P510/1
Physics
Paper 1
July/August 2024
2½ hours

NATIONAL EDUCATION RESEARCH & EXAMINATIONS BUREAU

UACE NEREB NATIONAL MOCKS 2024

PHYSICS

PAPER 1

2 HOURS 30 MINUTES

INSTRUCTIONS TO CANDIDATES:

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

- Acceleration due to gravity	=	$9.81 ms^{-2}$
- Electron charge, e	=	$1.6 \times 10^{-19} C$
- Electron mass	=	$9.11 \times 10^{-31} kg$
- Mass of the earth	=	$5.97 \times 10^{24} kg$
- Plank's constant, h	=	$6.6 \times 10^{-34} Js$
- Stefan's-Boltzmann's constant, δ	=	$5.67 \times 10^{-8} Wm^{-2}K^{-4}$
- Radius of the earth	=	$6.4 \times 10^{6} m$
- Radius of the sun	=	$7.0 \times 10^{8} m$
- Radius of earth's orbit about the sun	=	$1.5 \times 10^{11} m$
- Speed of light in a Vacuum, C	=	$3.0 \times 10^{8} ms^{-1}$
- Thermal conductivity of copper	=	$390 Wm^{-1}K^{-1}$
- Thermal conductivity of aluminium	=	$210 Wm^{-1}K^{-1}$
- 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 $\frac{1}{4\pi\varepsilon_o}$ = $9.0 \times 10^{9} F^{-1}m$
- Faraday's constant, **F** = $9.65 \times 10^{4} Cmol^{-1}$

1(a) Define the elastic and inelastic collisions. (02 marks)

(b) In an experiment to measures its velocity, a bullet of mass 10g is fired at short range from a gun of mass 0.8kg into a block of wood of mass 390g suspended from a vertical string. On striking the block, the bullet is embedded and the block rises to a vertical height of 6.0cm above its rest position. Calculate the;

(i) speed of the bullet (05 marks)

(ii) the recoil velocity of the gun (02 marks)

(c)(i) Distinguish between conservative and non-conservative forces and state an example of each. (03 marks)

(ii) Show that in a system where the only forces acting are conservative forces, mechanical energy is conserved. (04 marks)

(d) A car of mass 1.0×10^3 moves with uniform velocity of $36 kmh^{-1}$ up a straight track inclined at an angle of 20^o to the horizontal. The total frictional resistance to the motion of the car is 248N. Calculate the power developed in the engine (04 marks)

2(a) Define the following terms

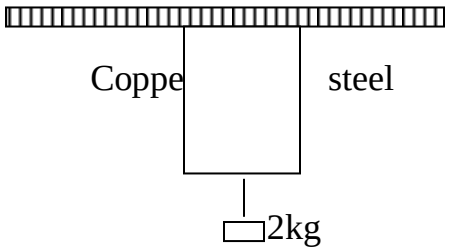
(i) Elastic limit (01 mark)

(ii) Young's modulus (01 mark)

(iii) Tensile stress (01 mark)

(b) Derive the expression for the energy stored on a unit volume of an elastic material in terms of its Young's modulus E and its strain. (04 marks)

(c) Two wires of copper and steel of the same length and of diameter 1.0mm are suspended side by side as shown in the figure below



A mass of 2kg is hung at the lower ends of the wires. If Young's Moduli for copper and steel are 1.0×10^{11}Pa and 2.0×10^{11}pa respectively find;

(i) the tension in each wire (4 marks)

(ii) the strain in the copper wire (3 marks)

(d) A uniform metal bar of length 1.0m and diameter 2.0cm is fixed between two rigid supports at 25°C. If the temperature of the bar is raised to 75°C, find:-

(i) the force exerted on the supports. (3 marks)

(ii) the energy stored in the bar at 75°C. (3 marks)

(Young's modulus for the metal = 2.0×10^{11}pa, coefficient of linear expansion = $1.0 \times 10^{-5}k^{-1}$)

3a(i) State Bernoulli's principle. (1 mark)

(ii) Explain why it is dangerous to stand close to a railway line to which a fast moving train is passing. (3 marks)

(b)(i) Explain the temperature dependence of viscosity of a liquid. (3 marks)

(ii) Water of negligible viscosity flows steadily through a horizontal pipe of varying cross-sectional area. At a point A, of cross-sectional area $10cm^2$, the velocity is $0.2ms^{-1}$. What is the pressure difference between A and B if the cross section area of point B is $2.5cm^2$? (Given that the density of water = 10^3kgm^{-3}) (4 marks)

(c)(i) Explain the origin of surface tension. (4 marks)

(ii) Describe an experiment to measure the surface tension of a liquid by the capillary tube method. (5 marks)

4a(i) State Keplar's laws of planetary motion. (3 marks)

(ii) Define the following; angular momentum and parking orbit. (2 marks)

(iii) What is meant by uniform circular motion? (1 mark)

(b) A motor cyclist rides round a circular track of radius r inclined at angle Θ to the vertical.

(i) Draw a sketch diagram of the motorist and show the forces acting on the motorist. (2 marks)

(ii) Explain why the motor cyclist leans towards the centre of the circular path. (2 marks)

(iii) If the coefficient of friction between the tyres and the ground is μ, derive the expression for which the motorcyclist will ride safely round the track (3 marks)

(c) A small mass of 20.0g is attached to one end of an inextensible string of length 0.8m. The mass is whirled through a vertical circle of radius 0.8m. If the maximum tension in the string is 0.2N, find:-

(i) the period of motion of the mass. (3 marks)

(ii) the tensions in the string when it makes an angle of 30^{o} with the vertical. (4 marks)

SECTION B

5a(i) Define critical temperature of a gas. (1 mark)

(ii) Distinguish between a vapour and a gas. (2 marks)

(b)(i) Draw a sketch graph of pressure against temperature for a saturated vapour in a sealed container whose temperature is gradually raised until all the liquid in the container is evaporated. (2 marks)

(ii) A horizontal tube of uniform bore, closed at one end has some air trapped by small quantity of water. The length of the enclosed air column is 20.0cm at 12^{o}C and 23.04cm at 38^{o}C. Given that the saturation vapour pressure of water at 12^{o}C is 10.5mm of mercury, find the saturation vapour pressure of water at 38^{o}C.
(Atmospheric pressure = 75.0cmHg). (4 marks)

(c)(i) With use of a labeled diagram, explain how a constant volume gas thermometer is used to measure the Kelvin temperature of a liquid. (5 marks)

(ii) Mention any two sources of error in the constant-volume gas thermometer and state how each one can be minimized. (2 marks)

(d) 15129 joules of heat is needed to raise the temperature of 288g of a gas by 41^{o}C at constant volume. If the molar mass is 16g, find the molar heat capacity of this gas at constant pressure. (4 marks)

6(a)(i) State Wein's displacement law. (1 mark)

(ii) Explain the mechanism of heat transfer by convection. (3 marks)

(b) A metal sphere of density $8.93 \times 10^{3}kgm^{-3}$ and specific heat capacity $370Jkg^{-1}k^{-1}$ is placed on an enclosure maintained at a temperature of 300K. When the temperature of the sphere is 150K, it changes at a rate of $0.065Ks^{-1}$.

(i) Calculate the diameter of the sphere. (4 marks)

(ii) State any assumption made. (1 mark)

(c) With the use of a diagram, explain how a thermopile is used to detect radiation. (4 marks)

(d) A car engine has four cylinders. At a certain speed, a piston in a cylinder executes twenty-four power strokes per minute. To keep the temperature of the engine constant, water circulates around the engine at a rate of 200g per second and its temperature rises by 10.0K. Calculate;

(i) the heat generated by each power stroke. (3 marks)

(ii) the power input of the car engine if its efficiency is 0.75. (3 marks)

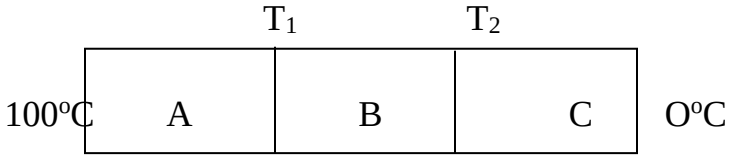
7a(i) Define cooling correction. (1 mark)

(ii) State Newton's law of cooling. (1 mark)

(b)(i) Using a well labeled diagram, describe an experiment to determine the specific latent heat of vapourisation of water by the method of mixtures. (6 marks)

(ii) State two advantages of the electrical method over the method of mixtures in determining the specific latent heat of vapourisation of a liquid. (2 marks)

(c) Three metallic conductors A, B and C of equal lengths and cross section area are joined to form an insulated composite rod as shown in the figure below.



The exposed end of A and C are maintained at 100°C and °C respectively. If the ratio of the thermal conductivities A, B and C is 1.5: 2: 2.5 respectively, find the steady temperature of the interfaces T_1 and T_2. (4 marks)

(ii) Draw a sketch graph of temperature against length of the composite rod.

(2 marks)

(d) Explain why;

(i) one feels cool after sweating. (2 marks)

(ii) green house effect causes global warming. (2 marks)

SECTION C

8(a) Define binding energy of a nuclide. (1 mark)

(b)(i) Sketch a graph showing how binding energy per nucleon varies with mass number. (1 mark)

(ii) describe the main features of the graph in b(i) above. (3 marks)

(c) Distinguish between nuclear fission and nuclear fusion and account for energy released.

(3 marks)

(d) With the aid of a labeled diagram, describe the working of an ionization chamber. (6 marks)

(e)(i) What is meant by half-life and decay constant as applied to radioactivity.

(2 marks)

(ii) A Gerger Muller (GM) tube placed 20cm from a 2.0g of Randon $^{222}_{86}Rn$ gives a count rate of 85 counts per second. If the entrance window of the GM tube has an area of $10cm^2$, calculate the half-life of radon. (4 marks)

9(a) Describe an experiment which justifies the existence of a small nucleus at the centre of an atom. (6 marks)

(b)(i) State Bohr's postulates of a hydrogen atom. (2 marks)

(ii) State the limitations of Bohr's model of the atom. (2 marks)

(c) Use Bohr's model to show that the total, E, of an electron in an atom is given by

$E = \frac{me^4}{8\varepsilon n^2 n^2 h^2}$, where m is the mass of the electron, ε_o is permittivity of free space, n is principal quantum number and h is Planck's constant. (5 marks)

(d) The ionization energy of helium is 24.6eV. An electron from an excitation level of helium of energy -21.4eV falls to the ground state.

(i) What is ionization energy? (1 mark)

(ii) Calculate the wave length of the radiation emitted in the above transition to the ground state. (3 marks)

(iii) In what region of the spectrum does the radiation emitted lie? (1 mark)

10a(i) Define stopping potential and threshold wavelength. (2 marks)

(ii) Explain why the wave theory of light fails to account for the photo electric emission of light. (4 marks)

(iii) Describe an experiment to determine Plank's constant. (5 marks)

(b) In X-ray production explain;

(i) the difference between occurrence of line and continuous spectra. (3 marks)

(ii) the difference between hard and soft x-rays. (2 marks)

(c) An x-ray tube is operated at 20KV with an electron current of 16mA in the tube Estimate the;

(i) number of electrons hitting the target per second. (2 marks)

(ii) rate of flow of cooling water needed to maintain a temperature difference of 12K between the inflow and outflow assuming 99.5% of the kinetic energy of electron is converted to heat. (2 marks)

END