the target. (2)

(c) (i) What is meant by uniform acceleration? (1)

(ii) A particle is projected vertically upwards from the top of a tree. Sketch a *displacement-time and a velocity-time graph* for the motion up to the time the particle hits the ground. (2)

(d) A car, which is slowing down steadily, passes a point **A** with a speed of **72 km h^{-1}** at the instant a motorcyclist at **A** is starting off in the same direction. If the motorcyclist maintains a steady acceleration of **2.5 ms^{-2}** and catches up with the car at point **B** when the car's speed is **18 km h^{-1}**, find;

(i) the time taken to move from **A** to **B.** (3)

(ii) the distance **AB** (2)

SECTION B

5 (a) (i) Define thermal conductivity. (1)

(ii) Explain the mechanism of heat transfer in metals. (3)

(iii) Describe an experiment to determine the thermal conductivity of a metal. (6)

(b) (i) What is a black body? (1)

(ii) Draw sketch graphs to show the variation of relative intensity of black body radiation with wavelength for different temperatures. (2)

(iii) Explain the appearance of a metal ball placed in a dark room when its temperature is progressively raised from room temperature to just below melting.

(3)

(c) A heating element in form of a cylinder **30 cm** long and **1.5 cm** in diameter has an output of **1.8 kW**. If its radiation is **85%** that of a black body, find its temperature.

(4)

6. (a) What assumptions are necessary in the derivation of the Kinetic theory expression for the pressure of an Ideal gas ? (4)

(b) A beam of **2×10^{22}** Nitrogen atoms, each of mass 2**.32 x 10^{-26} kg** is incident normally on a wall of a cubical container of edge **5. 0cm**. The beam is reflected through **180^{0}**. If the mean speed of the atoms is **500 ms^{-1}**, find the pressure exerted by the Nitrogen gas. (4)

(c) (i) State Dalton's law of partial pressures. (1)

(ii)Two containers **A** and **B** of volume **3×10^{3} cm^3** and **6×10^{3} cm^3** respectively contain helium gas at a pressure of **1.0×10^{3} Pa** and temperature **300 K**. Container **A** is heated to **373K** while container **B** is cooled to **273 K**. Find the final pressure of the Helium gas. (5)

(d) (i) Use the kinetic theory of gases to explain the effect of increasing temperature on saturation vapour pressure. (3)

(ii)Sketch a pressure versus volume curve for a real gas undergoing compression below its critical temperature. Explain the main features of the curve. (3)

7. (a) (i) Define specific latent heat of fusion. (1)

(ii) Describe an experiment to determine the specific latent heat of fusion of water. (5)

(b) (i) Explain why the molar heat capacity of an ideal gas at constant pressure differs from that at constant volume. (3)

(ii) Derive an expression for the difference of the above molar heat capacities. (4)

(c) (i) State the conditions necessary for a reversible adiabatic process. (2)

(ii) A gas initially occupying a volume of **1.0 litre** at a temperature of **47^0C** and a pressure of **1.40×10^5 Pa** expands isothermally to a volume of **2.0 litres**. It is then compressed adiabatically to its original volume. If **$\gamma = 1.4$** find the final temperature and pressure. (5)

SECTION C

8. (a) (i) What is meant by ionization energy of an atom? (1)

(ii) Explain why ionization energy is always quoted as a negative value. (2)

(b) Below are some of the energy levels of a mercury atom

Energy in eV

$E_\infty =$ 0.0 ——————————

$E_4 = -1.6$

$E_3 = -3.7$

$E_2 = -5.5$

$E_1 = -10.4$

Determine;

(i) the *minimum speed* of an electron that could just ionize the mercury atom.(3)

(ii) the *wavelength* of the radiation emitted in an electron transition from **E_3** to **E_2**. (3)

(c) Outline the principles of generation of continuous and line spectra of X-rays in an X-ray tube. (5)

(d) A monochromatic beam of X-rays of wavelength **2.0×10^{-10} m** is incident on a set of cubic planes of a potassium chloride crystal. If the interplanar spacing is **3.1×10^{-10} m** and the molecular mass of potassium chloride is **74.5**, find

(i) the glancing angle for first order diffraction maxima to be observed. (2)

(ii) the density of the potassium chloride. (4)

9. (a) (i) Distinguish between *radioactivity and nuclear fission*. (2)

(ii) Why are neutrons preferred to charged particles for inducing nuclear reactions. (2)

(b) Describe how a *Geiger-Muller tube* works. (6)

(c) **1.2g** of a substance form a point source of γ-rays. Only **1 in 10^{12}** of its atoms are radioactive and the half-life is **100 days**. A Geiger-Muller tube facing the source at a distance of **10 cm** gives a count rate of **11 s^{-1}**. If the window of the tube has an area of **7 cm^2** find

(i) the number of radioactive atoms present. (5)

(ii) the mass number of the substance. (2)

(d) Determine whether the nucleus $^{210}_{84}\mathbf{Po}$ is stable or it may undergo disintegration to produce $^{206}_{82}\mathrm{Pb}$ and an α-particle. (3)

Mass of ^{210}Po = 209.937u

Mass of ^{206}Pb = 205.929u

Mass of ^{4}He = 4.002u

10. (a) (i) Sketch the *I-V characteristic* for gaseous conduction. (2)

(ii) Explain the main features of the curve. (3)

(b) A beam of electrons moving with a velocity **v**, enters normally a strong magnetic field, which is uniform and of induction **B**. If each electron has a mass **m** and charge **e**, assuming that the electrons suffer a deviation of 180^0 by the time they leave the magnetic field,

(i) derive an expression for the distance **d,** covered by an electron while moving in the field. (3)

(ii) write down the relationship between **d** and **B**. (1)

(c) (i) Draw a labeled diagram of a cathode ray oscilloscope (C.R.O) (3)

(ii) Describe how an alternating p.d may be measured using a C.R.O (3)

(d) In a Millikan's oil drop experiment a single negatively charged drop of radius **6×10^{-6} m** was found to fall under gravity at a terminal velocity of **0.004 cm s^{-1}** and to rise at **0.012 cm s^{-1}** when a field of **2×10^{5} Vm^{-1}** was suitably applied. Given that the viscosity of the medium was **2.122×10^{-5} Nsm^{-2}** determine the number of electrons on the drop. 5)

END

P510/1
PHYSICS

Paper 1

UGANDA ADVANCED CERTIFICATE OF EXAMINATIONS

PHYSICS

PAPER 1 (PRACTICE PAPER)

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

*Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B** and **C**.*

Non-programmable scientific electronic calculators may be used.

Assume where necessary.

Permittivity of free space ε_o	=	8.85×10^{-12} Fm^{-1}
Acceleration due to gravity, g	=	9.81 ms^{-2}
Electronic charge, *e*	=	$1..6 \times 10^{-19}$ C
Mass of the earth	=	5.97×10^{24} kg
Planck's constant, *h*	=	6.6×10^{-34} Js
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} $Wm^{-2} K^{-4}$
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{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 aluminium	=	210$Wm^{-1} K^{-1}$
Specific heat capacity of water	=	4,200J $kg^{-1} K^{-1}$
Universal gravitational constant, G	=	6.67×10^{-11}N m^{2} kg^{-2}
Avogadro's number N_A	=	$6.02 \text{ X } 10^{23}$ mol^{-1}
Density of water	=	1000 kgm^{-3}
Gas constant, R	=	8.31 J $mol^{-1}K^{-1}$
Charge to mass ratio, $^{e}/m$	=	1.8×10^{11} C kg^{-1}
The constant $\frac{1}{4\pi\varepsilon_o}$	=	9.0×10^{9} F^{-1}m

SECTION A

1. (a) Define the terms: ***elastic limit*** and ***Young modulus.*** (2)

(b) Explain the energy transformations that occur when a wire is stretched;

(i) elastically. (3)

(ii) plastically. (2)

(c) A rod of mild steel of uniform cross sectional area **0.0030 m^2** and length **1.0 m** is stretched steadily until it breaks.

(i) Sketch a graph to show the relationship between the force and the extension.

Explain the shape of the graph. (4)

(ii) When the applied force on the rod is **120 kN** the strain is **4.0×10^{-4}**.

Calculate Young modulus for steel. (3)

(iii) The rod is found to break at a stretching force of **240 kN**.

Explain why the stress at the section of the rod where the break occurs is likely to be much greater than **80000 kN m^{-2}**. (2)

(iv) Just before the rod breaks, its extension is about **4 cm**. Estimate the work done in stretching the rod by this amount. Suggest why the calculated value of the work done is likely to be less than the actual value. (4)

2. (a) State Kepler's laws of planetary motion. (3)

(b) Derive the expression for the centripetal force on mass **m** moving with uniform speed **v** in a circular path of radius **r**. (4)

(c) Explain why:

(i) the earth has atmosphere. (2)

(ii) a cyclist has to lean over towards the centre of a bend in order to turn well. (2)

(d) A satellite of mass **120 kg** moves in a circular orbit around the earth with a period of **7.7×10^{27}s**.

(i) Find its height above the earth. (5)

(ii) Calculate the mechanical energy of the satellite. (4)

3. (a) (i) Define surface tension and show that it is equal to the work done per unit area in increasing the liquid surface under isothermal conditions. (3)

(ii) Find the energy required to break up a drop of water of radius **0.5 cm** into drops of water each of radius **1 mm.** [Surface tension of water is **2.27×10^{-2} Nm^{-1}**] (4)

(b) Describe an experiment to measure surface tension of a liquid by the capillary tube method. (6)

(c) (i) Derive an expression for the excess pressure in a soap bubble of radius **r** if the soap solution has surface tension **γ**. (3)

(ii) The pressure inside an air bubble formed **40 cm** below the water surface is

1.043×10^5 Pa. If the surface tension of water is **2.27×10^{-2} Nm^{-1},** find the radius of the bubble. [Atmospheric pressure = **1.013×10^5 Pa**] (4)

4. (a) What is meant by ***simple harmonic motion***? (1)

(b) A cylindrical vessel of cross-sectional area **A** contains air of volume **V**, at pressure **P**, trapped by a frictionless piston of mass **M**. The piston is pushed down and then released.

(i) If the piston oscillates with simple harmonic motion, show that its frequency **f** is given by

$$f = \frac{A}{2\pi}\sqrt{\frac{P}{MV}} \qquad (6)$$

(ii) Show that the expression for ***f***, in b(i) is dimensionally correct. (2)

(c) A mass of **0.1kg** suspended from a spring of force constant **24.5 Nm^{-1}** is pulled vertically downwards through a distance of **5.0cm** and released. Find the

(i) period of oscillation. (2)

(ii) position of the mass **0.3 seconds** after release. (4)

(d) Sketch the following graphs for a body performing simple harmonic motion:

(i) Velocity against displacement (1)

(ii) Displacement against time. (1)

(e) With the aid of sketch graphs, distinguish between free and damped oscillations. (3)

SECTION B

5. (a) (i)Explain why the difference between the principal heat capacities of a solid is negligible. (2)

(ii) Derive an expression for the difference in molar heat capacities of a gas. (4)

(b) (i)Explain why the sound propagation in air is considered to be an adiabatic process. (2)

(ii) A fixed mass of gas at a pressure $\mathbf{P_1}$ and volume $\mathbf{V_1}$ expands isothermally to a pressure $\mathbf{P_2}$ and volume $\mathbf{V_2}$. Derive an expression for the work done by the gas. (4)

(c) A gas of volume **2 litres** at a temperature of $\mathbf{27^oC}$ and pressure of $\mathbf{1.5 \times 10^5}$ **Pa** is heated at constant pressure until its volume doubles. It is then cooled at constant volume back to its original temperature before finally being compressed isothermally to its original volume.

Draw a p-V diagram of the whole cycle and find the net work done by the gas. (5)

(d) The pressure **P** of an ideal gas of density **ρ**, is given by $\mathbf{P = \frac{1}{3} \rho \overline{c^2}}$, where $\bar{c}^2$ is the mean-square speed of its molecules. Use this expression to derive Avogadro's hypothesis. (3)

6. (a) State Prevost's theory of exchange with reference to heat radiation. (1)

(b) Explain why metals are better conductors of heat compared to wood. (3)

(c) A is a composite slab made up of two layers of thickness $\mathbf{d_1}$ and $\mathbf{d_2}$ with thermal conductivities $\mathbf{k_1}$ and $\mathbf{k_2}$ respectively. **B** is a slab of thickness $\mathbf{d_1 + d_2}$ with thermal conductivity **k**. One face of each of the slabs is maintained by heating at a temperature $\mathbf{\theta_1}$ and the other end at $\mathbf{\theta_2}$. If the rate of conduction per unit area through the two slabs is the same, find **k** in terms $\mathbf{k_1}$, $\mathbf{k_2}$, $\mathbf{d_1}$ and $\mathbf{d_2}$. (6)

(d) The heat radiation received by the earth from the sun is $\mathbf{1.4 \times 10^3\ Wm^{-2}}$. Assuming this **90%** of what the sun emits as a black body, estimate the temperature of the sun. (4)

(e)(i) With the aid of a labeled diagram, describe the construction and mode of operation of the optical pyrometer. (5)

(ii) State how the range of an optical pyrometer can be extended. (1)

7. (a) (i) The specific heat capacity of copper is $\mathbf{400J\ kg^{-1}\ K^{-1}}$. Explain the meaning of the statement. (1)

(ii) State the factors that determine the rate of cooling of a body. (2)

(iii) Explain why a small body cools faster than a bigger one of the same material and shape. (4)

(b) With the aid of a well labeled diagram, describe an electrical method of determining the specific latent heat of vaporization of water, stating the precautions taken to minimize heat losses (7)

(c) Two taps, one delivering water at a temperature of **25^oC** at a rate of **$0.3\ g\ s^{-1}$** and the other delivering water at a temperature of **15^oC** at a rate of **$0.4\ g\ s^{-1}$**, are directed to a well-lagged copper calorimeter of mass **50 g** containing ice at **0^oC** while stirring. After **5** minutes the contents of the calorimeter are found to have attained a temperature of **5^oC**. Find the mass of ice originally in the calorimeter.
Specific latent heat of fusion of ice = $3.36 \times 10^5\ Jkg^{-1}$ (6)

SECTION C

8. (a) (i) Sketch the **I-V characteristic** for gaseous conduction and explain the main features of the curve. (4)

(ii) Explain why this is not a good method for producing cathode rays. (2)

(b) (i) What is meant by **thermionic emission**? (1)

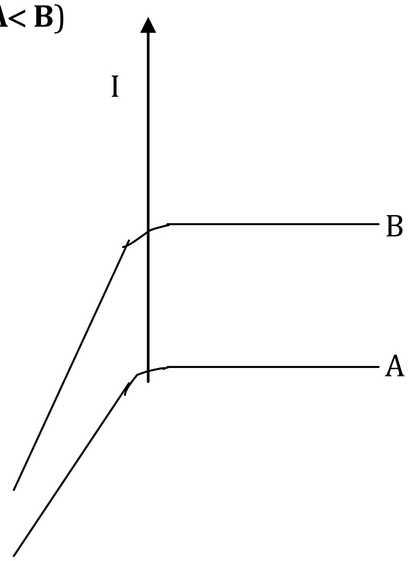
(ii) Describe an experiment to show that cathode rays travel in straight lines. (4)

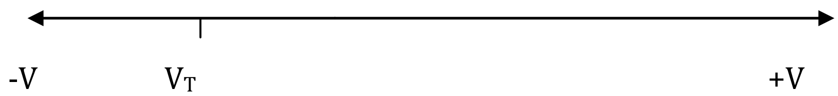
(c) A horizontal beam of electrons, moving with a uniform speed, enters a uniform electric field between two horizontal parallel charged plates. Show that the path of the beam between the plates is a parabola. (4)

(d) A charged oil drop of mass **6×10^{-15} kg** falls vertically in air with a steady velocity between two parallel vertical plates **5 mm** apart. When a p.d of **3000 V** is applied between the plates, the drop now falls with a steady velocity at an angle **58.5^o** to the vertical. Calculate the charge **Q** on the drop. (Neglect the up thrust on it) (5)

9. (a) State the characteristics of photoelectric emission. (4)

(b) The figure below shows graphs of current **I** against p.d **V** applied across a photoelectric cell that receives monochromatic light for two different intensities **A** and **B** (**A**< **B**)





(i) Draw a diagram to show the set-up you could use to establish these results. (3)

(ii) State what $\mathbf{V_T}$ represents and explain the features of the graphs. (3)

(c) Describe an experiment to determine Planck's constant in a laboratory. (5)

(d) Light of frequency **5.0×10^{14} Hz** liberates electrons with maximum energy **2.31×10^{-19} J** from a certain metallic surface. What is the wavelength of ultra-violet light which liberates electrons of maximum energy **8.93×10^{-19} J** from the surface? (5)

10. (a) (i) Distinguish between **radioactivity** and **nuclear fission**. (2)

(ii) Define **binding energy** of a nucleus (1)

(b) (i) What is half life of a radioactive substance? (1)

(ii) Derive the relationship between half life and the decay constant of a radioactive substance. (3)

(c) With the aid of a diagram describe how a Wilson type cloud chamber detects ionizing particles. (6)

(d) A nucleus of uranium **238** disintegrates with the emission of a nucleus **X** and an alpha particle.

(i) Write down the equation for the reaction. (1)

(ii) Find the velocity with which the alpha particle is released, assuming the uranium nucleus was at rest before disintegration.

Mass of ^{238}U = 238.12492 u

Mass of X = 234.11650 u

Mass of ^{4}He = 4.00387

1 u = 1.66×10^{-27} kg = 1.494×10^{-12} J (6)

END

P510/1
PHYSICS Paper 1

July, 2012

UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK TWO (2), 2012

PHYSICS

PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary:

Permittivity of free space ε_o = 8.85×10^{-12} Fm^{-1}

Acceleration due to gravity, g = 9.81 ms^{-2}

Electron charge, e = 1.6×10^{-19} C

Stefan's Boltzmann's constant, σ = 5.7×10^{-8} Wm^{-2} K^{-4}

Radius of the earth	=	6.4×10^6m
Radius of the sun	=	7.0×10^8m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m
Speed of light in a vacuum, c	=	$3.0 \times 10^8 ms^{-1}$
Specific heat capacity of water	=	4,200J $kg^{-1} K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} N\ m^{-2}\ kg^{-2}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of water	=	1000 kgm^{-3}
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^e/m$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^9\ F^{-1}m$

SECTION A

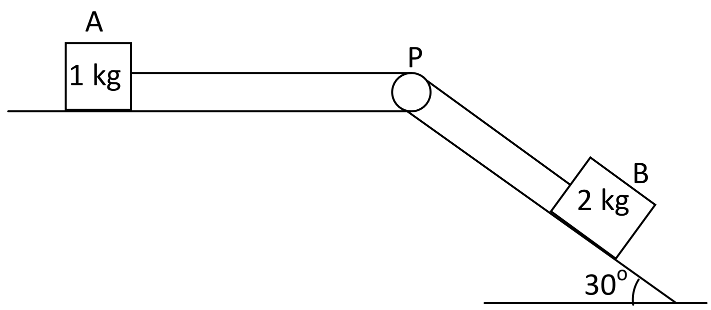
1. (a) (i) State the principle of conservation of linear momentum. (1)

(ii) Show how Newton's laws of motion may be used to arrive at the principle of conservation of momentum. (5)

(b) The engine of a 5-tonne lorry can develop 30kW, and its maximum speed on level road is 90 kmh^{-1}. Assuming that the friction resistance is constant, calculate the greatest speed at which the lorry can climb a hill of 1 in 25. (4)

(c) Explain the principle of rocket propulsion. (3)

(d) The figure below shows a block A of mass 1 kg resting on a horizontal plane. Another block B of mass 2 kg on a plane inclined at an angle of 30^o to the horizontal is connected to A by a string passing over a smooth pulley P. All the parts of the string are parallel to the respective planes.



Given that the coefficient of friction at each point of contact is 0.3, find

(i) the acceleration of the blocks. (5)

(ii) the tension in the string . (2)

2. (a) (i) Define ***coefficient of viscosity*** of a liquid . (1)

(ii) A ball of density σ and radius r is released to fall through a liquid of density ρ and viscosity η. Derive an expression for its terminal velocity during its motion. (3)

(iii) Describe a simple experiment to demonstrate stream line and turbulent flow in a liquid. (4)

(b) (ii) Given that the volume of a liquid issuing per second from a pipe depends on the co-efficient of viscosity η, the radius of the pipe a and the pressure gradient, show that

$$\text{Volume per second} = \frac{kpa^4}{\eta l} \qquad (5)$$

(c) (i) Given that the surface tension of a soap solution is $2.7 \times 10^{-2}\ Nm^{-1}$, calculate the work done in forming 10 soap bubbles each of diameter 1.6 cm. (3)

(ii) Two soap bubbles, one of radius x and the other of larger radius y, get attached to each other.

Find an expression for the radius of the common interface in terms of x and y. (4)

3. (a) (i) State Newton's law of gravitation. (1)

(ii) Deduce the dimensions of the Universal gravitational constant. (2)

(b) Assume that a planet moves with uniform speed in a circular orbit of radius r about the sun. The periodic time of the planet is T. Show that the quantity (r^3/T^2) is independent of the mass of the planet. (4)

(c) An artificial satellite is launched in a circular orbit round the equator at a height of 3.60×10^7 m above the surface of the Earth.

(i) Determine from first principles the speed with which the satellite must be launched to maintain it in the orbit. (5)

(ii) Determine the periodic time of the satellite. (3)

(iii) What deduction can be made from the result obtained in (ii) above with reference to the satellite? (2)

(iv) If another satellite moves in a circular orbit concentric with that of the above satellite, at a height of 1.48×10^7 m above the surface of the Earth, what is the periodic time of this second satellite? (3)

4. (a)(i) Account for the existence of intermolecular forces. (2)

(ii)Sketch a graph of potential energy against separation of two molecules in a substance and explain the main features of the graph. (4)

(c) A hydrometer floats in pure water with a volume V submerged. When in a liquid of density ρ, it floats with the liquid level at a distance X above the water mark. If the stem has a uniform cross sectional area φ, derive an expression for X in terms of V, ρ, and φ. (4)

(b) Derive an expression for energy stored per unit volume of a stretched elastic material, expressing your answer in terms of young's modulus and the strain of the material. (4)

(c) A cylindrical copper rod of length 0.5m and of diameter 4.0×10^{-2} m is fixed between two rigid supports at a temperature of 20.0°C. The temperature of the rod is raised to 70.0°C

(i) Calculate the force exerted on the rigid supports at this temperature (4)

(ii) What is the energy stored in the rod at 70°C? (3)

Young's modulus for copper = 1.2×10^{11} Nm^{-2}

Mean coefficient of linear expansion of copper between 20°C and 70°C = 1.7×10^{-5} K^{-1}

SECTION B

5. (a) (i) Mention the steps involved in establishing a temperature scale. (2)

(ii) State the advantages and disadvantages a thermocouple thermometer has over a platinum resistance one. (3)

(iii) Describe how the temperature of a liquid bath may be measured using a platinum resistance thermometer. (4)

(b) (i) The resistance R_θ of platinum varies with temperature θ°C as measured by a constant-volume gas thermometer according to the equation $R_\theta = R_o(1 + 8000\alpha\theta - \alpha\theta^2)$ where α is a constant. Calculate the temperature on the platinum scale corresponding to 400°C on this gas scale. (4)

(ii) Explain why the two thermometers do not agree exactly. (1)

(c) In a continuous flow experiment on a liquid of specific heat capacity 4200 $Jkg^{-1}K^{-1}$ the following results were obtained:

Ammeter reading/A	Voltmeter reading/V	Mass of liquid collected per min/g
2.00	25.2	75.0
2.52	30.0	115.9

If the inflow temperature was 15°C find

(i) the outflow temperature. (4)

(ii) the rate of heat loss. (2)

6. (a) (i) What is meant by cooling correction ? (1)

(ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of poor conductor of heat by the method of mixtures. (5)

(b) (i) Define the term specific heat capacity of a substance. (1)

(ii)An electrical heater rated 500W is immersed in a liquid of mass 2.0kg contained in a large thermos flask of heat capacity 840J K^{-1} at 28°C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid is 2.5 $x10^3 Jkg^{-1}K^{-1}$, its specific latent heat of vaporization is 8.54 x

$10^3 J\ kg^{-1}$ and its boiling point is 78^oC, estimate the amount of liquid which boils off stating any assumptions made. (7)

(c) With the aid of a diagram, describe how a total radiation pyrometer can be used to measure the temperature of a very hot body. (6)

7. (a) (i) State the conditions for an adiabatic change.
(2)

(ii) Explain why a gas cools when it undergoes an adiabatic expansion.
(2)

(iii) Show that an adiabatic is steeper than an isothermal on the same P-V diagram. (3)

(b) Describe an experiment to verify Charles's law.
(6)

(c) Derive the ***ideal gas equation***.
(4)

(d) A rigid vessel contains air initially at atmospheric pressure. It is then inflated using a pump whose barrel has an effective volume equal to a $\frac{1}{20}$th of the vessel's volume. Find the number of stroke to be performed before the pressure triples.
(3)

8. (a) Define the following terms as used in photo-electricity.

(i) **work function.** (1 mark)

(ii) **stopping potential** (1 mark)

(b) Using the quantum theory, explain the laws of photo-electric emission. (3)

(c) (i)Describe an experiment to determine Planck's constant. (5)

(ii)Electromagnetic radiation of frequency 8.8×10^{14} Hz falls upon a surface whose work function is 2.5eV. Calculate the maximum kinetic energy of photoelectrons released from the surface. (4)

(c)

Two parallel plates P and Q each of length 4.0cm and separated by a distance of 4.0cm in vacuum, have p.d. of 12V applied between them. A beam of electrons of speed $u = 1.0 \times 10^6$ ms^{-1} is directed midway between P and Q . Find the angle at which the beam emerges from the space between P and Q to the initial direction of the beam. (6)

9. (a) (i) What is meant by the term '***binding energy of a nucleus***'? (1)

(ii) Calculate the binding energy per nucleon of an α particle, expressing your result in MeV.

Mass of proton = 1.0080u

Mass of a neutron = 1.0087u

Mass of an α - particle = 4.0026u

1u = 931 MeV. (4)

(iii) Sketch a graph of binding energy per nucleon against mass number and use it to explain liberation of energy by nuclear fusion and nuclear fission.
(6)

(b) Derive an expression relating the half life of a radioactive material, $T_{½}$ and the decay constant ,λ. (6)

(c) When $^{238}_{92}U$ decays, the end product is $^{206}_{82}Pb$. The half life is 1.4 x 10^{17} s.

Suppose a rock sample contains $^{206}_{82}Pb$ and $^{238}_{92}U$ in the ratio 1: 5 by weight. Calculate the

(i) number of $^{206}_{82}Pb$ atoms in 5.0 g of the rock sample. (3)

(ii) age of the rock. (4)

10. (a) A high p.d is applied across two electrodes in air contained in a closed glass tube. Describe, with the aid of labeled diagrams, what will be observed when the pressure in the tube is progressively reduced down to very low pressures.
(5)

(b) List **four** main properties of cathode rays. (4)

(c) A charged oil drop of mass 3.27 x 10^{-15}kg is held stationary between two horizontal metal plates across which a p.d of 1000 V is applied. If the separation of the plates is 1.5 cm find the number of electrons on the drop.
(5)

(d) With the aid of a labeled diagram describe the principle of operation of an ionisation chamber. (6)

UGANDA ADVANCED CERTIFICATE OF EDUCATION

MOCK TWO (2), 2012

PHYSICS PAPER 1

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES:

Attempt **five** questions, including at least **one**, but not more than **two** from each of the sections **A, B,** and **C**.

Assume where necessary:

Permittivity of free space ε_o	=	8.85×10^{-12} Fm^{-1}
Acceleration due to gravity, g	=	9.81 ms^{-2}
Electron charge, e	=	1.6×10^{-19} C
Stefan's Boltzmann's constant, σ	=	5.7×10^{-8} $Wm^{-2} K^{-4}$
Radius of the earth	=	6.4×10^{6}m
Radius of the sun	=	7.0×10^{8}m
Radius of Earth's orbit about the sun	=	1.5×10^{11}m

Speed of light in a vacuum, c	=	$3.0 \times 10^8 ms^{-1}$
Specific heat capacity of water	=	$4,200 J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} N\ m^{-2}\ kg^{-2}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of water	=	$1000\ kgm^{-3}$
Planck's constant, h	=	6.63×10^{-34} Js
Charge to mass ratio, $^e/m$	=	$1.8 \times 10^{11}\ C\ kg^{-1}$
The constant $^1/_{4\pi\varepsilon_o}$	=	$9.0 \times 10^9\ F^{-1}m$

SECTION A

1. (a) (i) State the principle of conservation of linear momentum. (1)

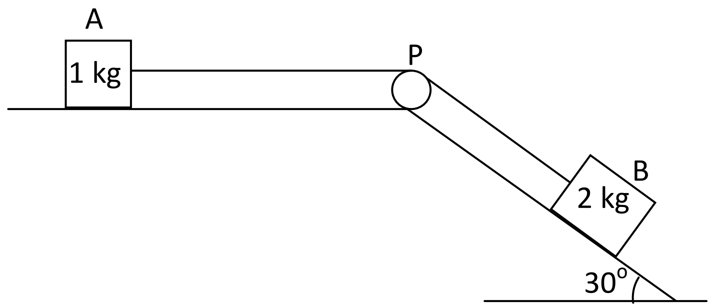
(ii) Show how Newton's laws of motion may be used to arrive at the principle of conservation of linear momentum. (5)

(b) The engine of a **5-tonne** lorry can develop **30kW**, and its maximum speed on level road is **90 kmh**$^{-1}$. Assuming that the frictional resistance is constant, calculate the greatest speed at which the lorry can climb a hill of **1** in 25.

(4)

(c) Explain the principle of rocket propulsion. (3)

(d) The figure below shows a block **A** of mass **1 kg** resting on a horizontal plane. Another block **B** of mass **2 kg** on a plane inclined at an angle of **30°** to the horizontal is connected to **A** by a string passing over a smooth pulley **P**. All the parts of the string are parallel to the respective planes.



Given that the coefficient of friction at each point of contact is 0.3, find

(i) the acceleration of the blocks. (5)

(ii) the tension in the string . (2)

2. (a) (i) Define ***coefficient of viscosity*** of a liquid. (1)

(ii) A ball of density **σ** and radius **r** is released to fall through a liquid of density **ρ** and viscosity **η**. Derive an expression for its terminal velocity during its motion. (3)

(iii) Describe a simple experiment to demonstrate stream line and turbulent flow in a liquid. (4)

(b) (ii) Given that the volume of a liquid issuing per second from a pipe depends on the co-efficient of viscosity **η**, the radius of the pipe **a**, and the pressure gradient, show that;

$$\text{Volume per second } = \frac{kpa^4}{\eta l}$$ (5)

(c) (i) Given that the surface tension of a soap solution is **2.7×10^{-2} Nm^{-1}**, calculate the work done in forming **10** soap bubbles each of diameter **1.6 cm**.

(3)

(ii) Two soap bubbles, one of radius x and the other of larger radius y, get attached to each other. Find an expression for the radius of the common interface in terms of x and y. (4)

3. (a) (i) State Newton's law of gravitation. (1)

(ii) Deduce the dimensions of the Universal gravitational constant. (2)

(b) Assume that a planet moves with uniform speed in a circular orbit of radius **r** about the sun. The periodic time of the planet is **T**. Show that the quantity **(r^3/T^2)** is independent of the mass of the planet. (4)

(c) An artificial satellite is launched in a circular orbit round the equator at a height of **3.60×10^7 m** above the surface of the Earth.

(i) Determine from first principles the speed with which the satellite must be launched to maintain it in the orbit. (5)

(ii) Determine the periodic time of the satellite. (3)

(iii) What deduction can be made from the result obtained in (ii) above with reference to the satellite? (2)

(iv) If another satellite moves in a circular orbit concentric with that of the above satellite, at a height of **1.48×10^7 m** above the surface of the Earth, what is the periodic time of this second satellite? (3)

4. (a)(i) Account for the existence of intermolecular forces. (2)

(ii)Sketch a graph of potential energy against separation of two molecules in a substance and explain the main features of the graph. (3)

(b)Describe an experiment to determine Young Modulus for a steel wire. (4)

(c) Derive an expression for energy stored per unit volume of a stretched elastic material, expressing your answer in terms of Young modulus and the strain of the material. (4)

(d) A cylindrical copper rod of length **0.5m** and of diameter **4.0×10^{-2} m** is fixed between two rigid supports at a temperature of **20.0^0C**. The temperature of the rod is raised to **70.0^0C**

(i) Calculate the force exerted on the rigid supports at this temperature. (4)

(ii) What is the energy stored in the rod at **70^0C**? (3)

Young modulus for copper = $1.2 \times 10^{11} Nm^{-2}$

Mean coefficient of linear expansion of copper between $20\,^0C$ and $70\,^0C$ = $1.7 \times 10^{-5} K^{-1}$

SECTION B

5. (a) (i) Mention the steps involved in establishing a temperature scale. (2)

(ii) State the advantages and disadvantages a thermocouple thermometer has over a platinum resistance one. (3)

(iii) Describe how the temperature of a liquid bath may be measured using a platinum resistance thermometer. (4)

(b) (i) The resistance R_θ of platinum varies with temperature **θ ^{0}C** as measured by a constant-volume gas thermometer according to the equation **$R_\theta = R_o(1 + 8000\alpha\theta - \alpha\theta^2)$** where α is a constant. Calculate the temperature on the platinum scale corresponding to **400 ^{0}C** on this gas scale.
(4)

(ii) Explain why the two thermometers do not agree exactly. (1)

(c) In a continuous flow experiment on a liquid of specific heat capacity **4200 J kg^{-1} K^{-1}** the following results were obtained:

Ammeter reading (A)	Voltmeter reading (V)	Mass of liquid collected per min (g)
2.00	25.2	75.0
2.52	30.0	115.9

If the inflow temperature was 15 ^{0}C, find;

(i) the outflow temperature. (4)

(ii) the rate of heat loss. (2)

6. (a) (i) What is meant by cooling correction ? (1)

(ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of poor conductor of heat by the method of mixtures.
(5)

(b) (i) Define the term specific heat capacity of a substance. (1)

(ii)An electrical heater rated **500W** is immersed in a liquid of mass **2.0 kg** contained in a large thermos flask of heat capacity **840 J K^{-1}** at **28 ^0C**. Electrical power is supplied to the heater for **10** minutes. If the specific heat capacity of the liquid is **2.5×10^{3} J kg^{-1} K^{-1}**, its specific latent heat of vaporization is **8.54×10^{3} J kg^{-1}** and its boiling point is **78^0C**, estimate the amount of liquid which boils off stating any assumptions made.
(7)

(c) With the aid of a diagram, describe how a total radiation pyrometer can be used to measure the temperature of a very hot body. (6)

7. (a) (i) State the conditions for an adiabatic change. (2)

(ii) Explain why a gas cools when it undergoes an adiabatic expansion. (2)

(iii) Show that an adiabatic is steeper than an isothermal on the same P-V diagram. (3)

(b) Describe an experiment to verify Charles's law. (6)

(c) Derive the ***ideal gas equation***. (4)

(d) A rigid vessel contains air initially at atmospheric pressure. It is then inflated using a pump whose barrel has an effective volume equal to a $\frac{1}{20}$th of the vessel's volume. Find the number of stroke to be performed before the pressure triples. (3)

SECTION C

8. (a) Define the following terms as used in photo-electricity.

(i) work function. (1)

(ii) stopping potential. (1)

(b) Using the quantum theory, explain the laws of photo-electric emission. (3)

(c) (i)Describe an experiment to determine Planck's constant. (5)

(ii)Electromagnetic radiation of frequency **8.8×10^{14} Hz** falls upon a surface whose work function is **2.5eV**. Calculate the maximum kinetic energy of photoelectrons released from the surface. (4)

(d)Two parallel plates P **and Q** each of length **4.0cm** and separated by a distance of **4.0cm** in vacuum, have p.d. of **12V** applied between them. A beam of electrons of speed u = **1.0×10^{6} ms^{-1}** is directed midway between **P and Q**. Find the angle at which the beam emerges from the space between **P** and **Q** to the initial direction of the beam. (6)

9. (a) (i) What is meant by the term '***binding energy of a nucleus***'? (1)

(ii) Calculate the binding energy per nucleon of an α particle, expressing your result in **MeV**.

Mass of proton = 1.0080u

Mass of a neutron = 1.0087u

Mass of an α - particle = 4.0026u

1u = 931 MeV. (4)

(iii) Sketch a graph of binding energy per nucleon against mass number and use it to explain liberation of energy by nuclear fusion and nuclear fission.

(6)

(b) Derive an expression relating the half life of a radioactive material, $T_{½}$ and the decay constant, λ. (6)

(c) When $^{238}_{92}U$ decays, the end product is $^{206}_{82}Pb$. The half life is 1.4 x 10^{17} s.

Suppose a rock sample contains $^{206}_{82}Pb$ and $^{238}_{92}U$ in the ratio 1: 5 by weight. Calculate the:

(i) number of $^{206}_{82}Pb$ atoms in 5.0 g of the rock sample. (3)

(ii) age of the rock. (4)

10. (a) A high p.d is applied across two electrodes in air contained in a closed glass tube. Describe, with the aid of labeled diagrams, what will be observed when the pressure in the tube is progressively reduced down to very low pressures.
(5)

(b) List **four** main properties of cathode rays. (4)

(c) A charged oil drop of mass **3.27×10^{-15} kg** is held stationary between two horizontal metal plates across which a p.d of **1000 V** is applied. If the separation of the plates is **1.5 cm,** find the number of electrons on the drop.

(5)

(d) With the aid of a labeled diagram, describe the principle of operation of an ionization chamber. (6)

END