Provincial Department of Education, Northern Province

Pilot Exam – October 2021

Physics – II

Part II B (Essay)

Answer four questions only

(Gravitational acceleration g=10 m s^{-2})

5. (a)

The viscous force F acting on a small sphere of radius a moving with velocity V through a liquid is given by F = 6πηaV where, η is viscosity of the fluid. Show that if the sphere moves with a terminal velocity V then the relation between these quantities can be written as

$$\frac{V}{a^2} = A\,\rho - B$$

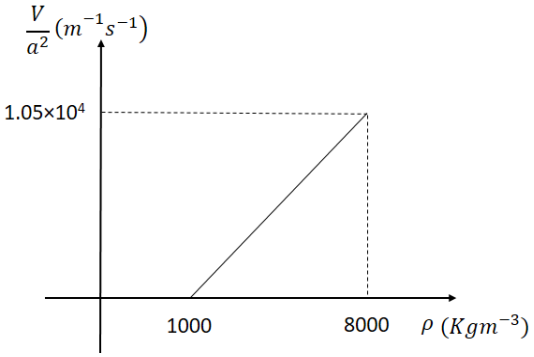
where, ρ is the density of the sphere. Illustrate the constants A and B and identify the additional usual terms.The following figure shows the graph of $\frac{V}{a^2}$ versus ρ obtained from such an experiment.

(i) Calculate the slope and intercept of the graph

(ii) Find the viscosity and density of the fluid using the quantities from the above part (i)

(iii) If, $\rho = 7500Kgm^{-3}, V = 0.39ms^{-1}$ find the value of a.

(iv) What happens to the value of A if the liquid is at a temperature higher than that tested here. Explain the answer



(b)

Poiseuille's formula for the volume 'V' of a liquid of density 'ρ' flowing in time 't' through a capillary tube of length 'L' and radius 'r' under a pressure difference 'P' between the ends of the tube is $\frac{V}{t} = \frac{\pi r^4 \rho}{8\eta l}$ where, $\frac{\rho}{l}$ – Pressure gradient, η –viscosity of the fluid.

A patient has to inject 10 $cm^3$of fluid into his blood vessel every 10 seconds using an injection.The average blood pressure in a vessel is $10mmHg$higher than the atmospheric pressure. The syringe has a needle with 2cm long and 0.05 cm inner radius.

(i) Find the pressure required to inject the liquid into the air in mmHg

(ii) What is the pressure required to inject the fluid into the patient?Viscosity of the fluid is $1x10^{-3}Nsm^{-2}$ and density of mercury is$13600Kgm^{-3}$.

6.

a) Draw the wave pattern of first over tone in a stretched string. Write down expression of its frequency in terms of length of string *l*, mass per unit length m and tension in the string T.

b) A vibrating source X resonates with a one end closed pipe with fundamental tone and a string of length three times of length of the one end closed pipe with first over tone. At another situation other vibrating source Y resonates with a two end opened pipe of length four times of the one end closed pipe with fundamental tone and the same string in different tension with first over tone. When X and Y are vibrates together, the beat frequency is 200 per second. Speed of sound is 300m s^{-1} (Neglect end correction) Find

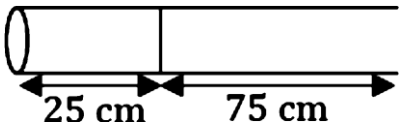
i) Lengths of two tubes and string.

ii) Frequencies of the sources X and Y.

iii) Speed of waves in strings at the above two situations.
iv) Ratio of tensions of strings at the above two situations.

c) An air column of an opened tube of length 100cm is vibrates by using a vibrating source at one end. Frequency of source increases from 0 to 1000Hz gradually. Speed of sound is 300m s^{-1} and neglect end correction.

i) Find resonance frequencies of air in the pipe with source.
ii) Draw variation of sound intensity level with frequency of source.
iii) A renewable thin metal plate is attached at a distance 25cm from one end as shown in the figure. Again, frequency of source increases from 0 Hz to 1000 Hz gradually. Find resonance frequencies of air in the pipe with source. Draw the wave pattern of standing waves corresponding to the pipe. (Assume that node of displacement is formed at thin metal plate.)



d) Sound intensity level is 40dB when resonate in first over tone of one end closed pipe. Sound intensity level is 90dB when resonate in fundamental tone of the tube. Find the increasing factor of sound intensity.

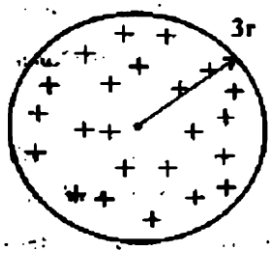
7. An isolated spherical conductor is charged positively.
a) Draw the spherical conductor on your answer script and
i) Draw the lines of electric force of the conductor. (Denote it by E.)
ii) Draw the equipotential surfaces on the conductor. (Denote it by V.)

b) Consider a charged spherical conductor, at any points above this conductor is same as a point charge at the center of it. Potential due to charged spherical conductor at a point with respect to the distance from center of conductor was measured. These values are given bellow.

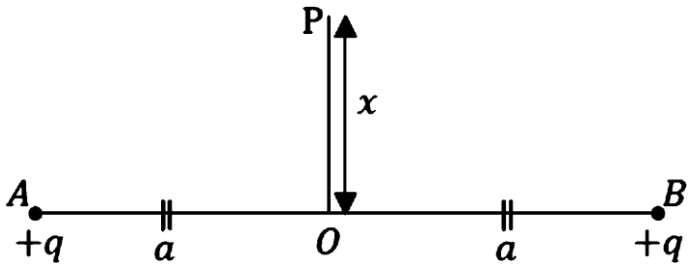
Distance x (cm)	Potential V
19	1.50×10^5
25	1.14×10^5
32	0.89×10^5
39	0.73×10^5

i) Show that the potential V is proportional to the distance x by using the given data, without drawing a graph.
ii) If the potential on the surface of the conductor is 1.9×10^5V then find radius of sphere.
iii) Find the charge on the conductor by using the answers in part (ii)

c) An insulating solid sphere of radius 3r is charged uniformly as shown in the figure. Charge density is ρ.
i) Find an electric field strength at a point that is in a distance x from its center when $x<3r$
ii) Find an electric field strength at a point that is in a distance x from its center when $x \geq 3r$
iii) Find an electric potential at a point that is in a distance x from its center when $x>3r$



d.



i) Two charges of charge +q are placed at points A and B as shown in the figure. Show that an electric field intensity at point P a distance x from a perpendicular bisector of AB is,

$$\frac{2qx}{4\pi\epsilon_0(x^2+a^2)^{\frac{3}{2}}}$$

ii) Find the electric force on an electron, when that electron is placed at *P*. (*e*- charge of anelectron)

iii) If $(x^2 + a^2)^{\frac{3}{2}} \simeq a^3$ show that the electron performs in a simple harmonic motion through PO and show that angular frequency of simple harmonic is

$w = \sqrt{\frac{2qe}{4\pi\epsilon_0 a^3 \mathrm{m}}}$ (m-mass of an electron.)

e. i) The distance between two horizontal plates is 10mm and potential difference is 500V. Find electric field intensity between two plates.

ii) Now positively charged oil drop of charge 1.6×10^{-19} C is in equilibrium. Find the mass of an electron. Denote the direction of electric field between the plates. .

iii) If the polarity of potential difference between the plates will interchange, find acceleration of charge.

8) a) Capacitance of an electric cell is measured by ampere hour (Ah). This capacitanceis given by the product of average discharge current and time taken for discharge. The characteristic of four different lead- acid cells (accumulators) are given bellow.

E,M.F (V)	Capacitance (Ah)	Maximum discharge Current (A)	Internal resistance (Ω)
12	3	60	0.14
12	6	80	0.07
12	10	80	0.042
12	20	100	0.021

Initially these cells (accumulators) must charge by a source with constant voltage. The suitable steady voltage is 13.8 V, to charge a cell of voltage 12V at 20°C. These cells should not be used in a place where the pressure is bove 4atm. (1atm = $4x10^5$Pa). If the pressure will increases above $4x10^5$Pathen the cell damages.

i) Give the value of 1 Ah in Coulomb.

ii) A lead- acid cell (accumulator) is in a sub marine. What is the depth of sub marine from water level to travel, for the cell without damage? (Density of water = 1000 kg m^{-3}).

iii) *a*) By using given table write down relation between internal resistance of the cell and the capacitance.

b) Generally, What will you say about the internal resistance of the cell?

c) Find internal resistance of accumulator of E.M.F 12V and capacitance 14 Ah.

iv) A fully discharged accumulator of capacitance 3.0Ah is charged by a steady current of 0.6A. What is the time taken for charging?

b) An uncharged battery of E.M.F 12V can charge from an ideal power supply of 16V. A steady current of 0.4A send through the cell for 90 minute. Its internal resistance is 5Ω.

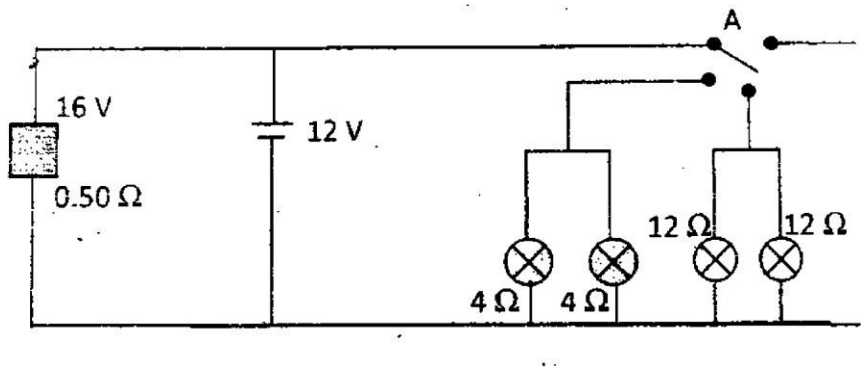
i) Draw an electrical circuit with a suitable resistance to this purpose. Indicate positive terminals of power supply and battery as (+)

ii) Calculate the charge capacitance of this battery in (Ah).

iii) When 5 hour charging, find the value of current will send through the battery in this time.

iv) When 5 hour charging, find resistance of the circuit.

c) Usually in cars, to supply current, a battery of E.M.F 12V and a generator of E.M.F 16V connected in parallel are used. The figure shows a part of electrical circuit of a car. Internal resistanceof cell is negligible. Internal resistance of the generator is 0.5Ω. Two head lights and two side lights are connected in circuit with switches.



i) Identify head lights and side lights.

ii) What is the use of three way key A?

iii) When generator works, what is the current through it?

iv) What is the generating power of generator?

v) What is the supply power of generator?

vi) When head lights works, find current through each head light.

vii) Find total power supplied by two head lights.

viii) In above (b), assume that there is no current supplied to other parts of the car, deduce that currentthrough the battery. What happened at this situation?

ix) When car works, if the power is supplied to other portion of car is 12 W, what happened for batterywhen head lights and side lights are in working condition?

9) a) Specific heat capacity of gas Cp at constant pressure is greater than specific heat capacity of gas Cv at constant volume. Explain it.

b) Thickness of wall is 10cm and area is $120m^2$ of a room. Heat transformation by roof and floor of roof is negligible. Some students are in room. Heat is released at an average rate of 10W from each student. Temperature of air and relative humidity are maintained at 20^oC and 40% respectively by using an air conditioner in the room. Temperature of the outside of the wall is 30^oC. Heat conductivity of brick in the wall is 0.6 w m^{-1} K^{-1}.

i) Find the rate of heat transformation from outside to inner side of the room.

ii) If heat is released at the rate of 7.6 KW from the room by using an air conditioner, Find number of student in the room.

iii) When the air conditioner is off, pressure of air in the room is 10^5N m^{-2}. Specific heat capacity of 1 mole gas is 3R/2 at constant volume. R is universal gas constant. Volume of air inside the room is $117.2m^3$

a) Calculate the number of mole of the air, in the room in terms of R.

b) In the above situation, if heat is absorbed only by the air , find rate of increase in temperature of air.

c) Steam of water is released at the rate of 4.688×10^{-4} kg s^{-1} by perspiration and breathe out, of a student. Find initial increasing rate of relative humidity of air in room at 20^oC. (Density of saturated water vapour is 16 g m^{-3} at temperature 20^oC)

iv) Again, the air conditioneris started to work and and the temperature of air and relative humidity are maintained at 20^oC and 40% respectively. Find the mass of water steam is removed by air conditioner in 5 minute.

10. (a) Figure (i) shows symbol of bipolar transistor and figure (ii) shows symbol of unipolar transistor.

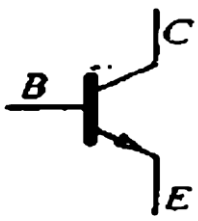


Figure (i)

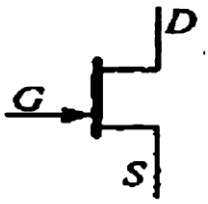


Figure (ii)

i) Explain the function of bipolar transistor and function of unipolar transistor.

ii) When a battery is connected across the terminals B and E in figure (i) and connected across the terminals G and S in figure (ii) denote the polarity of battery.

iii) Draw the characteristic curve of V_{CE} verses I_C graph for common emitter configuration of a npn transistor for three constant values of particular parameter. Denote that cut off region, and saturated region on the graph.

iv) *a*) Draw the characteristic curve of V_{DS} verses I_D graph of a field effect transistor for three constant values of particular parameter. Denote that cut off region, saturated region and transistor region on the graph.

b) Why the graph shows linear variation for small values of V_{DS}, in transistor region of V_{DS}verses I_D graph?

c) When V_{GS}=0 , draw the variation of I_D with V_{DS}. Also denote pinch off point and pinch off voltage Vp on the graph.

(b) The basic energy source is the sun. Solar power is spread throughout the world is in the form of electromagnetic wave. The waves have some special properties. One of the fundamental properties is diffraction. The diffraction of light is confirmed by Young's double-slit experiment. However, some of the appearences such as solar radiation spectrum and photoelectric effect cannot be explained by the wave theory. But it can be explained by the hypothesis of photon theory which is proposed by Einstein. It shows that the waves have particle nature, and it can be explained by photoelectric effect. The energy of the photon is given by $E = hf$. Where, h is the plank constant and f is the frequency of the wave.

The de Broglie proposed that "If the particles have wave-nature, the waves have particle-nature (wave-particle duality)".

When an electron beam passes through a small hole ($10^{-11}\ m$), the beam gets diffracted as the wave, which is shown by the experiment. Let the particle has the momentum P, then the de Broglie wavelength of the particle motion is given by $\lambda = \frac{h}{p}$.

The diffraction is the most important thing when we learnt the properties of molecular/nuclear structures by using microscopes. But when we study the properties of the large objects it is not necessary to consider the effect of refraction. In order to observe the diffraction, the length of the hole (or blocks) should be in the order of wavelength of the wave.

The electron microscope is based on the wave-nature of the electron. This is similar to the function of light microscope. Here, the electron beam is used instead of ight. The final image is focused by the electro magnetic field, and will be obtained on the fluorescence screen.

In the electron microscope, the wavelength of the electron is $\sim 2 \times 10^{-10} m$ which is very smaller than the wavelength of the light ($\sim 10^{-7} m$). Therefore, we can observe the objects with higher magnification with higher resolving power.

The electron beam can be travelled through the sub-nuclear space and can be diffracted. Using this diffraction angle the atomic structure can be studied.

a) Give three properties of the waves apart from the diffration.

b) Which of the followings show both wave-nature and particle-nature?
   A. visible light
   B. X-ray
   C. electron beam

c) What should be the diameter of the hole used to diffract the micro-wave which having wavelength of $3\ cm$.

d) Define h and f in the particle-nature equation $E = hf$.

e) Prove that, de Broglie wavelength is given by $\lambda = \frac{h}{mc}$ using Einstien equation $E = mc^2$, $E = hf$ and $f = \frac{c}{\lambda}$ where, c is the speed of light.

f)
   i. A mass of $50g$ moving with the velocity $40\ ms^{-1}$. Find the de Broglie wavelength? $h = 6.3 \times 10^{-34}\ Js$.
   ii. How did you explain the wave-nature is not important for big particles?.

g)

i. An electron is at rest, which is accelerated by the potential difference V. Show that the final velocity of the electron is $u = \sqrt{\frac{2Ve}{m}}$. (where m, e are the mass and charge of the electron respectiely).

ii. Write down the expression for the de Broglie wavelength (λ) interms of e, m, V.

iii. In graphite, the spacing between the atomic layers is $1.05 \times 10^{-10} m$. What is the potential difference is required to diffract the electron beam? $(e = 1.6 \times 10^{-19},\ m_e = 9 \times 10^{-31}\ kg)$.

h)

i. In an electron microscope, an electron beam passes through a perpendicular uniform magnetic flux density of $2.4\ T$. Find the magnetic force on the electron beam?.

ii. Find the radius of the electron by the magnetic force?.

i) How to show the wave-nature of the electrons?.

j) An electron is accelerated by $200\ V$. Find the following.

i. Kinetic energy

ii. Momentum

iii. de Broglie wavelength.