CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)
NORTHERN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)

FORM SIX PRE-NATIONAL EXAMINATIONS 2026
131/2 PHYSICS 2
MARKING SCHEME

1. (a) (i) Disorderly flow is the fluid flow in which the speed and direction of particles at any point vary with time WHILE Steady flow is the flow in which the speed and direction of flowing particle at a given point are the same at that time. (02 marks)

(ii) Compressible fluid is the fluid whose density changes with change in its pressure WHILE Incompressible fluid is the fluid whose density remains constant with change in its pressure ....(02 marks)

(iii) Critical velocity is the velocity of a fluid up to which the flow is steady and above which the flow is turbulent. WHILE Terminal velocity is the constant velocity attained by a body falling through a viscous fluid...(02 marks)

(b) (i) The equation of continuity is based on the conservation of mass. i.e the mass of the fluid entering the pipe is equal to the mass of the fluid leaving the pipe at the same time. (02 marks)

(ii) given; radius at $R_A = 0.3$ m, radius $R_B = 0.1$ m, pressure difference $\Delta P = 1$m of water

From the equation of continuity $V_1 = \left(\frac{r_2}{r_1}\right)^2 V_2$

$V_1 = 0.33V_2$..............................01 mark

For a non-viscous, incompressible fluid of density ρ, and in a horizontal steady flow.

$h_x = h_y = h$

so equation of Bernoulli's becomes,

$$P_x + \frac{1}{2}\rho v_x^2 + \rho gh = P_y + \frac{1}{2}\rho v_y^2 + \rho gh$$

$$\text{Then, } P_x + \frac{1}{2}\rho v_x^2 = P_y + \frac{1}{2}\rho v_y^2$$

$$\text{Hence, } P + \frac{1}{2}\rho v^2 = \text{constant}$$

From Bernoulli's equation for the horizontal pipe

$$\rho gh = \Delta P = \frac{1}{2}\rho(V_2^2 - V_1^2)$$

$$V_2 = \sqrt{\frac{2 \times 9.8 \times 1}{0.88911}}$$

$V_2 = 4.6951\ ms^{-1}$ or $V_1 = 0.495\ ms^{-1}$ ....01 mark

The area $A_2 = \pi r_2^2 = 0.0314\ m^2$

Hence the rate of flow $Q = V_2A_2 = 0.1475\ m^3s^{-1}$ .... 01 mark

Therefore velocity V = 10 x λ = 10 x 0.17 = 1.7 m/s or 170 m/s..............................01 mark

Period T

Period, $T = \frac{1}{f} = \frac{1}{10} = 0.1sec$ .... 01 mark

(ii) Phase difference, $\theta = \frac{2\pi x}{\lambda}$

$= \frac{2 \times 3.14 \times 0.02}{0.17} = 0.74\ rad/s$............................01 mark

(c)(i) Doppler's principle and its application

- When the source approaches the listener or the listener approaches the source, or both approach each other, the apparent frequency is higher than the actual frequency of the sound produced by the source
- Similarly when the source moves away from the listener or when the listener moves away from the source, or when both move away from each other, the apparent frequency is lower than the actual frequency of the sound produced by the source

…………………..01 mark

Application of Doppler Effect

- Doppler shift in ultra-sound reflected from moving body tissues allows measurement of blood flow
- It is commonly used by obstetricians to detect foetal heart muscle pulsates
- Similarly, sonar makes use of the Doppler effect in determining the velocity of a submarine relative to a ship
- The electromagnetic waves, including light, are also subject to the Doppler Effect
- In air navigation, radar works by measuring the Doppler shift of high frequency radio waves reflected from moving aero-planes.
- The Doppler shift of star-light allows us to study stellar motion. When we e xamine light from stars in a spectrograph, we observe several spectral lines.

any one application ....01 mark

(ii) $v = \frac{c\Delta f}{2f\cos\emptyset}$..01 mark

$$v = \frac{1500 \times 3200}{2 \times 4000000\cos 30}$$

$V = 0.69ms^{-1}$..................................01 mark

Volume rate of blood flow$= \frac{\pi d^2}{4} v = 1.4 \times 10^{-6} m^3 s^{-1}$..................................01 mark

(d)(ii) The diameter of p^{th} and $(p+10)^{th}$ bright rings are given by

$$D_p^2 = 4RL(p + \frac{1}{2})$$

$$D_{p+10}^2 = 4RL(p + 10 + \frac{1}{2})$$ ....01 mark

$$D_{p+10}^2 - D_p^2 = 4RL(p + 10 + \frac{1}{2}) - 4RL(p + \frac{1}{2})$$

$$R = \frac{D_{p+10}^2 - D_p^2}{40\lambda}$$

Substituting the given values it is clear that $R = 1.5m$..............................01 mark

When the space between the glass and lens was filled with liquid with refractive index μ and λ is the wavelength of light in air while L_L is the wavelength of light in liquid

$$D_p^2 = 4RL_L\,(p+\tfrac{1}{2}) = \tfrac{4R}{\mu}(p+\tfrac{1}{2})$$

$$D_{p+10}^2 = 4RL_L\,(p+10+\tfrac{1}{2}) = \tfrac{4R}{\mu}(p+10+\tfrac{1}{2})$$ ....01 mark

$$D_{p+10}^2 - D_p^2 = \frac{40R\,\lambda}{\mu}$$

$$\mu = \frac{40R\,\lambda}{D_{p+10}^2 - D_p^2}$$

Substituting the given values it is clear that $\mu = 1.327$ ....02 mark

3 (a)(i) Kinetic theory of gases states that " all gases consists of molecules or atoms which are in continuous random motion" ....02 mark

(ii) assumptions on deriving kinetic theory of gases

- The total volume of the molecules is negligible compared with the volume of the container
- The force of attraction between gas molecules is negligible
- The collision between gas molecules is elastic collision
- A sample of gases consist of a large number of identical molecules for statistical to be applied.................................02 mark@ 0.5 mark

(iii) Given the initial conditions, $P_1 = 15$atm, $V_1 = 30$litres, $T_1 = 27°C = 273K$

After removing some oxygen Final conditions, $P_2 = 11$atm, $V_2 = V_1 = 30$litres, $T_2 = 17°C = 290K$

From ideal gas equation PV = nRT, but $n = \dfrac{M}{M_R}$ ....01 mark

Then $PV = \dfrac{MRT}{M_R} \Rightarrow M = \dfrac{PVM_R}{RT}$ ....01 mark

Mass withdrawn $\Delta M = \dfrac{P_1V_1M_R}{RT_1} - \dfrac{P_2V_2M_R}{RT_2}$ ....01 mark

mass withdrawn

$$\Delta M = \frac{15\times101300\times0.03\times0.032}{8.31\times300} - \frac{11\times101300\times0.03\times0.032}{8.31\times290} = 0.141kg = 141.0g$$

Therefore mass of oxygen withdrawn = 141.0g.................................01 mark

(b)(i) Mean free path is the average distances a molecules travels between collisions. **WHILE**

Collision frequency is the number of collision made by molecules per second.................................. 02 mark

(ii) Given the diameter of argon, d = 0.3Angstron = 0.3×10^{-10}m, number of moles, n = 1mole,

pressure at S.T.P = 101300N/m^2 temperature at S.T.P = 273K, mean free path is given by

$$\lambda = \frac{KT}{\pi\sqrt{2}d^2P}$$

…………..01 mark

$$\Rightarrow \frac{1.38\times10^{-23}\times 273}{\pi\sqrt{2}(0.3\times10^{-10})^2\,(101300)} = 9.3\times10^{-6}\,m$$

Therefore mean free path is $9.3\times10^{-6}\,m$ .... 01 mark

Collision frequency is given by $f = \dfrac{V}{\lambda}$ but $V = \sqrt{\dfrac{3RT}{M_R}} = \sqrt{\dfrac{3\times8.31\times 273}{40\times10^{-3}}} = 412.6m/s$

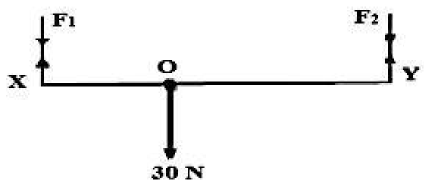
Then collision frequency $f = \dfrac{412.6}{9.3\times10^{-6}} = 4.44\times10^{7}\,s^{-1}$

… …………..01 mark

(c)(i) tensile stress is the tensile force per unit perpendicular cross-sectional area,.................................. 01 mark

(ii)

Consider the fig. below



Extension is given by $e = \dfrac{FL}{AE}$.............................. 01 mark

Since the rod remain horizontally.

$e_x = e_y$.................................. 01 mark

$\dfrac{F_xL_x}{A_xY_x} = \dfrac{F_yL_y}{A_yY_y}$ but $L_x = L_y$ and $A_x = A_y$ …………………..01 mark

$$\frac{F_x}{Y_x} = \frac{F_y}{Y_y}\text{.......................................(i)}$$

By principle of moment

Clockwise moment = anticlockwise moment.

$30 \times (OX) = F_y \times (OX + OY)$..............................(ii)................................... 01 mark

$$\text{but } \frac{OY}{OX} = 2$$

Then $F_Y = 10N$ and $F_x = 20N$

Therefore from equation (i) we have $Y_y = \frac{Y_x}{F_X} \times F_y = \frac{1.0 \times 10^{11} \times 10}{20} = 5 \times 10^{10}\ Pa$

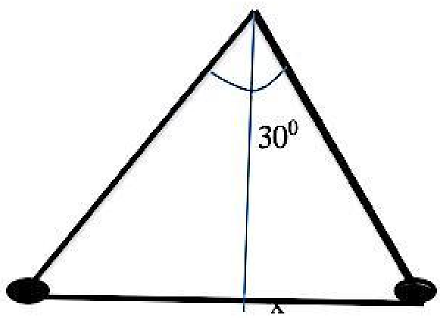
Young's modulus of a wire $y = 5 \times 10^{10}$Pa .... 02 mark

4. (a) (i) – it holds for stationary point charges only................................01 mark

- it does not give the direction of Coulomb's force................................01 mark

(ii), Referring to the figure , the coulomb force between the sphere in air is

$$F = \frac{q^2}{4\pi\varepsilon_0 x^2}$$ ....01 mark



in liquid

$$F = \frac{q^2}{4\pi K\varepsilon_0 x^2}$$ ....01 mark

$$Weight\ of\ sphere\ in\ air = mg$$

Apparent weight of sphere in liquid= $mg\left(1 - \frac{\acute{\rho}}{\rho}\right)$

Where ρ is density of material of sphere and $\acute{\rho}$ is density of liquid

For equilibrium of vertical and horizontal forces , let T be tension in air and $\acute{T}$ be tension in liquid

$$T\sin\theta = F\ and\ T\cos\theta = mg$$

$$\acute{T}\sin\theta = F\ and\ \acute{T}\cos\theta = mg\left(1 - \frac{\rho}{\bar{\rho}}\right)$$ .... 01 mark

Dividing each of four eqns

$$tan\theta = \frac{F}{mg} = \frac{F}{mg(1-\frac{\rho}{\rho})}$$ .... 01 mark

$$\frac{F}{mg} = \frac{F}{mg\,(1-\frac{\rho}{\rho})}$$

$$F = \frac{F}{(1-\frac{\rho}{\rho})}$$

$$\frac{q^2}{4\pi\varepsilon_0 x^2} = \frac{q^2}{\frac{4\pi K\varepsilon_0 x^2}{(1-\frac{\rho}{\rho})}}$$ .... 01 mark

$$1 = \frac{1}{K\,(1-\frac{\rho}{\rho})}$$

$$K = \frac{1}{(1-\frac{\rho'}{\rho})}$$

$$K = \frac{1}{(1-\frac{0.8}{1.6})}$$

$$K = \frac{1}{(1-0.5)} = 2$$ .... 01 mark

(b) (i) Potential energy of proton –electron system is; $U = \frac{q_1 q_2}{4\varepsilon_o r}$ .... 01 mark

q1 = 1.6 x 10-19 C q2 = -1.6 x 10^{-19} C, r = 0.53Å = 0.53 x 10^{-10} m. $\frac{1}{4\varepsilon_o} = 9 \times 10^9$

$$U = \frac{9 \times 10^9 (1.6 \times 10^{-19}) \times (1.6 \times 10^{-19})}{0.53 \times 10^{-10}} = -43.47 \times 10^{-19}\ \text{J} = -27.2\ \text{eV}$$ .... 02 mark

(ii) Kinetic energy = $\frac{1}{2}U = \frac{1}{2} \times 27.2\ \text{eV} = 13.6\ \text{eV}$ .... 01 mark

Therefore, total energy E = P.E + K.E = -27.2 eV + 13.6 eV = - 13.6 eV....... 01 mark

The amount of energy to be done for the total removal of the electron is + 13.6eV

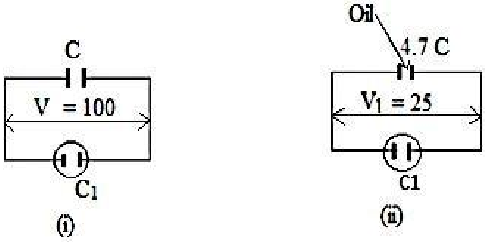
.... 01 mark

(c) Radius of the circular plates r = 10 cm, distance between the plates d = 2 mm ,

Voltimeter readings V = 100 V. c_o = 4.7, second voltimeter reading V_1 =25 .

(i) Required to calculate the capacitance of the voltimeter.

Solution



Suppose V is the initial p.d across the air capacitor and voltimeter, and let C1 be the voltimeter capacitor and C be the plates capacitance.

Then Total charge = $CV + C_1V = (C + C_1)V$ ....(i) ....01 mark

When the plates are filled with oil, the capacitance increases to 4.7 C, and the p.d falls to V1 but the total charge remains constant.

$4.7CV_1 + C_1V_1 = (C + C_1)V$

$(4.7\,C + C_1)\,V1 = (C + C_1)V$ ....(ii) ....01 mark

$$\frac{4.7\,C + C_1}{C + C_1} = \frac{V}{V_1} = \frac{100}{25} = 4$$

Therefore, $0.7C = 3C_1$, hence $C1 = \frac{0.7\,C}{3} = \frac{7}{30}C$

But $C = \frac{\varepsilon_0}{Ad}$ where A is in m^2 and d is in metres

$$C = \frac{8.85 \times 10^{-12} \times \ \times (10 \times 10^{-2})^2}{2 \times 10^{-3}} F = 1.4 \times 10^{-10}\ F$$ .... 01 mark

Therefore, $C1 = \frac{7}{30} \times 1.4 \times 10^{-10}$ F ....01 mark

(ii) The assumptions made in arriving to the answer are

- The voltage recorded by the voltimate is proportional to the scale reading
- Total charge is constant..............................01 mark
- P.d Is the same for both capacitors ....01 mark

5.(a) (i)Magnetic force: Is a cross product of the velocity vector of the charged particle and the magnetic field vector (i.e $F = qv \times B$ ....02 mark

Magnetic field strength

The S.I unit of magnetic field strength is Tesla T or $1kgA^{-1}s^{-2}$ ....01 mark

(ii) Data given,

Magnetic field strength $B = 2.0 \times 10^{-5}$ T

Current, I = 1A

Field due to current in a wire = $\frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7}) \times (1.0\ A)}{2\pi \times (0.01m)} = 2.0 \times 10^{-5}\ T$ ....02 mark

Therefore, total field at A = 2.0×10^{-5} T + 2.0×10^{-5} T = 4.0×10^{-5} T................. 01 mark

Total field at B = 2.0×10^{-5} T - 2.0×10^{-5} T = 0.0............................01 mark

(b) (i) Lenz's law of electromagnetic induction states that; The magnitude and direction of the induced EMF is such that the current which it causes to flow (or would flow in a closed circuit) opposes the change which is producing it ($E = N\frac{d\varphi}{dt}$)...............................02 mark

Or The magnitude of induced E.M.F is direct proportional to the rate of change of magnetic flux linking the coil

(ii) current, I = 1.2 mA, R = 10 Ω

Rate, $\frac{d\varphi}{dt}$ = ?

$E = N\frac{d\varphi}{dt}$ but E = IR=$1.2 \times 10^{-3} \times 10 = 1.2 \times 10^{-2}$ V, N = 1 ....01 mark

Therefore, $\frac{d\varphi}{dt} = \frac{e}{N} = \frac{1.2 \times 10^{-2}}{1} = 1.2 \times 10^{-2}\ Wb/sec$.............................03 mark

(c) Given magnetic induction, B = 1.2 Tesla, radius of a circle, R = 49 cm = 0.49m

(i) Speed of the particle V = ?

(ii) Kinetic energy of the particle = ?

(i) From $Bev = \frac{mv^2}{r}$, therefore, $v = \frac{Ber}{m}$............................01 mark

$V = \frac{1.2 \times 1.6 \times 10^{-19} \times 0.49}{9.1 \times 10^{-31}\ kg} = \frac{9.408 \times 10^{-19}}{9.1 \times 10^{-31}}$

V = 1.03×10^{12} m/s............................ 02 mark

Kinetic energy= $\frac{1}{2}mv^2$ .... 02 mark

(d) (i) Curie's temperature is the temperature at which ferromagnetic material changes to paramagnetic .... 01 mark

(i) Hysterisis is the lagging of magnetic flux density behind the magnetizing force .... 01 mark

6(a)(i) No, it is not necessary that if energy supplied to an electron is more than work function, the electron will come out. The electron after receiving energy may lose energy to the metal due to collisions with atoms of metal. Therefore most of electrons get scattered into the metal. Only few electrons in the metal may come out of metal surface for whom the incident energy is greater than work function of metal ....02 mark

(ii) - on reducing the distance the intensity increases. Photoelectric current increases with increase in distance ....01.5 mark

- stopping potential is independent of intensity and therefore remains unchanged ....01.5 mark

(b) (i) Why are the energies of various energy levels of hydrogen are negative.

The reason is that, an atom of hydrogen consists of proton its nucleus and an electron around it. The two particles are held together by the columbic force of attraction. When the electrons and the nucleus are at the infinite distance apart, they do not interact with each other. The energy of the electron and the nucleus when are separated from each other by infinite distance is arbitrary taken as zero. When the two particle are brought close to each other, the attraction interaction starts developing. Due to this interaction a certain amount of energy is released. Thus the energy of the system fall below zero (i.e. energy becomes negative)

OR

Negative energy shows that an electron is bound to atom........................... 01 mark

(ii) Total energy of electron in Hydrogen atom is;

$E = -13.6eV = -13.6 \times 1.6 \times 10^{-19}\ J = -2.2 \times 10^{-18}\ J$............................01 mark

But, $E = \frac{e^2}{8\pi\varepsilon_o r}$......................01 mark

Therefore, $r = \frac{e^2}{2(4\pi\varepsilon_o)E} = \frac{-9 \times 10^9 \times (1.6 \times 10^{-19})^2}{2 \times (-2.2 \times 10^{-18})} = 5.3 \times 10^{-11}\ m$........................... 01 mark

Velocity, $v = \frac{e}{\sqrt{4\pi\varepsilon_o m r}}$, where, $m = 9.1 \times 10^{-31}$ kg

$V = \frac{1.6 \times 10^{-19}}{\sqrt{\frac{9.1 \times 10^{-31} \times 5.3 \times 10^{-11}}{9 \times 10^9}}} = 2.2 \times 10^6\ m/s$............................02 mark

(c) (i) **Binding energy of atom:**

- Is the energy required to break up the nucleus into its components of protons and neutron ....01 mark

Mass defect of atom: is the difference between mass of the nucleons and electrons of an atom with the mass of the atom ....01 mark

(ii) Binding energy of the Helium atom which consist of 2 proton and 2 neutrons and 2 electrons.

Mass of Helium atom = 4.002600 u, Mass of proton, m_p = 1.00728 u, mass of neutrons = 1.00867u mass of electron, m_e = 0.00055u

1u = 932eV

The total mass of the particle is Mt = 2(Mp) + 2(Mn) + 2(Me)

= 9(1.00728) + 2(1.00867) + 2(0.00055) = 4.003300u............................01 mark

The mass defect = Mass of nucleon – mass of nucleus

= 4.003300 – 4.002600 = 0.00304 u ....01 mark

Binding energy = 932 x mass defect = 932 x 0.00304 u = 28.3 MeV ....01 mark

(d) Calculate the energy released when 10 kg of ${}^{235}_{36}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n$

Mass of ${}^{235}_{36}U = 235.04u$, Mass of ${}^{141}_{56}Ba = 140.91u$, mass of ${}^{92}_{36}Kr = 91.91u$, mass of ${}^{1}_{0}n = 1.01u$, 1u = 932 MeV and Na = 6.0×10^{23} mol^{-1}

Mass difference = (235.04 + 1.01) – (140.91 + 91.91 + 3 x 1.01) = 0.20 u

Energy released = 0.2 x 932 = 186.4 MeV ....01 mark

235.04 x 10^{-3}Kg of ${}^{235}_{36}U$ contains 6.02×10^{23} atoms........................... 01 mark

10 kg of ${}^{235}_{36}U$ contains $\frac{10 \times 6.02 \times 10^{23}}{235.04 \times 10^{-3}} = 2.56 \times 10^{23}\ atoms$ ....01 mark

Energy released by 10 kg of ${}^{235}_{36}U = 2.56 \times 10^{25} \times 186.4 = 4.77 \times 10^{27}\ MeV$

…………………01 mark