P510/1
PHYSICS
Paper 1
2024
2 ½ hours

AITEL PRE-REGISTRATION EXAMINATION

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

Time: 2 ½ hrs

INSTRUCTIONS TO CANDIDATES:

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

 Turn over

Where necessary, assume the following constants*;*

Acceleration due to gravity, g,	$=9.81ms^{-2}$
Avogadro's number NA	$=6.02x10^{23}mol^{-1}$
Density of water	$=1000kgm^{-3}$
Electronic charge, e,	$=1.6x10^{-19}C$
Electronic mass	$=9.11x10^{-31}kg$
Gas constant, R,	$= 8.31Jmol^{-1}k^{-1}$.
One electron volt, eV	$=1.6x10^{-19}J$
Radius of the earth	$=6.4 \times 10^{6}$ m
Radius of earth's orbit about the sun	$= 1.5 \times 10^{11}m$
Wien's displacement constant	$=2.90 \times 10^{-3}\ JKg^{-1}K^{-1}$
Charge to mass ration, e/m	$=1.8 \times 10^{11}Nm^{2}Kg^{-2}$
Planks constant, h	$=6.6x10^{-34}Js$
Specific heat capacity of water	$=4.2x10^{3}Jkg^{-1}K^{-1}$
Speed of light in vacuum, c	$=3.0x10^{8}ms^{-1}$
Stefan's – Boltzmann's constant, δ	$=5.67x10^{-8}Wm^{-2}K^{-4}$
Surface tension of water	$=7.0x10^{-2}Nm^{-1}$
Unified mass unit, U	$=1.66x10^{-27}kg$
Universal gravitational constant, G	$= 6.67x10^{-11}Nm^{2}kg^{-2}$
Thermal conductivity of copper	$=390\ Wm^{-1}K^{-1}$
Thermal conductivity of aluminium	$= 210\ Wm^{-1}K^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	$=9.0 \times 10^{9}F^{-1}m$
Faraday constant, F	$= 9.65 \times 10^{4}C\ mol^{-1}$

SECTION A

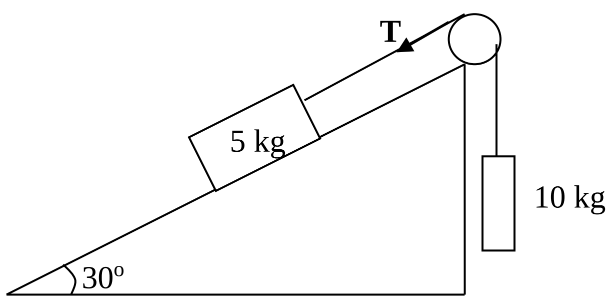
1. (a) Distinguish between *fundamental* and *derived quantities* and give **one** example of each. (03mk)

b) The velocity of sound traveling along a rod made of a material of Young's modulus, Y, and density , *p*, if given by $V = \sqrt{\frac{Y}{p}}$. Show that the formula is dimensionally constant. (04mks)

c) (i) Define **linear momentum** and **impulse**. (02mks)
ii) State the law of conservation of linear momentum. (01mk)
iii) Show that the law in (c) (ii) above follows from Newton's laws of motion. (05mks)
d) A car of mass 1000 kg traveling at uniform velocity of 20 ms^{-1}, collides perfectly in elastically with a stationary car of mass 1500 kg. Calculate the loss in kinetic energy of the car as a result of the collision. (05mks)

2. (a) (i) Distinguish between **conservative** and **non conservative force fields**. (02mk)

b) (i) State the principle of conservation of mechanical energy. (01mk)
ii) Using a stone vertically thrown upwards show that mechanical energy is constant. (04mks)
c) A rectangular block of mass 5.0 kg is pulled from rest along a rough inclined plane by a light inelastic string which passes over a light frictionless pulley P and carries a mass of 10.0 kg as shown in the figure below;



The inclined plane makes an angle of 30° with the horizontal. if the coefficient of sliding friction between the block and the plane is 0.2, calculate;

i) the acceleration of the block. (04mks)

ii) the tension in the string T. (01mk)

iii) the kinetic energy of the block when it has moved through a distance of 1.0m along the inclined. (03mks)

d) (i) State **two** ways in which viscosity differs from solid friction. (02mks)

ii) Account for the differences between kinetic friction and static friction. (03mks)

3. (a) Define **surface tension** and derive its dimensions. (03mks)

b) Explain using molecular theory the occurrences of surface tension. (04mks)

c) Describe an experiment to measure the surface tension of a liquid by the capillary method. (06mks)

d) (i) Show that the excess pressure in a soap bubble is given by

$$P = \frac{4\gamma}{r}$$

ii) Calculate the total pressure within a bubble of air of radius 0.1 mm in water if the bubble is formed 10 cm below the water surface and surface tension of water is $7.27 \times 10^{-2}Nm^{-1}$.

(Atmospheric pressure = 1.01×10^5Pa) (04mks)

4. (a) State **Kepler's law of gravitation.** (03mks)

b) Show that the period of a satellite in a circular orbit of radius, r , about the earth is given by $T = \left(\frac{4\pi^2}{GMe}\right)^{\frac{1}{2}} r^{\frac{3}{2}}$, where G is the universal gravitational constant and Me is the mass of the earth. (05mks)

c) Derive an expression for the speed of a body moving uniformly in a circular speed. (03mks)

d) A satellite of mass 2000 kg is in a circular orbit at a height of 3.59×10^7m above the earth's surface;

i) Find the mechanical energy of the satellite (04mks)

ii) Explain the effects of friction between such a satellite and the atmosphere in which it moves. (03mks)

e) Explain the meaning of a parking orbit as applied to communication via satellite. (02mks)

SECTION B

5. (a) (i) State **Newton's law of cooling**. (01mk)

ii) Describe an experiment to verify the law in (a) above. (05mks)

iii) Explain why a small body cools faster than a large one of the same material. (03kms)

b) (i) What is meant by **cooling correction** ? (01mk)

ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of a poor conductor of heat by the method of mixtures. (05mks)

c) Oil at 15.6^oC enters a long glass tube containing an electrically heated platinum wire and leaves it at 17.4^oC, the rate of flow being 25 cm^3 per minute and the rate of supply of energy 1.34W on changing the rate of flow to 15cm^3 per minute and the power to 0.76W. The temperature rises from 15.6^oC to 17.4^oC. Calculate the mean specific heat capacity of oil.

(Assume density of oil = 870 kgm^{-3}) (05mks)

6. (i) What is meant by **reversible isothermal** and **reversible adiabatic changes**? (02mks)

ii) Using the same axes and starting from the same point, sketch a P-V diagram to illustrate the changes in (a) (i). (02mks)

b) An ideal gas is trapped in a cylinder by a movable piston initially it occupies a volume of 8.0 x 10^{-3} m^3 and exerts a pressure of 108 kPa. The gas undergoes an isothermal expansion until its volume is 27 x $10^{-3}m^3$. It is then compressed adiabatically to the original volume of the gas.

Calculate the final pressure of the gas (05mks)

c) (i) State the assumptions made in the derivation of the expression $P = \frac{1}{3} p\overline{C^2}$ for the pressure of an ideal gas. (02mks)

ii) Use the expression in (c) (i) above to deduce Dalton's law of partial pressures. (03mks)

d) With the aid of a diagram, describe an experiment to show how the volume of a fixed mass of a gas varies with temperature at constant pressure. (06mks)

7. (a) Explain the mechanism of heat conduction in solids. (01mk)

b) Describe a method of determining the thermal conductivity of cork in the form of a thin sheet. (06mks)

c) A window of height 1.0 m and width 1.5 m contains a double glazed unit consists of two single glass panes, each of thickness 4.0 mm separated by an air gap of 2.0 mm. Calculate the rate at which heat is conducted through the window if the temperatures of the external surfaces of glass are 15°C and 35°C respectively. **(Thermal conductivity of glass and air are 0.72 $Wm^{-1}k^{-1}$ and 0.025$Wm^{-1}k^{-1}$).** (02mks)

d) (i) What is meant by **a black body**? (01mk)

ii) Describe how a black body can be realized in practice. (03mks)

SECTION C

8. (a) (i) What is meant by the term **radioactivity**? (01mk)

ii) Given the radioactive how $N_t = N_0 e^{-\lambda t}$, obtain the relation between λ and $T_{1/2}$. (02mks)

iii) What are **radioisotopes**? (01mk)

iv) The radioisotope $^{90}_{38}Sr$ decays by emission of β-particles. The half life of the radioisotopes is 28.8 years. Determine the activity of 1g of the isotope. (05mks)

b) (i) With the aid of a diagram, describe the structure and action of a Geiger – muller tube. (05mks)

ii) Distinguish between **a scalar** and **rate meter**. (01mk)

iii) Sketch the count rate voltage characteristics of the Geiger – muller tube and explain its main features. (03mks)

iv) Identify, giving reasons the suitable range in b) (ii) of the operation the tube. (02mks)

9. (a) (i) Describe a modern x –ray tube and how the x-rays are produced in the tube. (04mks)

ii) State **one** industrial and **one** biological use of x –rays. (01mk)

b) (i) Using a suitable sketch graph, explain how x –ray spectrum in an x –ray tube are formed. (03mks)

ii) Calculate the maximum frequency of x –rays emitted by an x-ray tube operating a voltage of 340kv. (03mks)

iii) Explain why x –ray production is considered as the reverse photo electric emission. (02mks)

c) In the measurement of electron charge by Milkan's apparatus a potential difference of 1.6kv is applied between two horizontal plates 14mm apart. With the potential difference switched off, an oil drop is observed to fall with constant velocity $4.0 \times 10^{-4}ms^{-1}$. When the potential difference is switched on, the drop rises with constant velocity $8.0 \times 10^{-5}ms^{-1}$. If the mass of the oil drop in 1.0×10^{-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) (04mks)

10. (a) State the laws of photoelectric emission. (04mks)

b) Define;

i) a photon (01mk)

ii) work function of a metal (01mk)

c) Describe an experiment to determine the work function of a metal surface. (04mks)

d) A 100mW point source emits light of wave length 4.0×10^{-7}m, from a caesium surface per second.

i) the number of photons striking the caesium surface per second. (03mks)

ii) the resulting photo – current if 70% of the photons emit photo electrons. (02mks)

iii) the maximum kinetic energy of the photoelectrons given that the work function of caesium is 2.1eV. (02mks)

e) Describe one application of photoelectric emission. (03mks)

END