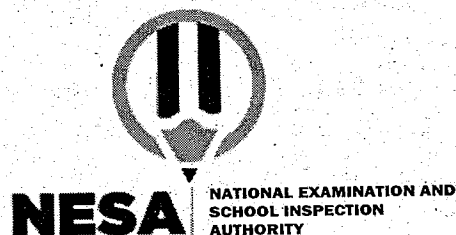


Physics II

030

21/07/2021 08.30 AM - 11.30 AM



ADVANCED LEVEL NATIONAL EXAMINATIONS, 2020-2021

SUBJECT: PHYSICS II

COMBINATIONS:

PHYSICS - CHEMISTRY- MATHEMATICS (PCM)

PHYSICS - CHEMISTRY- BIOLOGY (PCB)

MATHEMATICS - PHYSICS - GEOGRAPHY (MPG)

MATHEMATICS - PHYSICS - COMPUTER SCIENCE (MPC)

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as written on your registration form and **DO NOT** write your names and index number on additional answer sheets if provided.
2. Do not open this question paper until you are told to do so.
3. This paper consists of **two** sections **A** and **B**.

Section A: Attempt **all** questions.

(55 marks)

Section B: Attempt **any three** questions.

(45 marks)

4. Non- programmable scientific calculator and mathematical set may be used.

5. Useful constants

Acceleration due to gravity $g=9.81 \text{ m/s}^2$

Planck's constant $h = 6.63 \times 10^{-34} \text{ m}^2 \text{ kg /s}$

Magnitude of electron's charge $e = 1.6 \times 10^{-19} \text{ C}$

Speed of light in vacuum $C = 3 \times 10^8 \text{ m/s}$

Wien's constant $b = 2.9 \times 10^{-3} \text{ mK}$

SECTION A: ATTEMPT ALL QUESTIONS (55 marks)

- 1) Indicate **true** if the statement is correct and **false** if it is wrong.
- a) In order to determine a star's luminosity, one must measure its apparent brightness (flux) and the angle between the star and his/her location. (1 mark)
- b) A lunar eclipse occurs when the Earth is between the Sun and the Moon and Earth's shadow darkens the Moon. (1 mark)
- c) The inner planets consist of gases instead of rocks. (1 mark)
- d) Declination is angular distance of a celestial object's position measured eastwards along the celestial equator starting at the vernal equinox. (1 mark)

- 2) a) Some characteristics of two quarks are given below:

Quark	Electric charge(unit of $e=1.6 \times 10^{-19}$ C)	Spin
Down (d)	-1/3	1/2
Up(u)	+2/3	1/2

Copy the following table and fill in the blanks using the given data

Quark	Electric charge (unit of e)	Name of the corresponding subatomic particle
uud		
udd		

(3 marks)

- b) Name a group of heavy subatomic particles made up of three quarks characterized by spins that are equal to half -integer values.
Choose from the two options mesons and baryons. (1 mark)

- 3) **Analog system, half-duplex, mobile phone, digital system and radio broadcasting** are some terms used in communication.

Fill in the blanks by selecting the correct term from the given list above.
Use each term only once and one term is not appropriate.

- a) In thetransmission mode, data can be transmitted in both directions on a signal carrier but not at the same time. (1 mark)
- b)is an example of full duplex system. (1 mark)
- c) A technique of transmitting information such as data, images, videos, using continuous signal is..... (1 mark)
- d) An example for simplex transmission mode is..... (1 mark)
- 4) a) What do you understand by the term wave –particle duality? (1 mark)
- b) A gamma –ray photon has a momentum of $8.00 \times 10^{-21} \text{ kg m/s}$. Calculate its energy. (2 marks)
- 5) a) Suggest a condition necessary for destructive interference to take place when monochromatic waves from two coherent sources meet. (1 mark)
- b) Which phenomenon is responsible for light spreading as it passes through a narrow slit? (1 mark)
- c) Explain the term “monochromatic waves”. (1 mark)
- 6) a) State any one property of cathode rays. (1 mark)
- b) Assume that a positive electric charge q moves in the direction of the electric field as shown (figure 1).

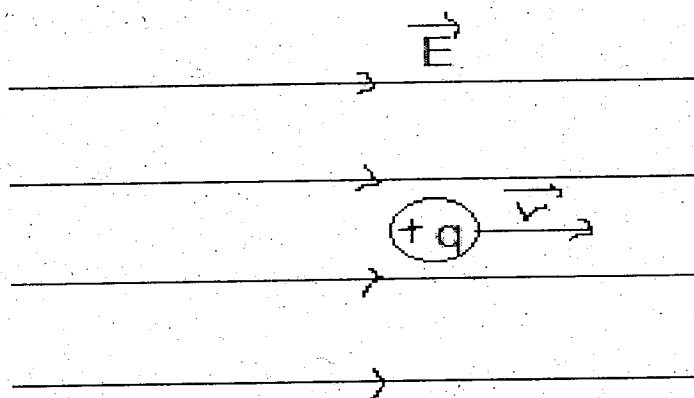


Figure 1

- (i) Assume that the work done by the electrostatic force on the electric charge $+q$ is W . Is W positive or negative? Justify your answer. **(2 marks)**
- (ii) Does the electric potential energy associated with this electric charge decrease or increase? **(1 mark)**
- 7) a) According to you, which natural disaster hits most frequently Rwanda as country? **(1 mark)**
- b) Suggest any two security measures to be reinforced by the Rwandan government to prevent the negative impacts of natural disaster given in a). **(2 marks)**
- 8) Ultrasound imaging is quick, cheap, non- invasive and non- ionizing radiation (NIR). It is therefore a regularly used diagnostic's tool in medicine.
- a) Why is ultrasound imaging non- ionizing radiation? **(1 mark)**
- b) (i) Suggest another medical imaging method that is non-ionizing. **(1mark)**
- (ii) Identify any one medical imaging with ionizing radiation. **(1mark)**
- c) How is ultrasound used in medical imaging? **(1 mark)**
- 9) a) Propose any one impact of greenhouse effect on climate change. **(1mark)**
- b) The Sun emits maximum radiation of wavelength $475 \times 10^{-9} \text{ m}$. Assuming the sun to be a black body, use Wien's law of black body radiation to find the surface temperature of the sun. **(2 marks)**
- 10) A prism is made from transparent plastic. In this plastic, light travels at $2.4 \times 10^8 \text{ m/s}$. The refractive index of air n_{air} is $\cong 1$. Monochromatic light enters one face of the prism at right angle as shown below (figure 2).

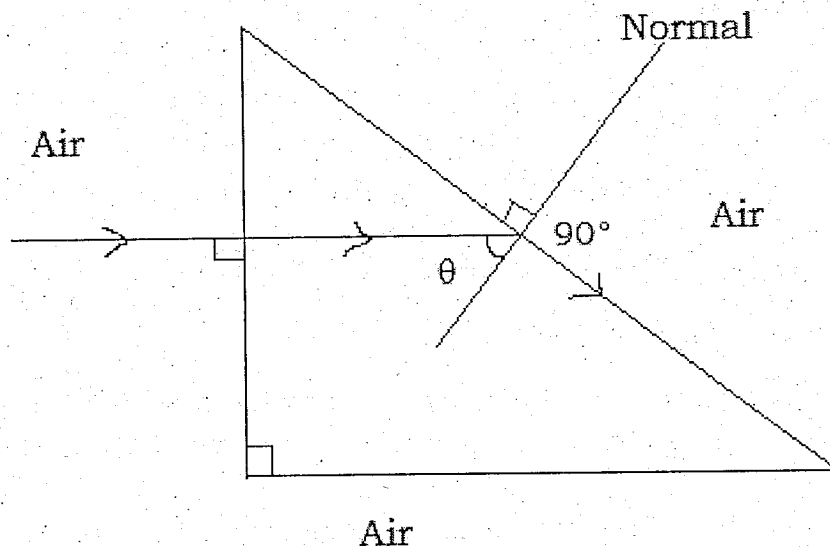


Figure 2

- a) Find the refractive index n of the prism. **(1 mark)**
 - b) What is the angle θ such that the light just escapes from the sloping face of the prism as shown above? **(2 marks)**
 - c) Why does the ray of light used deviate without dispersion? **(1 mark)**
- 11) A ball is thrown from the top of a cliff 19.62 m high with a horizontal velocity of 10 m/s (figure 3).

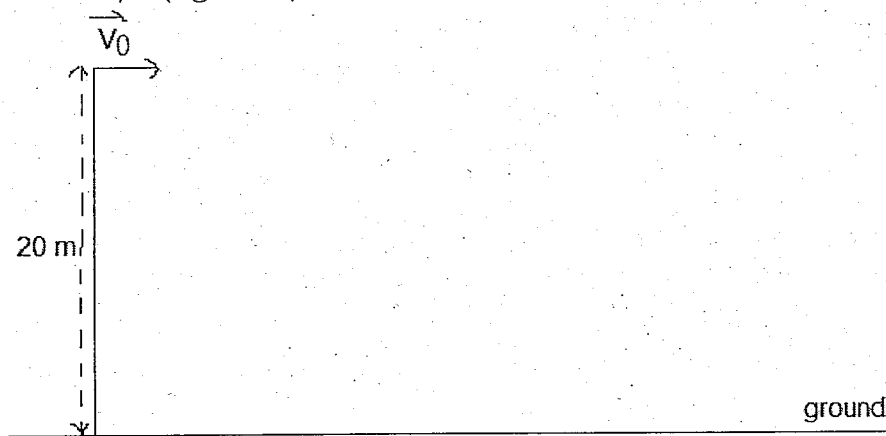


Figure 3

- a) Find the time taken by the ball to strike the ground. **(2 marks)**
- b) Determine the horizontal distance from the foot of the cliff to where the ball strikes the ground. **(2 marks)**

- 12) a) Identify any one factor on which gravitational force depends. (1 mark)
- b) The Earth may be considered to be a uniform sphere with its mass M concentrated at its centre. A communication satellite of mass m orbits the Earth such that the radius of the geostationary orbit is r .
Derive a formula for the linear velocity (orbital velocity) v of the satellite in terms of G (gravitational constant), M and r . (2 marks)
- 13) A vessel containing 2 m^3 of air initially at a temperature of 298K and a pressure of 760 mmHg is heated at constant pressure until its volume becomes 4 m^3 .
- a) Draw a PV diagram (Pressure against volume graph) for this isobaric process (just schematically). (1 mark)
- b) Find the final temperature of the air. (2 marks)
- c) How does the internal energy of a closed system of gas change when the gas expands at constant pressure? (1 mark)
- 14) a) What is the type of motion characterized by each of the following acceleration? The symbols used have their usual meanings.
- (i) $a = -\omega_0^2 x$ (1 mark)
- (ii) $a = \frac{v_0^2}{r}$ (1 mark)
- b) A mass connected to a spring of force constant ($k = 35 \text{ N/m}$) oscillates on a horizontal, frictionless surface with amplitude of 4.0 cm .
Show that the total mechanical energy of the system is equal to 0.028 J . (2 marks)
- 15) a) In which galaxy do you live? (1 mark)
- b) How does Doppler Effect support the big bang theory? (1 mark)
- c) An absorption feature of calcium usually has a wavelength of 393.4 nm , but it is observed in a galaxy to have a wavelength of 400.2 nm .
At what speed is this Galaxy moving with respect to Earth? (2 marks)

SECTION B: ATTEMPT ANY THREE QUESTIONS (45 marks)

16) Read carefully the following paragraph and answer related questions..

Out of all the renewable energy options that are available, solar energy is the most plentiful. It is an energy source that comes directly from the Sun. Energy from the sun reaches the Earth by way of electromagnetic radiation. The Sun, with its tremendous power output, can easily supply humanity with all the energies it needs and will ever need. The origin of some kinds of energy called “renewed” traces back to solar radiation.

- a) Write a short note about the life on Earth without the Sun.
15 lines maximum. **(4 marks)**
- b) (i) What nuclear reaction occurring inside the sun is the source of solar energy? **(2 marks)**
(ii) Formulate any two technologies and explain how they work to tap/exploit solar energy. **(4 marks)**
- c) Explain how the origin of the hydroelectric power traces back to solar energy. **(3 marks)**
- d) The above paragraph shows us the importance of solar energy but the solar energy users say that some disadvantages related to the use of solar energy exist. Do you agree or disagree with users’ statement? Defend your idea. **(2 marks)**

17) A learner investigated the properties of the photocell which uses the photoelectric effect to provide a current in an external circuit (figure 4). Its photoemissive surface has a work function of 2.1 eV . The frequency of the electromagnetic radiation used by the learner is $7.23 \times 10^{14}\text{ Hz}$.

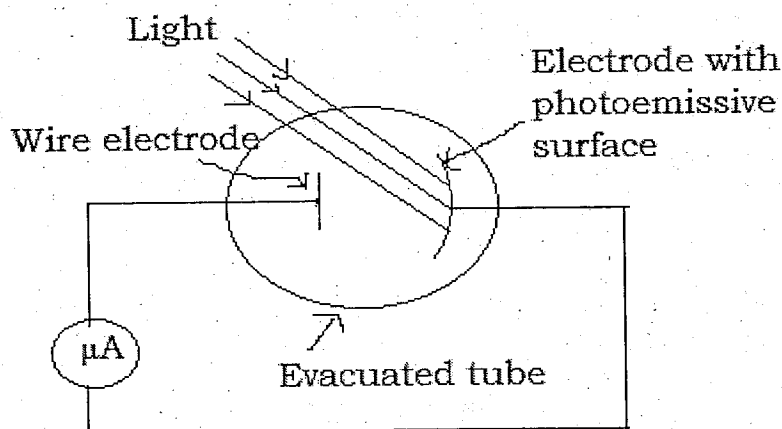


Figure 4

- a) (i) What is meant by the term work function of a metal as used in photoelectric effect? **(2 marks)**
(ii) Express the given work function in Joules. **(2 marks)**

(iii) Does the photoelectric effect best prove that the light is a wave instead of particle? Justify your answer **(2 marks)**

(iv) Find the energy of each photon incident on the photo emissive surface in J. **(2 marks)**

(v) Why did photons of this light cause the photoelectric effect to take place? **(2 marks)**

b) The same learner used a source of electromagnetic radiation of fixed frequency $7.23 \times 10^{14} \text{ Hz}$ as mentioned above and observed that there was a current in the external circuit. The learner used a new circuit shown in figure 5.

As the learner increased the supply voltage, the current decreased and eventually became zero. The minimum voltage at which this happens is called the stopping potential.

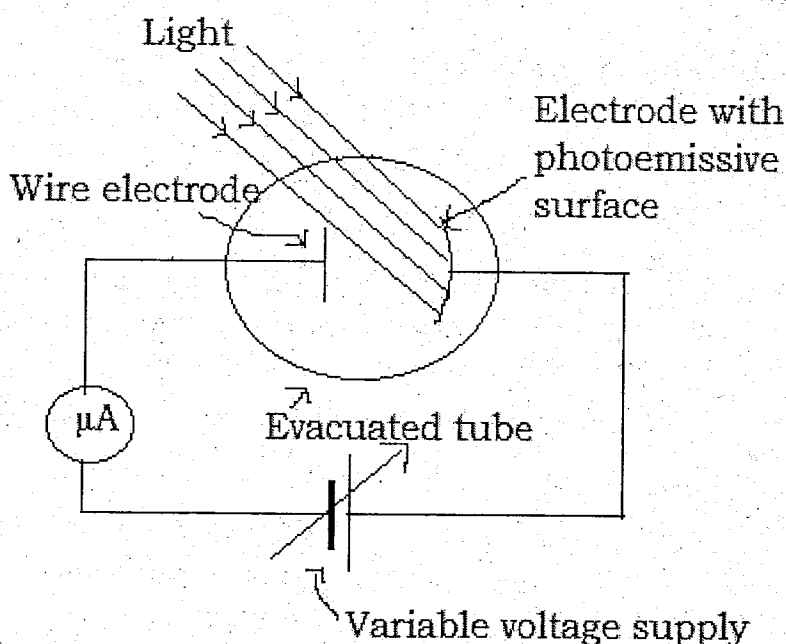


Figure 5

(i) Use Einstein equation to find the maximum kinetic energy, in J, of the electrons emitted from the photoemissive surface. **(2 marks)**

(ii) Determine the stopping potential for this photoemissive surface. **(2 marks)**

c) Where is the photoelectric effect used in everyday life? **(1 mark)**

18) a) What do you understand by the following terms?

(i) Electromotive force (emf) of a cell.

(1 mark)

(ii) Internal resistance of a cell.

(1 mark)

b) A cell has an electromotive force ε of 1.52 V and internal resistance of $0.45\ \Omega$. The figure 6 shows the cell connected to a variable resistor R

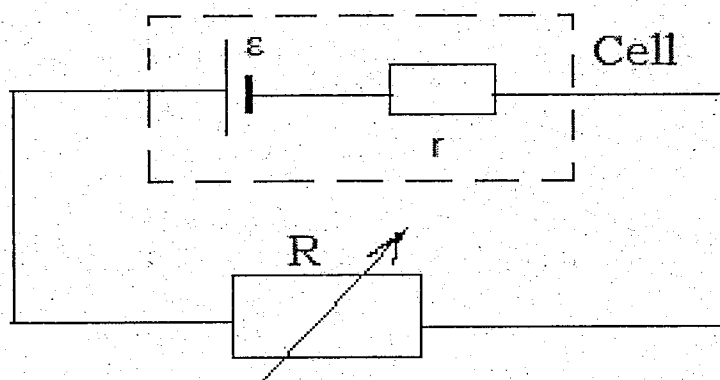


Figure 6

The resistance of R is set to a value of $2.55\ \Omega$. Calculate:

(i) The terminal potential difference across the cell

(2 marks)

(ii) The power dissipated in R

(2 marks)

c) In different parts of a complex electrical network, currents are determined using Kirchhoff's laws.

(i) 1) State Kirchhoff's current law/junction rule.

(1 mark)

2) State Kirchhoff's voltage law/loop rule

(1 mark)

3) Which of the Kirchhoff's laws is a consequence of the principle of conservation of energy?

(1 mark)

4) Which of the Kirchhoff's laws is based on a principle of charge conservation?

(1 mark)

- (ii) Find the electric currents I_1, I_2, I_3 as shown on the electric circuit below (figure 7).

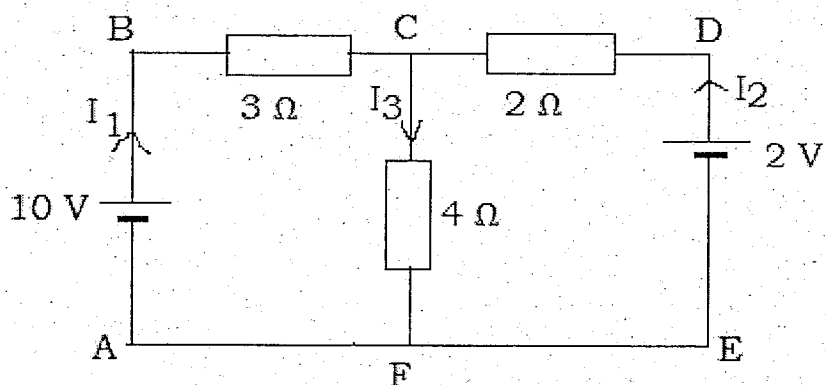


Figure 7

(5 marks)

- 19) a) The figure 8 represents the waveform of a sound wave. The wave is travelling at constant speed in x-direction.

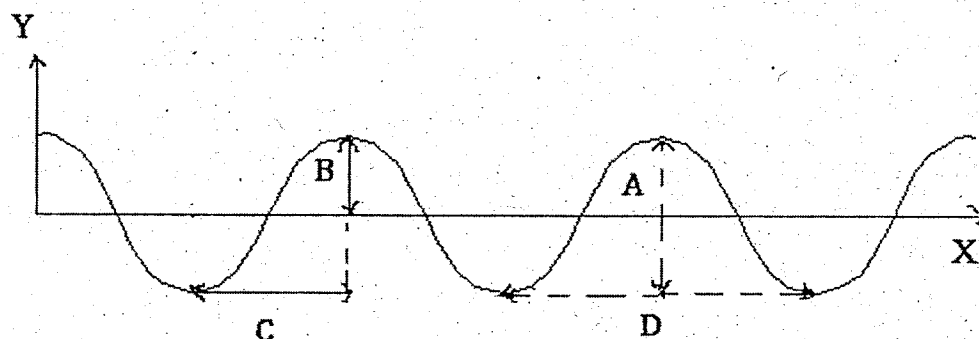


Figure 8

- (i) From the graph, determine the marked distance labelled with one of the letters A, B, C and D corresponding to the:
 - 1) wavelength of the wave **(1 mark)**
 - 2) amplitude of the wave **(1 mark)**
- (ii) What happens to the loudness and the pitch of the sound wave if the following changes occur?
 - 1) The amplitude of the sound is increased at constant wavelength. **(2 marks)**
 - 2) The wavelength of the sound is increased at constant amplitude. **(2 marks)**
- (iii) How are sound waves produced? **(1 mark)**

b) (i) How are stationary waves formed? **(1 mark)**

(ii) What is the importance of resonance in musical instruments? **(1 mark)**

(iii) A stretched string of a guitar has a length of 791 mm.
The string emits a note of 256 Hz when it vibrates at its fundamental frequency.

1) Draw a diagram to represent the fundamental frequency of a stationary wave in a string. **(1 mark)**

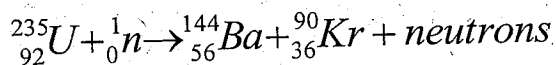
2) Calculate the speed of waves in this stretched string of a guitar. **(2 marks)**

c) An ambulance siren emits a sound of frequency 750 Hz. When the ambulance is travelling towards a stationary observer, the frequency detected by the observer is 820 Hz. The speed of sound in air is 340 m/s

(i) What is the speed of the ambulance? **(2 marks)**

(ii) How is Doppler Effect used in everyday life? **(1 mark)**

20) a) Nuclear reaction occurs when a neutron collides with a uranium -235 nucleus as shown by the nuclear equation below



(i) Name this type of nuclear reaction. **(1 mark)**

(ii) Calculate the number of neutrons released during this nuclear reaction. **(1 mark)**

(iii) Use information from the given nuclear equation to explain how a chain reaction can occur in uranium -235. **(1 mark)**

(iv) Calculate the energy in MeV released in the given nuclear reaction.

U-235 atomic mass: 235.0439299 u

Ba-144 atomic mass: 143.9229531 u

Kr-90 atomic mass: 89.9195172 u

Mass of neutron: 1.0086649 u

1u=931.5 MeV/C²

(3 marks)

- b) A nucleus of ${}^{90}_{38}\text{Sr}$ decays by the emission of a β^- particle and a nucleus of ${}^{64}_{29}\text{Cu}$ decays by the emission of a β^+ particle.

(i) Complete the table below using the nucleon number and proton number for the nucleus produced in each of these two decay processes.

Nuclear number and proton number of nucleus produced	Nucleus formed by β^- particle	Nucleus formed by β^+ particle
Nucleon number		
Proton number		

- (ii) What are the names of the particles produced in each of the above decay processes namely β^- decay and β^+ decay? **(4 marks)**
- (iii) State the name of the fundamental interaction/ force responsible for β (beta) decay. **(1 mark)**