Physics II

030

26/07/2023 08:30 AM – 11:30 AM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ADVANCED LEVEL NATIONAL EXAMINATIONS, 2022-2023

SUBJECT: PHYSICS II

PAPER II: THEORY

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. **(70 marks)**
   Section B: Attempt any **THREE** questions. **(30 marks)**
4) Scientific calculator and mathematical set may be used.
5) **Useful constants**

   Wien's constant $b=2.898\times10^{-3}mK$

   Planck's constant $h=6.626\times 10^{-34}\ m^2\ kg\ /\ s$

   Rest mass of the electron $m_e=9.1\times10^{-31}\ kg$

   Boltzmann's constant $k=1.38\times10^{-23}\ J/K$

   Avogadro's number $N_A=6.022\times10^{23}\ particle$

   Gas constant $R=8.31\ J\cdot K^{-1}\cdot mol^{-1}$

SECTION A: ATTEMPT ALL QUESTIONS (70 marks)

1) a) List two phenomena that illustrate the wave nature of light. **(2 marks)**

b) On what factor does the black body radiation depend? **(1 mark)**

c) Define the term black body. **(1 mark)**

2) Choose the correct answer or the suitable term that completes the statement.

a) An example of fossil fuel is:

i) Sediment. ii) Non-renewable. iii) Coal. iv) Hydropower. **(1 mark)**

b) Consider the following statements related to a nuclear power plant.

A: It works on the principle of controlled chain production.

B: The moderator's function is to slow down the fast-moving secondary neutrons produced during fission.

i) **A** is true and **B** is false. ii) Both **A** and **B** are true.

iii) Both **A** and **B** are false. iv) **B** is true and **A** is false. **(1 mark)**

c) The main interest of shielding in nuclear reaction is protection against:

i) Neutrons and gamma rays. ii) Infrared rays.

iii) Alpha, beta and gamma rays. iv) X-rays. **(1 mark)**

d) Which of the following medical condition is caused by the high exposure to radiation?

i) Kidney stone. ii) Blood pressure. iii) AIDS. iv) Mutation. **(1 mark)**

3) Match each element from **column A** with its corresponding element from **column B**. **(4 marks)**

Column A	Column B
a) Jupiter	i) Waxing crescent
b) Right ascension	ii) Inner planet of the solar system
c) Venus	iii) Outer planet of the solar system
d) Phase of the Moon	iv) The angular distance of an object measured eastward from the first point called the Vernal Equinox.

4) Complete each of the following statements using appropriate term from the box.

amplitude	frequency	displacement
period	velocity	restoring force
angular frequency	kinetic energy	

a) The particle's acceleration in a simple harmonic motion (SHM) is proportional to the .....from equilibrium position. **(1 mark)**

b) In SHM, ...acts in the direction opposite to the displacement. **(1 mark)**

c) In SHM, the displacement is maximum when the .....is zero. **(1mark)**

d) The total energy of a simple harmonic oscillator is proportional to the square of ..... **(1 mark)**

5) Indicate whether each of the following statements is **true** or **false.**

a) Bosons obey the Pauli's exclusion principle. **(1 mark)**

b) A baryon is a combination of three quarks. **(1 mark)**

c) Fermion's spin is always a multiple of half integers. **(1 mark)**

d) For a weak force, there is an exchange of photons. **(1 mark)**

6) a) What does LASER stand for in Physics? **(1 mark)**

b) What is meant by the following properties of LASER?

i) Coherence. **(1 mark)**

ii) Collimation. **(1 mark)**

c) Enumerate any one:

i) Application of LASER. **(1 mark)**

ii) Danger of LASER. **(1 mark)**

7) a) How do earthquakes affect people and the environment? **(2 marks)**

b) How can you protect yourself during an earthquake? **(2 marks)**

8) a) Why do people still use analog signals? **(2 marks)**

b) What transmission mode would be the ideal choice for making a phone call? Explain your answer. **(2 marks)**

9) a) How does gravitational force depend on distance between two bodies? **(1 mark)**

b) How are Kepler's laws of planetary motion important to Astronomy? **(3 marks)**

10) A projectile of mass **m** is launched with a launch velocity $\overrightarrow{v_0}$ at an angle θ from the horizontal.

a) Does this projectile undergo a deceleration? Explain. **(2 marks)**

b) How does the launch angle affect the range (horizontal distance attained by the projectile) of the projectile? **(2 marks)**

11) Figure 1 shows three cells each with electromotive force (emf) of 1.5 V in series.

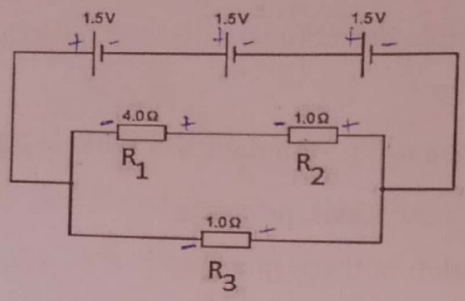


Figure 1

a) Calculate the combined emf of the cells. **(1 mark)**

b) Calculate the combined resistance of the three resistors shown above. **(3 marks)**

c) Find the electric current in the 4.0 Ω resistor. **(2 marks)**

12) A fixed mass of an ideal gas undergoes a cycle **ABCA** of changes, as shown in figure 2.

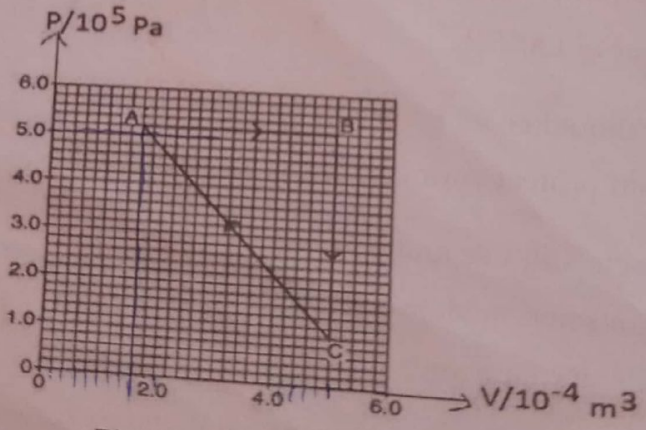


Figure 2

a) Calculate the work done by the system during the change from **A** to **B**. **(2 marks)**

b) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J. Use the first law of thermodynamics to find the change in internal energy of the gas. **(2 marks)**

c) The temperature of the ideal gas at point A is 500 K. Calculate the number of molecules in the fixed mass of the gas. One mole of substance contains 6.022×10^{23} particles (atoms, molecules or ions). **(2 marks)**

13) Analyze the optical fiber below, drawn not to scale (figure 3), and answer related questions. The core has a refractive index equal to 1.5 and the refractive index of cladding is 1.4.

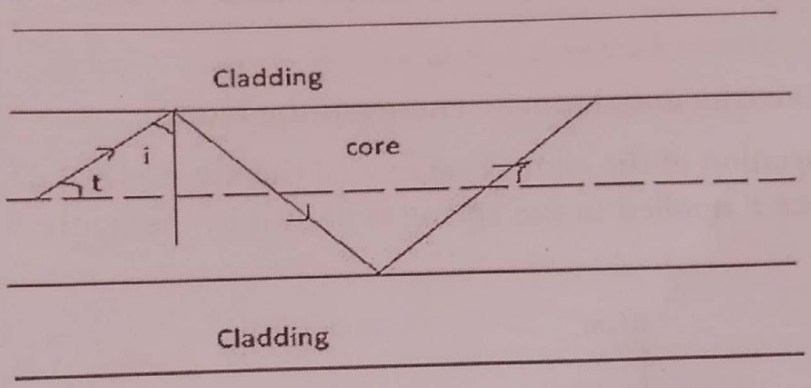


Figure 3

a) What is the speed of light inside the core?
Speed of light in free space C=3 x 10^8 m/s. **(2 marks)**

b) What is the critical angle at the core-cladding interface? **(2 marks)**

c) What is the maximum angle **t** that the rays leaving the source of light should make with the axis of the fiber so that the total internal reflections take place at the core-cladding interface? **(2 marks)**

14) A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m/s along a horizontal surface as shown in the figure 4.

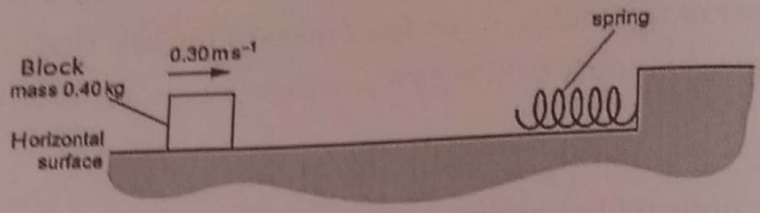


Figure 4

Assume that there are no resistive forces opposing the motion of the block. The block hits a spring. The speed of the block becomes zero when the compression of the elastic spring is 8.0 cm.

a) Calculate the initial kinetic energy of the block. **(2 marks)**

b) The variation of the compression X of the spring with the force *F* applied to the spring is shown in the figure 5.

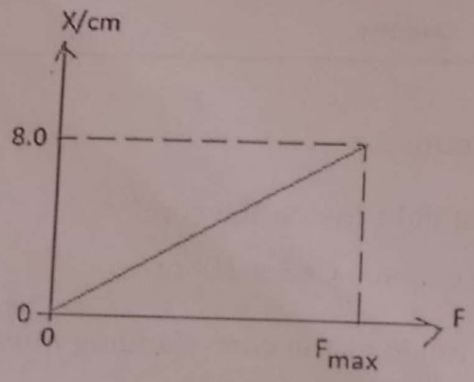


Figure 5

Assume that the elastic potential energy of the spring when its compression is 8.0 cm is equal to the initial kinetic energy of the block. Calculate the maximum force F_{max} exerted on the spring by the block.

(2 marks)

c) What will happen to the block after the collision? Justify your answer.

(2 marks)

15) Consumers have an important role in reducing radiation risks from medical X-rays. Formulate any five questions that a patient may ask himself/herself or health care before undergoing an X-rays investigation in order to reduce the radiation risks. **(5 marks)**

SECTION B: ATTEMPT ANY THREE QUESTIONS (30 marks)

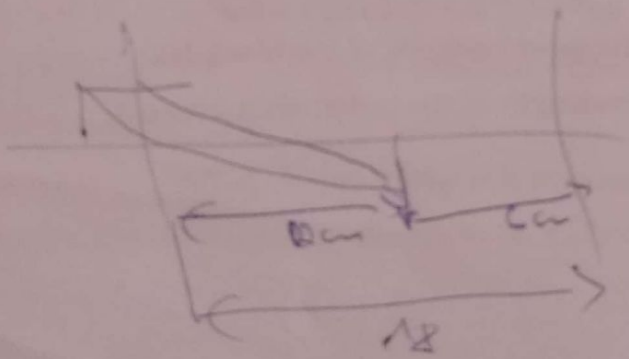
16) A student investigates how the resonant length **L** of a loaded wire varies with frequency f using a sonometer or other apparatus.

It is suggested that f and **L** are related by the equation $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

where **T** is the tension in the wire and **μ** is a constant called linear mass density. Design a laboratory experiment set up to test the relationship between f and **L**.

a) You should draw a labelled diagram showing the arrangement of your equipment. **(4 marks)**

b) In your account you should pay a particular attention to: the procedure to be followed; the measurements to be taken; the control of variables; the analysis of the data; any safety precautions to be taken if need be. **(6 marks)**



17) Analyze the black body radiation curves shown below (figure 6) before answering related questions. **P** is the power density of emitted radiation and λ is the wavelength of the emitted radiation.

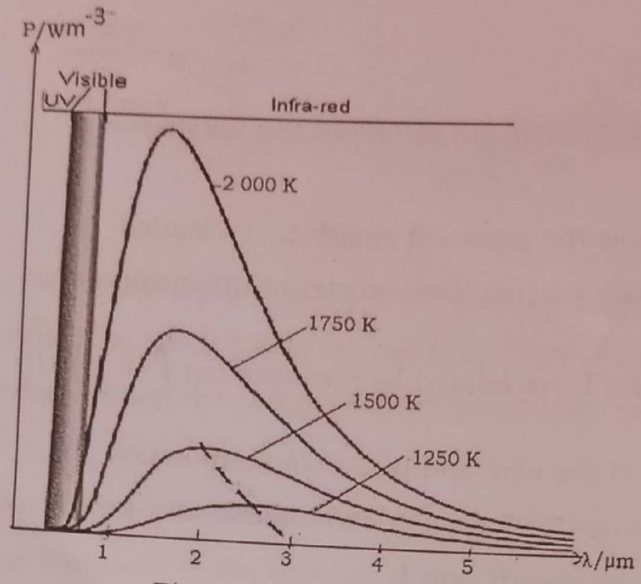


Figure 6

a) How does the power radiated by a black body vary with temperature? **(2 marks)**

b) How does the peak of the wavelength of radiation emitted by a black body vary with the temperature of the black body? **(2 marks)**

c) Determine the maximum/peak wavelength of radiation emitted by the black body whose temperature is 2 000 K. **(2 marks)**

d) None of the graphs touches the x-axis. What does this mean? **(2 marks)**

e) What happens to the power density of the black body radiation as the wavelength of the radiation decreases? **(2 marks)**

18) A toy train with a height of 4.0 cm is placed at 24 cm from a converging lens that has a focal length of 8.0 cm. A second converging lens, identical to the first, is placed at 18 cm from the first lens and on the opposite side of the lens from the train as shown in figure 7.

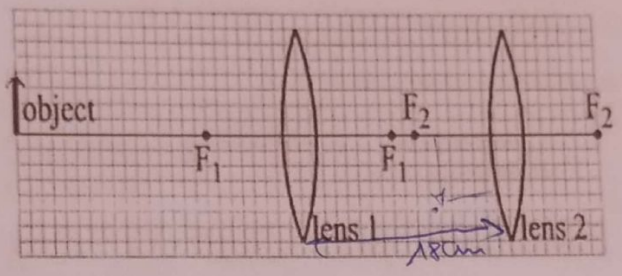


Figure 7

a) Calculate the position of the image created by the first lens. **(2 marks)**

b) Repeat part (a), but for the second lens, to find the position of the final image. **(2 marks)**

c) Use a graph paper to draw a ray diagram to support your calculations. Use appropriate scale. **(2 marks)**

d) Determine the overall magnification of this two-lens system. **(2 marks)**

e) Deduce, from your results, the characteristics of the final image. **(2 marks)**

19) a) A spherical oil drop has a radius of 1.2×10^{-6} m. The density of the oil is 940 kgm^{-3}. Charge of proton e $=1.6 \times 10^{-19}$C and acceleration due to gravity $g=9.81 m/s^2$.

The oil drop is charged. Explain why it is impossible for the magnitude of the electric charge to be 8.0×10^{-20} C. **(2 marks)**

b) The charged oil drop in a) is in a vacuum between two horizontal metal plates, as illustrated in figure 8.

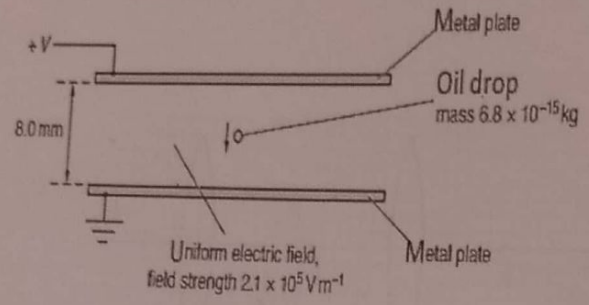


Figure 8

The plates are separated by a distance of 8.0 mm. The electric field between the plates is uniform and has a field strength of 2.1×10^{5} Vm^{-1}. The oil drop moves vertically downwards with a constant speed.

i) Show that the oil drop is in equilibrium or not. **(2 marks)**

ii) Calculate the potential difference V between the plates. **(2 marks)**

iii) Someone calculated the charge of the oil drop and found + 3.2 x10^{-19} C because the oil drop moved vertically downwards. Evaluate his/her results. **(2 marks)**

c) What will happen to the motion of the oil drop if the magnitude of the potential difference between the plates in b) is decreased? Justify your answer. **(2 marks)**

20) a) i) What do Compton effect and the Photoelectric effect prove? **(1mark)**

ii) Identify one limitation of Bohr's Atomic model theory. **(1mark)**

b) A photon of wavelength 6.50×10^{-12} m is incident on an isolated stationary electron as illustrated in figure 9.

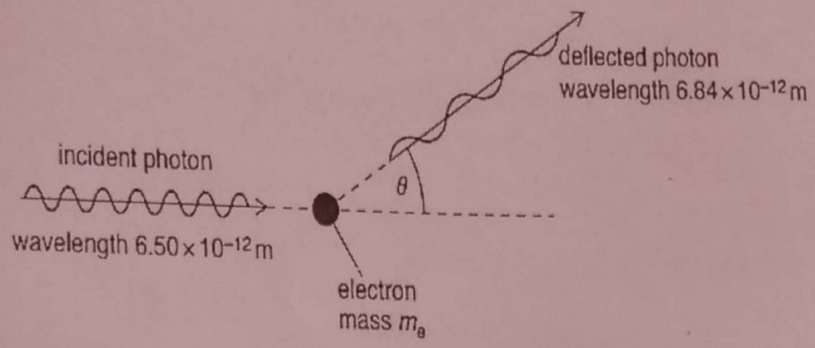


Figure 9

The photon is deflected elastically by the electron of mass m_e. The wavelength of the deflected photon is 6.84×10^{-12} m.

i) Calculate the angle of deflection θ. **(2 marks)**

ii) Use energy considerations to suggest why the change in wavelength of the photon $\Delta\lambda$ must always be positive. **(1 mark)**

c) The lowest electron energy levels in an isolated hydrogen atom are shown in figure 10.

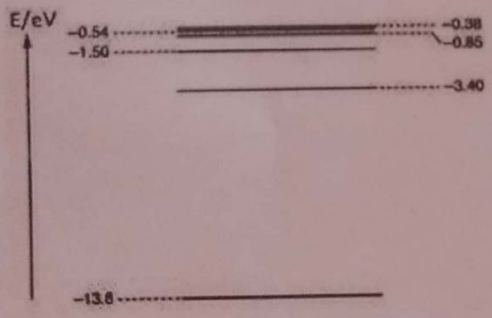


Figure 10.

An electron is initially at the energy level –0.85 eV.

i) State the total number of different wavelengths that may be emitted as the electron de-excites (loses energy). **(1 mark)**

ii) Photons resulting from electron de-excitation from the –0.85 eV energy level are incident on the surface of a sample of platinum. Platinum has a work function energy of 5.6 eV. Determine:

- The maximum kinetic energy, in eV, of a photoelectron emitted from the surface of the platinum. **(2 marks)**
- The wavelength of the photon producing the above photoelectron. **(2 marks)**

-END-