THE UNITED REPUBLIC OF TANZANIA
PRESIDENT'S OFFICE, REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

FORM SIX SPECIAL SCHOOLS JOINT EXAMINATION

CODE: 131/1 **PHYSICS 1**

Time: 3:00 HRS Tuesday **27-February-2024 AM**

INSTRUCTIONS

1.This paper consists of sections A and B with a total of **ten (10)** questions.

2. Answer **all** questions in section A and choose **two (02)** questions from section B.

3. Marks for each question or part thereof are indicated.

4. Non-programmable scientific calculators are allowed in the examination room.

5. Cellular phones and any unauthorized materials are **not** allowed in the examination room.

6. Write your Examination Number on every page of your answer booklet.

7. The following information may be useful:

(a) Acceleration due to gravity, $g = 9.8\text{m/s}^2$.

(b) Thermal conductivity of aluminium, $k_{Al} = 200\text{Wm}^{-1}\text{K}^{-1}$.

(c) Thermal conductivity of copper, $k_{cu} = 390\text{Wm}^{-1}\text{K}^{-1}$.

(d) Radius of the Earth, $r_E = 6.4 \times 10^6\text{m}$.

(e) Stefan's-Boltzmann's constant, $\sigma = 5.7 \times 10^{-8}\text{Wm}^{-2}\text{K}^{-4}$.

(f) Sun's radius, $r_s = 7.8 \times 10^8$m.

(g) Distance of the sun from the Earth, $d = 1.50 \times 10^{11}$m.

(h) Molar heat capacity for diatomic, $\gamma = 1.40$.

(i)Latent heat of vaporization of sulphur $= 50 Jg^{-1}$

(j)Ratio of heat capacities for monoatomic gas $\gamma = 1.69$

(k) Pie, $\pi = 3.14$

(L)Molar gas constant R = 8.31 $Jmol^{-1}K^{-1}$

SECTION A (70 Marks)

Answer **all** questions from this section.

i) **1.**(a)(i) A new catalyst is discovered that significantly speeds up the decomposition of hydrogen peroxide ($H_2\ O_2$) into water (H_2 O) and oxygen (O_2). Chemists studying the reaction measure the rate of decomposition as the amount of $H_2\ O_2$ decreases over time. They observe the following relationship: $\mathbf{Rate = k\,[H_2O_2]^n}$.

Where:

- Rate is expressed in units of moles/litre/second
- k is the rate constant
- [$H_2\ O_2$] is the concentration of hydrogen peroxide in moles/litre
- n is the order of the reaction

Can the value of n be a fraction? Explain your reasoning using the principle of homogeneity of dimensions. **(02 marks)**

(ii) A student writes, $\sqrt{\frac{R}{2GM}}$ for escape velocity. If R is the radius of the planet, G is universal gravitational constant and M is the mass of the planet. Check the correctness of the formula by using dimensional method. **(03 Marks)**

(b)(i) Define *least count* of an instrument. **(01 Mark)**

(ii) The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a micrometer screw gauge, whose pitch is 0.5mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.50mm and that on

the circular scale is 20 divisions. If the measured mass of the ball has relative percentage error of 2.0%, what is the relative percentage error in the density of the material of the ball? **(04 Marks)**

2. (a) (i) State the principle of conservation of linear momentum **(1 mark)**

i) (ii) Two students facing one another stand a few meters apart on a trolley which is at rest but can move freely on a smooth horizontal surface. If one of them throws a heavy ball to the other who catches it. Describe what happens to the speed of trolley and to the position of the trolley during this process? (**3marks**)

(b) During a thrilling football game, a player on the upper-level stands at building A (1000 m high) kicks the ball at an angle of 60° with a velocity of 80 m/s. However, instead of soaring onto the field, the ball unfortunately enters a window of building B (400 m high) across the street. As a safety inspector, you are tasked with investigating this incident and ensuring future safety. Determine:

i) The time it takes for the ball to hit a window in building B.

ii) The horizontal distance between building A and B (ignoring building dimensions).

(**6 marks**)

3. (a)(i) Why simple harmonic motion is not a wave? **(02 Marks)**

(ii) Show that for a sinusoidally simple harmonic motion, the phase difference between displacement and acceleration is π rad. or 180^o. **(03 Marks)**

(b) An object describing simple harmonic motion (SHM) in the horizontal plane has velocity of 2.50m/s to the right when displaced 0.575m to the right of its equilibrium position. If such object has acceleration of 8.60m/s^2 to the left at that position, how far from this point will the object move before it stops momentarily and start to move back to the left? **(05 Marks)**

4. (a)(i) Why is it easier to open the door by pushing a long way from the hinge? **(02Marks)**

(ii) A solid sphere of mass 5.0Kg is placed on a rough inclined plane of inclination 30^o. What is the minimum frictional force required for it to roll without slipping down the plane? **(03 Marks)**

(b) If the earth were made of lead of relative density of 11.3, what would be the value of acceleration due to gravity on the surface of the earth? **(5 marks)**

5. (i) Two chefs are baking simultaneously in separate ovens, aiming for perfectly golden-brown cookies. They each use an old-fashioned thermometer to monitor their oven temperature, one based on mercury expansion and the other on alcohol expansion. While both thermometers were calibrated at the standard ice point and boiling point of water, the chefs notice their readings differ slightly between these fixed points. Explain why their thermometers might not agree? (**2 marks**)

(ii) If a car is left in sunlight on hot day with all the windows closed after sometimes it is found that the inside of the car is considerably warmer than the air outside. Why? (**3 marks**)

(b)A local brewery is experiencing inconsistent output and suspects their brass kettles are not efficiently transferring heat from the gas burners. They ask you, a physics enthusiast, to investigate. You measure the base area of one kettle as $0.15\ m^2$ and its thickness as 1 cm. During operation, the kettle boils water at a rate of 6 kg/min. Given the thermal conductivity of brass ($K = 109\ J/mK$) and the heat of vaporization of water ($L = 2256 \times 10^3 J/kg$), can you estimate the maximum temperature of the flame in contact with the kettle. (**5 marks**)

6. (a)Resistance of thermometer R_t of platinum at room temperature t^0C measured on a gas scale is given by $R_t = R_o\left(1 + at + bt^2\right)$ where $a = 3.8 \times 10^{-3\,o}C$ and $b = 5.6 \times 10^{-7\,o}C^{-2}$. What will be the platinum thermometer reading, if the thermometer on the gas scale is 200^0C? **(4marks)**

(b) An ideal monoatomic gas of 0.15mole is enclosed in a cylinder at a pressure of 250kPa and a temperature of 320k. The gas is allowed to expand adiabatically and reversibly until its pressure is 100kPa. Calculate;-

(i) the final temperature **(3 marks)**

(ii) the amount of work done by the gas **(3 marks)**

7. (a)(i) Why is it advised to use rainwater in irrigation than tap water for plants growth? **(02 Marks)**

(ii) Briefly explain any three primary energy sources obtained from the environments. **(03 Marks)**

(b)(i) Distinguish *seismical lines* from *seismic waves*. **(02 Marks)**

(ii) Briefly explain how Raid's elastic rebound theory explains about earthquakes. **(03 Marks)**

SECTION B (30 Marks)

Answer **two (02)** questions from this section.

8.(a)(i) The resistance of human body is very large. Then why does one experience a strong shock (sometimes even fatal) when one accidently touches the live wire of say, a 240V supply? **(2 marks)**

(ii) How many dry cells, each of e.m.f $1.5V$ and internal resistance of 0.5Ω must be joined in series with a resistor of 20Ω to give a current of $0.6A$ in the circuit? **(03 Marks)**

(b) In the circuit figure 1; the battery B_1 has an e.m.f of $12V$ and zero internal resistance, while battery B_2 has an e.m.f of $2.0V$. If the galvanometer G reads zero;

(i) what is the current flowing through resistor X? **(02 Marks)**

(ii) what is the value of resistance X? **(03 Marks)**

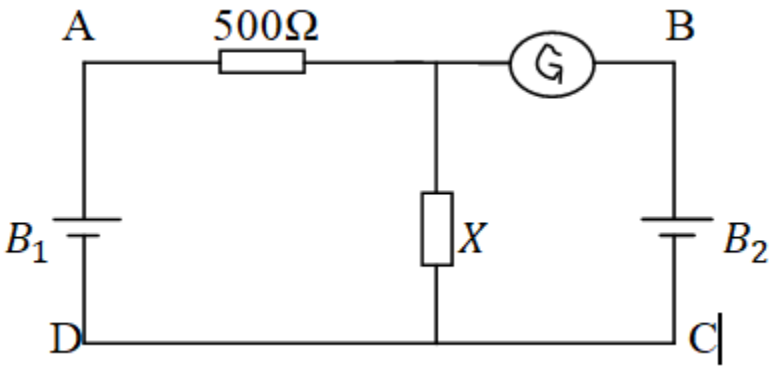


Figure 1.

(c) In RLC alternating current series circuit, the inductive reactance, capacitive reactance and resistance are 184Ω, 144Ω and 30Ω respectively. Calculate;

(i) the impedance of the circuit. **(03 Marks)**

(ii) the phase angle between voltage and current. **(02 Marks)**

9. (a)(i)What is a p-n junction? Describe the formation of potential barrier of a p-n junction diode. **(4 marks)**

(ii) Why silicon is preferred to Germanium in manufacturing for semiconductor devices? **(2 marks)**

(iii)The circuit in the figure 2 shows two diodes each with forward resistance of 50Ω and with infinite reversed resistance. If the battery voltage is 6V, what is the current through the 100Ω resistor? **(3 marks)**

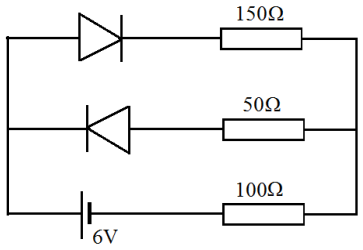


Figure 2

(b)(i)Why the junction transistor is also called Bipolar transistor? **(1 mark)**

(ii)Why is collector of a transistor made wider than emitter base? **(1 mark)**

(c) The V_{BB} supply can be varied from 0 to 6V. The silicon transistor has $\beta = 100$, $R_B = 10k\Omega$, $R_C = 4k\Omega$, $V_{CC} = 6.0V$. Assume that when the transistor is saturated $V_{CE} = 0V$ and $V_{BE} = 0.7V$;-

(i) Calculate the minimum base current for the transistor will reach saturation. **(2 marks)**

(ii) Determine V_i when the transistor is switched on. **(1 mark)**

(iii)Find the range of V_i for which the transistor is switched off and on. **(1 mark)**

10.(a)(i) How many AND gates are required to obtain an expression; $X = AB + CD + E$. **(02 Marks)**

(ii) Figure 3 shows a logic circuit with two inputs A and B and the output Q. The voltage waveforms across A, B and Q are as given. Name and draw the logic circuit gate. **(04 Marks)**

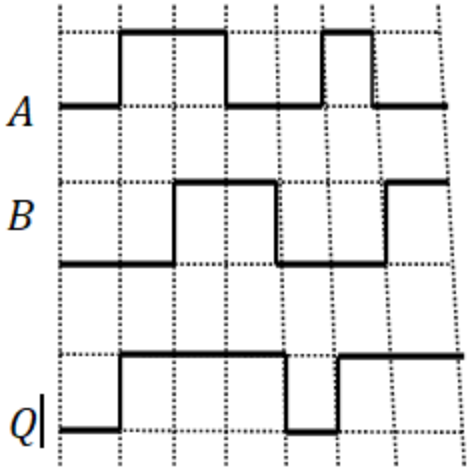


Figure 3

(b) Study the operational amplifier circuit in figure 4 and then answer the questions that follow.

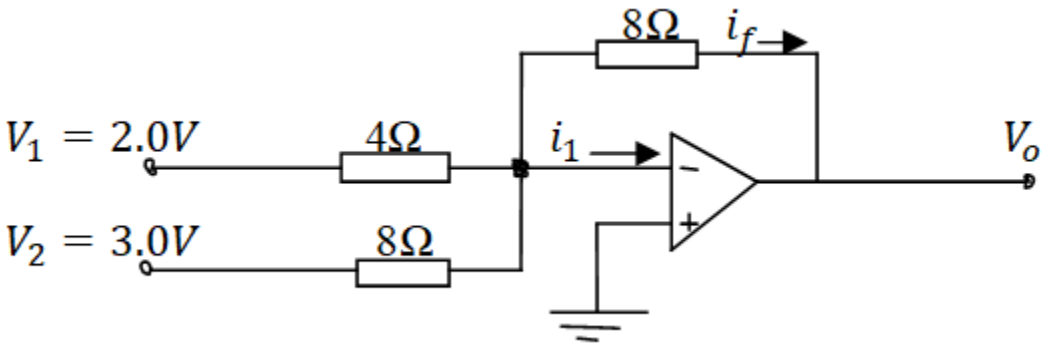


Figure 4.

(i).What are the values of currents i_1 and i_f? **(02 Marks)**

(ii) What is the output voltage, V_o ? **(03 Marks)**

(b)(i) What is *modulation*? What is its importance in telecommunication? **(02 Marks)**

(ii) A TV transmitting antenna at the top of a tower has total height of 40m and the height of a receiving antenna is 60m. Calculate the maximum distance between the two antennae for satisfactory communication. **(02 Marks)**

END.

FORM SIX SYNDICATE EXAMINATIONS

131/1-PHYSICS 1 MARKING SCHEME

1.(a)(i) No, the value of n cannot be a fraction. The principle of homogeneity of dimensions requires all terms in an equation to have the same dimensions. Since rate has units of moles/liter/second, and $[H_2O_2]$ has units of moles/liter, the order of the reaction (n) must be dimensionless (no units) to ensure the correct overall units for the rate equation. **(02 marks)**

(ii) If $v_{es} = \sqrt{\frac{R}{2GM}}$ and $v^2 = \frac{R}{2GM}$ $[v]^2 = \frac{[R]}{[G][M]}$ *(01 mark)*

$L^2T^{-2} \neq L^{-2}T^2$ *(01 mark)*

The formula is WRONG. *(01 mark)*

(b) Least count error in diameter, $\Delta d = \frac{0.5mm}{50} = 0.01mm.$ *(01 mark)*

Diameter of solid ball, $d = 2.5 + (0.01\times20) = 2.70mm.$ *(01 mark)*

Density of ball material, $\rho = \frac{m}{vol} = \frac{24m}{4\pi d^3}$

$ln\rho = \ln ln\left(\frac{24}{4\pi}\right) + \ln ln\, m - 3d$.

$\frac{\delta\rho}{\rho} = \frac{\delta m}{m} + 3\frac{\delta d}{d}$ and percentage error in $\rho = p_m + 3\times\frac{\delta d}{d}\times100\%$. *(01 mark)*

$= 2.0\% + \left(3\times\frac{0.01mm}{2.70mm}\times100\%\right)$ *(01 mark)*

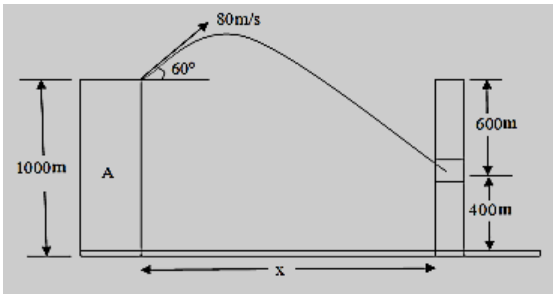
$= 2.0\% + 1.11\% = 3.11\%$. *(01 mark)*

2 (i) If there is no external force acting to the system, the total momentum is always conserved. **(01 mark)**

ii)Since there is no external force acting on the system the speed of trolley remains constant. **(1.5)**

The trolley comes to rest at original position in the final motion due to force of reaction. **(1.5)**

(b)



(02 marks)

i) Using $-h = V_0 \sin sin\,\theta t - \frac{1}{2}gt^2$ **(01 mark)**

$-600 = 80 \sin sin\,60°t - 4.9t^2$

Hence it will take 20.2 seconds to hit the window of the second building **(01 mark)**

ii) $X = V_0 \cos cos\,\theta t$ **(1)**

Hence the distance between buildings is 808 m **(011 mark)**

3. (a)(i) Because waves are phenomenon not objects. The oscillating object does not lose any energy in SHM. *(02 marks)*

(ii) From; $= A\,sin\omega t$. *(01 mark)*

$\longrightarrow v = \frac{dy}{dt} = \omega A\,cos\omega t$ and $a = \frac{d^2y}{dt^2} = -\omega^2 A\,sin\omega t = \omega^2 A\,sin(\omega t + \pi)$.

(01 mark)

The phase difference between acceleration and displacement $= (\omega t + \pi) - \omega t = \pi$ rad. Or 180°. Hence shown. *(01 mark)*

(b) $a = -\omega^2 x$. Considering magnitude only, $= \sqrt{\frac{a}{x}}$. *(01 mark)*

$\omega = \sqrt{\frac{8.60}{0.575}}$ Hz $= 3.87$ Hz. *(01 mark)*

From: $v = \omega\sqrt{A^2 - x^2}$ where A = amplitude. $A = \sqrt{\left(\frac{v}{\omega}\right)^2 + x^2}$ *(01 mark)*

$= \sqrt{\left(\frac{2.50}{3.87}\right)^2 + 0.575^2}$ m

Amplitude, $A = 0.865m$. *(01 mark)*

The distance moved by the object just before it stops momentarily $= 0.865m - 0.575m = 0.29m$. *(01 mark)*

4. (a)(i) This increases the perpendicular distance from the hinge where the axis of rotation is located as a result little force is required to provide sufficient torque needed to rotate the door while opening. *(02 marks)*

(ii) $f_{min} = \frac{mg\,sin\theta}{1+\frac{mr^2}{I}}$. But $I_{sphere} = \frac{2}{5}mr^2$, substituting we have;

$$f_{min} = \frac{2}{7}mg\,sin\theta. \qquad \textit{(01 mark)}$$

$$= \frac{2}{7}\times 5\times 9.8\times sin30^o \qquad \textit{(01 mark)}$$

Needed minimum frictional force = $7.0\ N$. *(01 mark)*

(b) From $mg = \frac{GM_E m}{R_E}$ (At normal situation) **(01 mark)**

$$M_E = \frac{gR_E^2}{G} = \frac{10\times(6.4\times10^6)^2}{6.67\times10^{-11}} = 6.14\times10^{24}\,kg$$ **(01 mark)**

For the Relative density of 11.3, density $11300 kgm^{-3}$ **(01 mark)**

New mass $M_E^I = \rho\times V = \rho\times\frac{4}{3}\pi R^3 = 11300\times\frac{4}{3}\times3.14\times(6.4\times10^6)^3$

$$M_E^I = 1.24\times10^{25}\,kg$$ **(01 mark)**

Since $g\alpha M$

$$g^I = g\left(\frac{M_E^I}{M_E}\right) = 10\times\left(\frac{1.25\times10^{25}}{6.14\times10^{24}}\right) = 20.2 Nkg^{-1}$$ **(01 mark)**

5 (i)This is because different thermometric properties do not change proportionally with the same change in degree of hotness. **(02 marks)**

(ii) Due to it, when a car is left in the sun, heat radiations form the sun gets into the car but as the temperature inside the car is moderate, they do not pass back through its windows. Hence, the air inside the car becomes considerably warmer. **(3)**

(b) The amount of heat flowing into water through the brass base of the boiler is given by:

$Q = \frac{KA(\theta_1 - \theta_2)t}{l}$ …….…..... (i) **(01 mark)**

Where,

θ_1 = Temperature of the flame in contact with the boiler

θ_2 = Boiling point of water 100℃

Heat required for boiling the water:

$Q = mL$ …….. (ii) **(01 mark)**

Equating equations **(i)** and **(ii)**, we get:

$mL = \frac{KA(\theta_1 - \theta_2)t}{l}$ **(01 marks)**

$\theta_1 - \theta_2 = \frac{mLl}{KAt}$

$\theta_1 - \theta_2 = \frac{6 \times 2256 \times 10^3}{109 \times 0.15} = 137.98℃$

$\theta_1 - 100℃ = 137.98℃$

The temperature of the part of the flame in contact with the boiler is $237.98℃$ **(02 marks)**

6. (a) From;- $R_t = R_o(1 + at + bt^2)$

$R_0 = R_o$

$R_{100} = R_o(1 + 3.8 \times 10^{-3} \times 100 + 5.6 \times 10^{-7} \times 100^2) = 1.3856R_o$ **(01 mark)**

$R_{100} = R_o(1 + 3.8 \times 10^{-3} \times 200 + 5.6 \times 10^{-7} \times 200^2) = 1.7824R_o$ **(01 mark)**

Since, $\theta = \left(\frac{R_{200} - R_0}{R_{100} - R_0}\right) \times 100^oC$ **(01 mark)**

$= \left(\frac{1.7824R_o - R_o}{1.3856R_o - R_o}\right) \times 100^oC = 202.9^oC$ **(01 mark)**

(b) (i) From;- $P_1^{I-\gamma} T_1^{\gamma} = P_2^{1-\gamma} T_2^{\gamma}$

$T_2^{\gamma} = T_1^{\gamma} \left(\frac{P_2}{P_1}\right)^{1-\gamma}$ **(01 mark)**

$$T_2^{\gamma} = 320^{1.67}\left(\frac{100}{250}\right)^{1-1.67}$$ **(01 mark)**

$$= 462.2K$$ **(01 mark)**

(ii) Work done in adiabatic $W = \frac{nR}{\gamma - 1}(T_1 - T_2)$ **(01 mark)**

$$= \frac{0.15 \times 8.31}{1.67 - 1} \times (320 - 462)$$ **(01 mark)**

$$= -26.42J$$ **(01 mark)**

7. a)(i) Tap water often has added chemicals as it is treated and recycled for human consumption. Rainwater has a higher level of oxygen and is free from harmful mineral additives found in tap water. *(02 marks)*

(ii) 1. Solar energy – is the energy fetched from electromagnetic radiation emitted from the sun which can be converted into usable form of energy.

2. Wind energy – is the kinetic energy of air in motion which can be converted into electrical energy, mechanical, pumping water etc.

3. Geothermal energy – is the energy derived from the heat of the Earth which can be used to generate electricity.

4. Water energy – is the kinetic energy of flowing water which can be used to drive turbines in order to generate electricity (hydroelectric power), transport material etc.

5. Wave energy – is the transport of energy by ocean surface waves and capture of that energy to do useful work e.g. producing electrical energy, pumping water etc.

6. Natural gas – is fossil fuels that exist in a gaseous state and is composed mainly of methane (CH_4) and small percentage of other hydrocarbons.

7. Nuclear energy – is the energy which is obtained as a result of nuclear fission or nuclear fusion to generate electricity. *(03 marks), 01 mark@ for any three*.

(b)(i) Seismical lines are lines plotted to show places suffering from equal damage due to an earthquake, while seismic waves are mechanical waves associated with an earthquake when the earthquake occurs. *(02 marks), 01 mark@*

(ii) According to Elastic rebound Theory; "The plates inside the Earth are pushed together at a fault line until they are deformed and the built up energy is released and the plates snap back to their original position which results in the vibration of the Earth's crust". *(03 marks)*

8. (a)(i)Because when touching the live wire, the human complete the circuit hence the electrons will be flowing from the live wire to the ground which cause electric shock. **(02 mark)**

(ii) $n\varepsilon = i(nr + R)$ $i = \frac{n\varepsilon}{nr+R}$. *(01 mark)*

$0.6 = \frac{1.5n}{0.5n+20}$. *(01 mark)*

$0.6(0.5n + 20) = 1.5n$, solving for n we have;

Required number of cells = 10. *(01 mark)*

(b)(i) $12 - 500i - 2 = 0$ *(01 mark)*

solving for i we have; $i = \frac{10}{500}$ A.

Needed current = 0.02 A. *(01 mark)*

(ii) $12 - (500 \times 0.02) - 0.02X = 0$ *(01 mark)*

$12 - 10 - 0.02X = 0$ *(01mark)*

$0.02X = 2$

Needed value of $X = 100\Omega$. *(01 mark)*

(c)(i) $Z = \sqrt{\left(X_L - X_C\right)^2 + R^2}$ *(01 mark)*

$= \sqrt{(184 - 144)^2 + 30^2}$ *(01 mark)*

Needed impedance =50Ω *(01 mark)*

(ii) From $tan\theta = \frac{X_L - X_C}{R}$ $\theta = tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ *(01 mark)*

$\theta = tan^{-1}\left(\frac{184-144}{30}\right)$

Needed phase angle = 53.13° *(01 mark)*

9. (a) (i) A p-n junction is the semiconductor device which consists of P-type semiconductor in one side and the other side N-type semiconductor and conducts electric current in one direction only **(01 mark)**

The potential barrier is formed when P-type materials come in contact with N-type semiconductor hence electrons from the N-type side fills the holes in p-type so the barrier developed between them **(03 marks)**

(ii) Because it has low potential barrier compared to Germanium.**(02 marks)**

(iii) From the diagram, the current flows through 100Ω and 150Ω is the same. No current is flowing through 50Ω. **(01 mark)**

$$I = \frac{V}{R_T} = \frac{V}{R_{100} + R_{150}}$$ **(01 mark)**

$$= \frac{6}{100 + 150}$$

$$= 0.024A$$ **(01 mark)**

(b) (i) Both are amplifiers and acts as switching devices in saturation region or cut-off region **(01 mark)**

(ii) A large number of combinations of electrons and holes will take place in base region, resulting in increase in base current; as a result, current amplification will increase **(01 mark)**

(c) (i) Minimum base current when transistor reach saturation

$$V_{CE} = 0$$

$$V_{CC} = I_C R_C$$

$$I_C = \frac{V_{CC}}{R_C} = \frac{6V}{4 \times 10^3 \Omega} = 1.5 \times 10^{-3} A$$ **(01 mark)**

$$\beta = \frac{I_C}{I_B}$$

$$I_B = \frac{I_C}{\beta} = \frac{1.5\times10^{-3}}{100}$$

$$= 1.5\times10^{-5} A$$ **(01 mark)**

(ii) Input voltage $V_{in} = I_B R_B + V_{BE} = (1.5\times10^{-5}\times10\times10^{3}) + 0.7 = 0.85V$ **(01 mark)**

(ii) When transistor is off, $I_C = 0$

$$V_{in} = V_{BE} = 0.7V$$

Range from $0.7V$ to $0.85V$ **(01 mark)**

10.(a)(i) $X = AB + CD + E.$

AND AND *(01 mark)*

Therefore there are two AND gates. *(01 mark)*

(ii) Truth table

A	B	Q
0	0	0
1	0	1
1	1	1
0	1	1
0	0	0
1	0	1
0	1	1

(02 marks)

OR gate *(02 mark)*

(b)(i) Current, $i_1 = 0$ as no current enters the operational amplifier. *(01 mark)*

Current, $i_f = \frac{V_o}{R_f} = \frac{7.0V}{8\Omega} = 0.875\ A.$ *(01 mark)*

(ii) $V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2\right)$ *(01 mark)*

$V_o = -\left(\frac{8}{4}\times 2V + \frac{8}{8}\times 3V\right)$ *(01 mark)*

$V_o = -(4V + 3V) = -7.0V$. *(01 mark)*

(c)(i) is the process of varying some characteristic of a carrier wave (amplitude or frequency) by using an information signal. *(01 mark)*

- It is used to send an information bearing signal over long distances without attenuation. *(01 mark)*

(ii) $d_m = \sqrt{2h_t r_E} + \sqrt{2h_r r_E}$ *(01 mark)*

$d_m = \sqrt{2\times 40\times 6.4\times 10^6}\ \text{m} + \sqrt{2\times 60\times 6.4\times 10^6}\ \text{m}$

$= 50340m$

= 50Km. *(01 mark)*