**P510/1**
**PHYSICS**
**Paper 1**
**June/July 2022**
**2½ hours**

# MWALIMU EXAMINATIONS BUREAU

## UACE RESOURCE MOCK EXAMINATIONS – 2022

**PHYSICS**
**Paper 1**
Time: 2 hour 30 min

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

| | | |
|---|---|---|
| *Acceleration due to gravity, g* | = | $9.81 ms^{-2}$ |
| *Electron charge, e* | = | $1.6 \times 10^{-19} C$. |
| *Electron mass* | = | $9.11 \times 10^{-31} kg$ |
| *Mass of earth* | = | $5.97 \times 10^{24} kg$. |
| *Plancks constant, h* | = | $6.6 \times 10^{-34} Js$. |
| *Stefan's – Boltzmann's constant, σ* | = | $5.7 \times 10^{-8} Wm^{-2} K^{-4}$ |
| *Radius of Earth* | = | $6.4 \times 10^{6} m$. |
| *Radius of the sun* | = | $7 \times 10^{8} m$. |
| *Radius of earth's orbit about the sun* | = | $1.5 \times 10^{11} m$ |
| *Speed of light in a vacuum, c* | = | $3 \times 10^{8} ms^{-1}$ |
| *Thermal conductivity of copper* | = | $390 Wm^{-1} K^{-1}$ |
| *Thermal conductivity of aluminum* | = | $210 Wm^{-1} K^{-1}$ |
| *Specific heat capacity of water* | = | $4200 Jkg^{-1} K^{-1}$ |
| *Universal Gravitational constant, G* | = | $6.67 \times 10^{-11} Nm^2 kg^{-2}$ |
| *Avogadro's number $N_A$* | = | $6.02 \times 10^{23} mol^{-1}$. |
| *Density of water* | = | $1000 kgm^{-3}$ |
| *Gas constant, R* | = | $8.31 Jmol^{-1} K^{-1}$ |
| *Charge to mass ratio, e/m* | = | $1.8 \times 10^{11} Ckg^{-1}$ |
| *The constant* $\frac{1}{4\pi\varepsilon_o}$ | = | $9.0 \times 10^{9} F^{-1} m$ |
| *Faradays constant, F* | = | $9.65 \times 10^{4} Cmol^{-1}$ |

## SECTION A

1. (a) Define

(i) **Work** (1mark)

(ii) **Friction** (1mark)

(b) (i) Distinguish between a **conservative force** and a **non-conservative force**. (2marks)

(ii) Give one example of each type of force. (1mark)

(c) (i) State the laws of **static friction**. (3marks)

(ii) Using the **molecular theory** explain the laws of solid friction. (4 marks)

(iii) Describe an experiment to determine the coefficient of kinetic friction between two solid surfaces. (4marks)

(d) A car of mass $1.2 \times 10^3$kg increases its speed from $10ms^{-1}$ to $20ms^{-1}$ while moving up an incline of inclination 1 in 20. The car moves through 500m against a constant resistance to motion of 300N. Calculate the driving force exerted by the engine and a maximum speed the car can possibly attain with its engine working at a constant rate. (5 marks)

2. (a) What is meant by the following terms?

(i) **Velocity gradient**. (1mark)

(ii) **Coefficient of viscosity**. (1mark)

(b) Derive an expression for the terminal velocity of steel ball bearing of radius r, and density $\rho$, falling through a liquid of density $\sigma$ and coefficient of viscosity $\eta$. (5marks)

(c) (i) Define **surface tension**. (1mark)

(ii) Explain the origin of surface tension. (3marks)

(iii) Describe an experiment to measure the surface tension of a liquid by the capillarity method. (6marks)

(d) Explain, with the aid of a diagram why air-flow over the wings of an aircraft at take-off causes a lift. (3marks)

3. (a) What is meant by a **conservative force**, and give two examples? (2marks)

(b) (i) State the law of **conservation of mechanical energy**. (1mark)

(ii) A body of mass **M**, is projected vertically upwards with a speed**, u**. Show that the law of conservation of mechanical energy is obeyed throughout its motion. (5marks)

(iii) Sketch a graph showing variation of kinetic energy of the body with time. (1mark)

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

(i) Friction force between the block and the table. (2marks)

(ii) Velocity of the bullet just before it strikes the block. (4marks)

(d) (i) Define **centre of gravity**. (1mark)

(ii) Describe an experiment to determine the **centre of gravity** of an irregular lamina. (4marks)

4. (a) Define the terms;

(i) **Stress** (1mark)

(ii) **Work hardening** (1mark)

(b) (i) Distinguish between **elastic deformation** and **plastic deformation**. (2marks)

(ii) Describe an experiment to determine **Young's modulus of steel wire**. (6marks)

(c) Two wires of lengths $\mathbf{L_1}$ and $\mathbf{L_2}$ cross sectional areas $\mathbf{A_1}$ and $\mathbf{A_2}$ and Young's moduli $\mathbf{E_1}$ and $\mathbf{E_2}$ respectively are joined in series. Show that the force, **F** exerted on the wire to produce total extension, e is given by,

$$F = \frac{(E_2 E_1 A_2 A_1)}{(L_2 E_1 A_1) + (L_1 E_2 A_2)}(e)$$ (4marks)

(d) (i) Distinguish between **stable equilibrium** and **unstable equilibrium.** (2marks)

(ii) A uniform ladder 5.0m long and of mass 40kg rests with its upper end against a smooth vertical wall and its lower end 3.0m from the wall on a rough ground. Calculate the force at the foot of the ladder. (4marks)

## SECTION B

5. (a) Define the following

(i) **Isothermal change**. (1mark)

(ii) **Critical temperature.** (1mark)

(b) The equation of state for one mole of real gas of volume, V and pressure P at a temperature T is given by $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ where a and b are constants.

Explain the significance of the terms $\frac{a}{V^2}$ *and* b. (2marks)

(c) (i) State the **kinetic theory of matter**. (1mark)

(ii) Describe briefly an experiment to demonstrate the kinetic theory of matter. (3marks)

(iii) A gas of density $\ell$, with molecules moving at a mean speed, $\overline{C^2}$, is contained in a cube of side, l. Show that the pressure exerted by the gas is $P=\frac{1}{3}\ell\overline{C^2}$ (4marks)

(d) (i) Distinguish between **saturated vapour** pressure and **partial pressure**. (2marks)

(ii) Explain the effect of increase in temperature on the saturated vapour pressure of a liquid. (3marks)

(e) An ideal gas at a pressure of $1.0 \times 10^5$ Pa and temperature of 27°C is compressed isothermally to half its volume. The gas then expands adiabatically to its original volume. Taking $\gamma = 1.4$, calculate the final temperature of the gas. (3marks)

6. (a) (i) State the laws of **black body radiation**. (2marks)

(ii) Why is black body radiation referred to as temperature radiation? (1mark)

(iii) Sketch the variation of intensity of radiation emitted with wavelength for a black body at three different temperatures. (3marks)

(b) (i) If the equilibrium temperature of the earth's surface is T and the total rate of emission by the sun is E, show that $\boldsymbol{T=\frac{E}{16\sigma\pi R^2}}$, where σ = Stefan's constant and R is the radius of the earth's orbit around the sun. (4marks)

(ii) State the assumption made in b (i) above. (1mark)

(c) (i) What is meant by **temperature gradient** as applied to a thermal conductor? (1mark)

(ii) Two perfectly lagged metal bars A and B, each of length 20cm, are arranged in parallel, with their hot ends maintained at $90^{o}$ C and their cold ends at $30^{o}$C. If the cross sectional area of each bar is $2.5cm^2$, find the net rate of heat flow through the parallel bars. Take thermal conductivity of A = $400Wm^{-1}K^{-1}$ and that of B = $200Wm^{-1}K^{-1}$. (4marks)

(d) Explain how **Greenhouse effect** leads to **global warming**. (4marks)

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

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

(ii) Explain why the pressure of a fixed mass of gas rises if its temperature is increased. (2marks)

(b) (i) Define the term **thermometric property** and give four examples. (3marks)

(ii) State two qualities of a good thermometric property. (1mark)

(c) (i) With reference to a liquid in glass thermometer, describe the steps involved in setting up a **Kelvin scale of temperature**. (3marks)

(ii) State one advantage and one disadvantage of the resistance thermometer. (1mark)

(d) A resistance thermometer has a resistance of 21.42Ω at the ice point, 29.10Ω at steam point and 28.11Ω at some unknown temperature Θ. Calculate Θ on the scale of this thermometer. (3marks)

## SECTION C

8. (a) Define the terms

(i) **Mass number**. (1mark)

(ii) **Decay constant**. (1mark)

(b) Derive the relation between **half-life**, $T_{\frac{1}{2}}$ and the **decay constant** λ. (3marks)

(c) With the aid of a labelled diagram describe the operation of a **diffusion cloud chamber** in detecting radiation. (6marks)

(d) (i) What is meant by **binding energy of a nucleus**? (1mark)

(ii) Distinguish between **nuclear fusion** and **nuclear fission**. (2marks)

(iii) State the significance of each of the process in (ii) above. (1mark)

(e) The radioactive nuclei $^{210}_{84}Po$ emits alpha particles and the product nuclei are of $^{206}_{82}Pb$, taking the mass of $^{210}_{84}Pb = 209.937\text{u}$, $^{206}_{82}Pb = 205.929u$, $^{4}_{2}He = 4.002u$ and 1 u = 931 MeV.

(i) Calculate the energy released in the disintegration. (4marks)

(ii) Explain why not all the energy does not appear as the kinetic energy of the alpha particle. (1mark)

9. (a) (i) Describe with aid of a diagram, the production of **cathode rays**. (4marks)

(ii) State and justify two properties of cathode rays. (2marks)

(b) Explain each of the following terms as applied to photo-electric emission:

(i) **Stopping potential**. (1mark)

(ii) **Threshold frequency**. (1mark)

(c) Explain X-ray diffraction by crystals and derive **Bragg's law**. (6marks)

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

(i) Current that flows. (3marks)

(ii) Speed of the electrons striking the target. (3marks)

10. (a) What is meant by the following.

(i) **Isotopes**. (1mark)

(ii) **Specific charge of an ion**? (1mark)

(b) With the help of a diagram, describe how specific charge of an ion can be determined using the **Bainbridge mass spectrometer**. (6marks)

(c) In a Bainbridge mass spectrometer, the magnesium ions $^{24}Mg^{+}$ and $^{26}Mg^{2+}$ are deflected in circular paths by a uniform magnetic field. Calculate;

(i) The ratio of the specific charges of the two ions. (3marks)

(ii) The radius of the path of the heavier ion if that of the lighter ion is 0.36m. (2 marks)

(d) In a simple model of the hydrogen atom, an electron of mass m and charge –e, moves in a circular orbit about the nucleus.

(i) Show that the kinetic energy of the electron is given by $\frac{e^2}{8\pi\varepsilon r}$, where r is the radius of the electron's orbit, ε is the permittivity of free space. (2marks)

(ii) Given that the angular momentum of the electron is $\frac{nh}{2\pi}$, where n is an integer and h is Planck's constant, show that the total energy of the electron is $E_n = -\frac{me^4}{8n^2h^2\varepsilon^2}$. (3marks)

(iii) Explain the significance of the minus sign in the expression for $E_n$ in (d)(ii) above. (2marks)

**END**