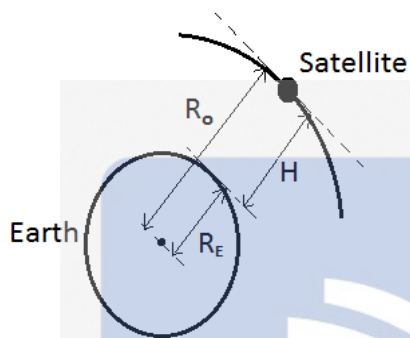


SOUTH WEST REGIONAL MOCK

(C/O BGS –MOLYKO BUEA)

Physics 2**0780****MARCH 2025****ADVANCED LEVEL**

Subject Title	PHYSICS
Subject Code Number	780
Paper Number	2

MARKING GUIDE**[1].**

$$R_0 = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

(a) From $R_0 = \sqrt[3]{\frac{GMT^2}{4\pi^2}} \rightarrow G = \frac{4\pi^2 R_0^3}{MT^2}$.

Units of $G = \frac{m^3}{kg s^2} = kg^{-1} m^3 s^{-2}$

(b)

(i) $R_0 = \sqrt[3]{\frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})(24 \times 3600)^2}{4\pi^2}} = \dots = 4.2 \times 10^7 \text{ m}.$ ✓

(ii) $H = R_0 - R_E = 4.2 \times 10^7 \text{ m} - 6.4 \times 10^6 \text{ m} \dots = 3.6 \times 10^7 \text{ m}.$ ✓

(iii) Assume the period of revolution of the satellite equals the period of rotation of the Earth. ✓

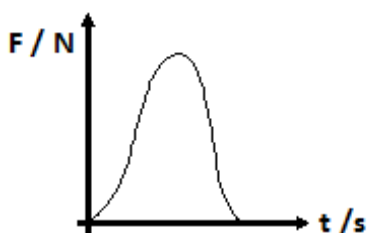
[2].

a) Newton's second law states that: the time rate of change of the momentum of a body is directly proportional to the applied force and takes place in the direction of the force. (any correct version of the law) ✓

b)

i. $F = \left| \frac{\Delta p}{\Delta t} \right| = m \left| \frac{v - u}{t} \right| = (3.0 \times 10^3) \left| \frac{0 - 4}{2} \right| = 6.0 \times 10^3 \text{ N}$ ✓

ii.

**[3].**

a) A thermometric property is any physical property of a substance that varies uniformly with temperature and is constant at a particular temperature. ✓

b) [01 mark each for any correct points amongst A to E].

- A: liquid in glass thermometer. ✓
- B: it is portable or easy to read, etc. ✓
- C: constant volume gas thermometer. ✓
- D: change in pressure of an ideal gas with temperature at constant volume. ✓
- E: change in electrical resistance of platinum with temperature. ✓

[4].

- a)
- i. A potentiometer is more accurate than a voltmeter as its measurements are taken when there is no current hence there are no errors caused by internal resistance of the cell. ✓
 - ii. A voltmeter is faster in operation than a potentiometer hence it can be used to follow rapidly changing temperatures, voltmeter is also more portable than a potentiometer (any one given) ✓
- b) Either
- Opposite terminals of the driver cell and the test cell have been joint together at the same point on the potentiometer wire. ✓
 - OR ✓
 - The EMF to be measured is greater than the EMF of the driver cell (or the potentiometer wire).
- c)
- $R = \frac{V^2}{P} = \frac{144}{48} = 3 \Omega$ ✓
 - $R = R_0 (1 + \alpha \theta) \Rightarrow R_0 = \frac{R}{1 + \alpha \theta} = \frac{3}{1 + (6.4 \times 10^{-3})(2700)} = 0.16 \Omega$ ✓

[5].

- a) Thermionic emission is the release of electrons by a metal surface when heated above a certain temperature WHILE photoelectric effect is the release of electrons by a metal surface when light of sufficiently high frequency falls on it. ✓
- b)
- i. Photoelectrons emitted by plate P are attracted back by the positive charges on the plate hence there is no resultant loss of charge. ✓
 - ii.
 - The divergence of the leaf decreases (i.e. the leaf falls). ✓
 - Photoelectrons emitted by plate Q are repelled by the negative charges on the plate hence there is a resultant loss of charge. ✓
 - iii. The UV light is placed equidistant from each plate so that each plat receives light of same intensity OR the set-up is placed in the dark room to ensure that the same frequency of light (UV – light) reaches both plates. ✓

[6 – EITHER].

- a)
- i. **Young's modulus** is the ratio of the tensile stress to the tensile strain of material. ✓
 Its S.I. unit is $N m^{-2}$ or Pa. ✓

ii. Measurement of Young's modulus of a copper wire

- Diagram ✓✓
- Procedure ✓✓
- Observations ✓
- Processing ✓
- conclusion ✓
- Precaution ✓

b) $F = \frac{7.8 \times 10^{-20}}{d^2} - \frac{3.0 \times 10^{-96}}{d^{10}}$

i. $F_{\text{att}} = \frac{3.0 \times 10^{-96}}{d^{10}}$ ✓ (the negative component).

ii. $F_{\text{rep}} = \frac{7.8 \times 10^{-20}}{d^2}$ ✓ (the positive component).

iii. At equilibrium, $d = r_0$, $F = 0 \Rightarrow \frac{7.8 \times 10^{-20}}{r_0^2} = \frac{3.0 \times 10^{-96}}{r_0^{10}}$ ✓
 i.e. $r_0^8 = 3.846 \times 10^{-77} \Rightarrow r_0 = \sqrt[8]{3.846 \times 10^{-77}} = 2.8 \times 10^{-10} \text{ m}$ ✓

c)

- i. With Longitudinal waves, the vibrations of the particles of the medium are parallel to the direction of propagation of the wave
 WHILE
 with Transverse waves, the vibrations of the particles of the medium or fields are perpendicular to the direction of propagation of the wave.

ii. Doppler Effect for a sound source approaching and passing a stationary observer.

$f_1 = 438 \text{ Hz}$, $f_2 = 378 \text{ Hz}$, $v = 340 \text{ m s}^{-1}$, $u_s = ?$

- The frequency of the sound from the ambulance is constant but its wavelength **decreases** as it approaches the observer and **increases** as the source moves away from the observer. This leads to the apparent change in the perceived frequency.
- Source approaching: $f_1 = \left(\frac{v}{v - u_s} \right) f_s$
- Source moving away: $f_2 = \left(\frac{v}{v + u_s} \right) f_s$
- $\frac{f_1}{f_2} = \frac{v + u_s}{v - u_s} \Rightarrow u_s = \left(\frac{f_1 - f_2}{f_1 + f_2} \right) v = (340 \text{ ms}^{-1}) \left(\frac{438 - 378}{438 + 378} \right) \Rightarrow u_s = 25.0 \text{ m s}^{-1}$ ✓

[6 – OR].

d)

- i. Decay constant is the time taken for the activity of a radioactive sample to drop to half of its initial value.

ii. Measurement of half-life of radon-220 gas.

- Diagram ✓✓
- Procedure ✓✓
- Observations ✓
- Processing ✓
- Conclusion ✓
- Precaution ✓

e)

- Three years ago $\Rightarrow$ time interval = $(t - 3)$ years.

• $I_0 = 19 \text{ counts. min}^{-1} \cdot \text{g}^{-1}$

• $I = 7 \text{ counts. min}^{-1} \cdot \text{g}^{-1}$

• Duration, $t - 3 = \frac{1}{\lambda} \ln \left(\frac{I_0}{I} \right) = \left(\frac{1}{1.2 \times 10^{-4} \text{ year}^{-1}} \right) \ln \left(\frac{19}{7} \right) = 8321 \text{ years}$ ✓

• Hence the age, $t = 8321 + 3 = 8324 \text{ years} = 8.3 \times 10^3 \text{ years}$ ✓

f) $L = 0.4 \text{ H}$, $R_L = 5 \Omega$, $R = 25 \Omega$, $V = 200 \text{ V (rms)}$, $f = \left(\frac{50}{\pi}\right) \text{ Hz}$.

i. $Z = \sqrt{X_L^2 + (R + R_L)^2}$

• $X_L = \omega L = 2\pi fL = 2\pi \left(\frac{50}{\pi}\right) (0.4) = 40 \Omega$. ✓

• $R + R_L = 30 \Omega$

• $Z = \sqrt{(40)^2 + (30)^2} = 50 \Omega$. ✓

ii. $I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{200}{50} = 4 \text{ A}$. ✓

iii. $Z_L = \sqrt{X_L^2 + R_L^2} = \sqrt{(40)^2 + (5)^2} = \sqrt{1625} = 40.3 \Omega$. ✓

• $V_L = I Z_L = (4 \text{ A})(40.3 \Omega) = 161 \text{ V(rms)}$. ✓

[7].

DATA ANALYSIS

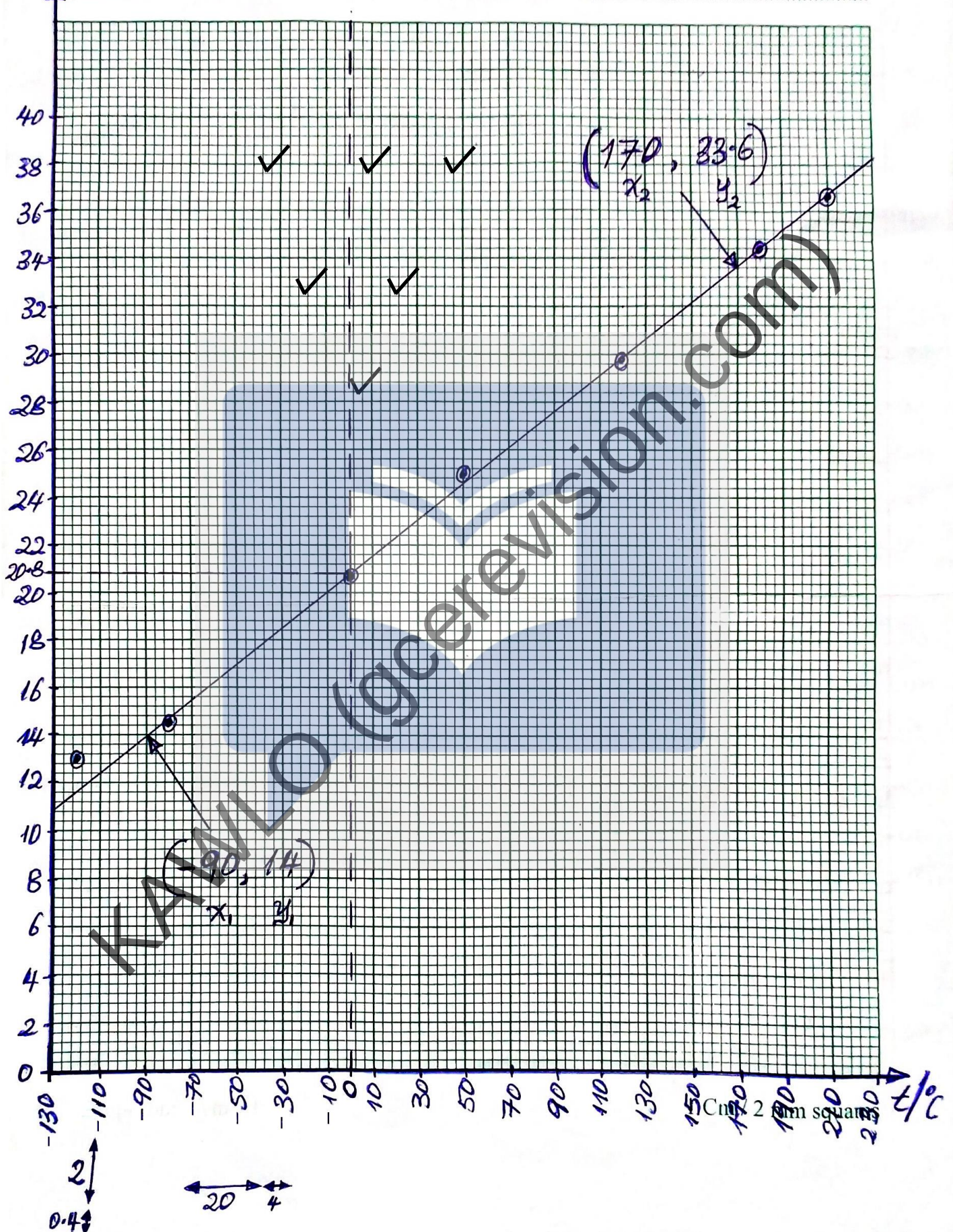
a) $\frac{PV}{t - t_0} = Q \Rightarrow (PV) = Q(t) - (Q t_0)$ ✓ $\equiv Y = MX + C$

i.e. a graph of **(PV)** against **t** is a straight line with gradient **(Q)** ✓
and vertical intercept **− (Q t₀)**. ✓

t/°C	P / 10 ⁵ Pa	V / m ³	PV/10 ⁵ Pa. m ³
210	4.3	0.85	3.655
180	4.0	0.86	3.440
120	2.8	1.06	2.968 ✓
50	2.2	1.14	2.508
0	1.5	1.38	2.070
- 80	1.0	1.45	1.450
- 120	0.84	1.55	1.302

$PV/10^4 P_0 \cdot m^3$

Question N°.....



b)

- Slope, $M = \frac{(33.6 - 14) 10^4 \text{ Pa.m}^3}{(170 - -90)^\circ\text{C}} = \frac{(19.6 \times 10^4) \text{ Pa.m}^3}{260^\circ\text{C}} = 7.54 \times 10^2 \text{ Pa.m}^3 \cdot ^\circ\text{C}^{-1}$.
- $Q = M = 7.54 \times 10^2 \text{ Pa.m}^3 \cdot ^\circ\text{C}^{-1}$
- Vertical intercept, $C = 20.8 \times 10^4 \text{ Pa.m}^3$
- But $C = -Qt_0 \Rightarrow t_0 = -\frac{C}{Q} = -\left(\frac{20.8 \times 10^4 \text{ Pa.m}^3}{7.54 \times 10^2 \text{ Pa.m}^3 \cdot ^\circ\text{C}^{-1}}\right) = -276^\circ\text{C}$

c) $Q = KN \Rightarrow N = -\frac{Q}{K} = \left(\frac{7.54 \times 10^2 \text{ Pa.m}^3 \cdot ^\circ\text{C}^{-1}}{1.38 \times 10^{-23} \text{ J.K}^{-1}}\right)$

i.e. number of molecules, $N = 5.5 \times 10^{25}$ (or in unit of $\text{Pa.m}^3 \cdot \text{J}^{-1} \equiv \text{unitless}$)

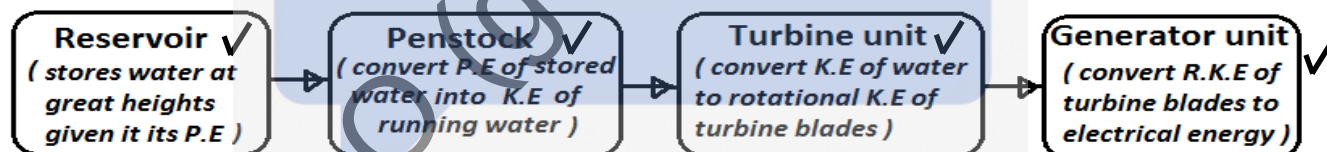
[8]. OPTION I – ENERGY RESOURCES AND ENVIRONMENTAL PHYSICS

a)

- **Biofuels** are organic materials from the existing remains of plants and animal matters accumulated over a short period of time
 - **Fossil fuels** are organic materials from the buried remains of plants and animal matters accumulated over millions of years.
- **Biofuel digester** is a system or device that breaks down organic waste materials anaerobically to produce biogas such as methane and ethane.
- $P_{\text{windmill}} = \frac{1}{2} \rho A v^3 \Rightarrow E_{\text{windmill}}$ depends on density of wind or cross-sectional area of windmill blades or speed of wind or duration of the wind.

b)

- The photovoltaic plate generate energy without polluting the environment and its inhabitants.
- Block diagram of HEP.**



directed arrows in order

iii.

- Most countries lacks suitable sites (a bay) for the generation of tidal power, or
- Generation of tidal power requires high initial cost of installation.

c)

- Global warming increases the speed and frequency of wind resulting to more tornados.
 - Global warming increases the strength and frequency of rainfall resulting to more floods.
- Some strategies to reduce Global warming include:**
 - Encouraging afforestation and re-afforestation, or
 - Reduce the use of fossils by encouraging the use of renewable energy sources, etc.

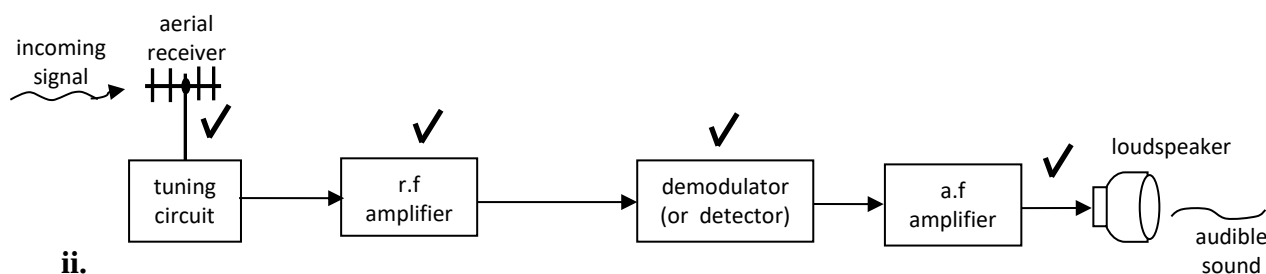
[9]. OPTION II – COMMUNICATION

a)

- Any three differences between digital and analogue transmission in relation to: **waveform, interference, fidelity, range, security, information capacity,** etc.
- Bandwidth, $BW = usf - lsf = 45 \text{ kHz} - 35 \text{ kHz} = 10 \text{ kHz}$.

b)

i. Block diagram of an AM radio receiver.



ii.

- $C = 4.00 \text{ pF}$, $f_c = 94.5 \text{ MHz}$, $L = ?$
- $f_c = \frac{1}{2\pi\sqrt{LC}} \Rightarrow L = \frac{1}{(2\pi f)^2 C}$
- i.e. $C = \frac{1}{[2(3.14)(94.5 \times 10^6)]^2 (4.00 \times 10^{-12})} = 709 \times 10^{-9} \text{ H}$

c)

- **SIM Card:** a **Subscriber Identity Module** (SIM) is a small chip used in mobile devices to store the user's subscription information to a cellular network, including the phone number and encryption keys.
- **Cell:** a **cell** is a geographical area covered by a single base station in a cellular network. Each base station provides radio coverage for mobile phones within its cell.
- **Handover:** a process in which an ongoing call or data session is transferred from one cell to another without interruption as the user moves through different coverage areas.

[10].

OPTION III – ELECTRONICS

a)

i. Comparing n-type and p-type semiconductors.

Properties	n - type semiconductors	p -type semiconductors
Formation	Created by doping a pure semiconductor crystal with a pentavalent impurity atom.	Created by doping a pure semiconductor crystal with a trivalent impurity atom.
Majority charge carriers	The majority charge carriers are free electrons	The majority charge carriers are holes
Minority charge carriers	The minority charge carriers are holes.	The minority charge carriers are free electrons.

ii. Formation of a p-n junction.

- A pn - junction is formed by welding P and N type semiconductors together end to end to form a thin boundary between them called a pn-junction.
- OR
- A pn – junction can also be formed by introducing donor impurities on one end and acceptor impurities on the other end of a pure semiconductor crystal.

b)

i. How the device Y = thermistor could function in the circuit as an alarm.

- At certain lower temperatures, the resistance of the thermistor increases far above $10 \text{ k}\Omega$ leading to a high V_{in} .
- I_b and hence I_c are high which switches ON the alarm bell.

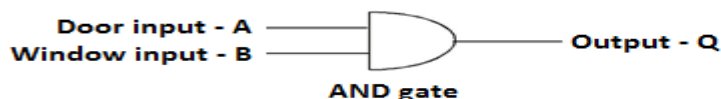
ii. How the device Y = LDR could function in the circuit as an alarm.

- When exposed to darkness, the resistance of the LDR increases far above $10 \text{ k}\Omega$ leading to a high V_{in} .
- I_b and hence I_c are high which switches ON the alarm bell.

iii.

- When $R_{LDR} = 1 \text{ k}\Omega$, $V_{LDR} = \left(\frac{1 \text{ k}\Omega}{(1 + 10) \text{ k}\Omega} \right) (6 \text{ V}) = \left(\frac{6}{11} \right) \text{ V} = 0.55 \text{ V} \checkmark$
- V_{in} is low $\Rightarrow I_b$ and hence I_c are low which switches OFF the alarm bell. $\checkmark$

c)



Truth Table

INPUTS		OUTPUT
A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

i. Use of an AND gate in the burglar alarm system:

- The **AND gate** has two inputs: one from the door sensor and one from the window sensor. $\checkmark$
- Opening** the door (or window) triggers a high input and **closing** the door (or window) triggers a low input. $\checkmark$

ii. Why does the alarm activate only when both inputs are triggered?

- When **both** the door and the window are opened at the same time, both sensors send high inputs to the **AND gate**. $\checkmark$
- The **output** to the AND gate is then high which activates the alarm. $\checkmark$

NB: An AND gate gives a high output only when **all** the inputs are high, and a low output when any of the input is low.

[11].

OPTION IV – MEDICAL PHYSICS

a) **Astigmatism:**

- Effect on vision:** Light rays entering the eye from any distance (near or far objects) are scattered away resulting in a distorted or blurry vision at any distance. $\checkmark$
- Cause:** Astigmatism is caused by a rough or non – uniform curvature of the cornea. $\checkmark$
- Correction:** Astigmatism is corrected using spectacles with special spherical cylindrical lenses. $\checkmark$

b) **BP reading** = $\frac{A}{B}$, in mm Hg

i.

- A** is called **Systolic** reading which measures the pressure in the arteries when the heart beats (i.e. when the heart muscles contract). $\checkmark$
- B** is called **Diastolic** reading which measures the pressure in the arteries between heart beats (i.e. when the heart muscles are relaxing). $\checkmark$

ii. A **normal BP** reading = $\frac{118}{78} \text{ mm Hg}$ $\checkmark$

iii. A **Hypertensive BP** reading = $\frac{129}{85} \text{ mm Hg}$ $\checkmark$

iv. Some **likely precautions and control** of high blood pressure include – any one:

- Increase level of physical activities by doing some sports
- Avoid too much alcohol
- Avoid smoking
- Avoid anger and fear and try to be happy always.
- Etc.

c)

i.

- The **Quality Factor** of a radiation is a number which expresses the destructive power of the radiation. $\checkmark$

- Hence the higher the quality factor of radiation the lower the administered dose and the lower the quality factor of radiation the higher the administered dose. ✓

ii.

- Alpha radiation from an external source is particularly less dangerous as it will be stopped by the human outer skin thus limiting its ionizing effects to external body cells only. ✓
- However, an internal alpha source is potentially very dangerous as it will lead to ionization of internal cells leading to genetic mutilation and other severe forms of cancer. ✓

