Class: 10th

Subject: Physics

Unit 16: BASIC ELECTRONICS

Exercise MCQs:

1. The process by which electrons are emitted by a hot metal surface is known as:

(a) boiling

(b) evaporation

(c) conduction

(d) thermionic emission ✅

ii. The particles emitted from a hot cathode surface are:

(a) positive ions

(b) negative ions

(c) protons

(d) electrons ✅

iii. The logical operation performed by this gate is:

(Based on the diagram: It's an OR gate with a small circle at the output, which indicates NOR gate)

(a) AND

(b) NOR ✅

(c) NAND

(d) OR

iv. AND gate can be formed by using two:

(a) NOT gates

(b) OR gates

(c) NOR gates

(d) NAND gates ✅

v. The output of a two-input NOR gate is 1 when:

(a) A is '1' and B is '0'

(b) A is '0' and B is '1'

(c) both A and B are '0' ✅

(d) both A and B are '1'

vi. If X = A.B, then X is '1' when:

(a) A and B are '1' ✅

(b) A or B is '0'

(c) A is '0' and B is '1'

(d) A is '1' and B is '0'

vii. The output of a NAND gate is '0' when:

(a) both of its inputs are '0'

(b) both of its inputs are '1' ✅

(c) any of its inputs is '0'

(d) any of its inputs is '1'

Important MCQs:

1. Which branch of physics deals with the control of motion of electrons in devices for useful purposes?

(A) Mechanics

(B) Thermodynamics

(C) Electronics ✅

(D) Electromagnetism

2. The process of emission of electrons from the surface of a hot metal is called:

(A) Conduction

(B) Thermionic Emission ✅

(C) Induction

(D) Electrolysis

3. Cathode rays are:

(A) Protons moving from anode to cathode

(B) Neutrons moving randomly

(C) Electrons emitted from cathode ✅

(D) Ions produced by chemical reaction

4. Cathode rays can be deflected by:

(A) Gravity only

(B) Heat and pressure

(C) Electric and magnetic fields ✅

(D) Sound waves

5. Which part of the cathode-ray oscilloscope

displays the electron beam?

(A) Deflecting plate

(B) Cathode

(C) Fluorescent screen ✅

(D) Transformer

6. Quantities that change continuously with time are called:

(A) Digital quantities

(B) Random quantities

(C) Static quantities

(D) Analogue quantities ✅

7. Quantities that change in discrete steps are known as:

(A) Analogue quantities

(B) Magnetic quantities

(C) Digital quantities ✅

(D) Oscillating quantities

8. The circuits that perform logic operations are

called:

(A) Transformers

(B) Amplifiers

(C) Logic gates ✅

(D) Rectifiers

9. Which logic gate gives output '1' only when all inputs are 1?

(A) OR gate

(B) NOT gate

(C) NAND gate

(D) AND gate ✅

10. Which table shows all possible input and output values of logic gates?

(A) Value Table

(B) Current Table

(C) Logic Table

(D) Truth Table ✅

11. Who discovered that cathode rays are

deflected by electric and magnetic fields?

(a) Rutherford

(b) Newton

(c) J.J. Thomson ✅

(d) Faraday

12. What charge do cathode rays carry?

(a) Positive

(b) Neutral

(c) Negative ✅

(d) Both positive and negative

13. What is the name of the process in which electrons are emitted from a hot metal surface?

(a) Photoelectric emission

(b) Thermionic emission ✅

(c) Nuclear emission

(d) Chemical emission

14. Why can't free electrons escape from a metal at room temperature?

(a) Because the metal is non-conductive

(b) Due to attractive forces of atomic nuclei ✅

(c) Because electrons are not free

(d) Due to external pressure

15. What are the typical voltage and current used for thermionic emission in a tungsten filament?

(a) 12 V and 1 A

(b) 6 V and 0.3 A ✅

(c) 9 V and 0.5 A

(d) 3 V and 2 A

16. What is the main purpose of a Cathode-Ray Oscilloscope (C.R.O)?

(a) To measure temperature

(b) To store energy

(c) To display changing electric currents or potentials ✅

(d) To control current flow

17. What component in the C.R.O controls the

brightness of the screen?

(a) The anode

(**b**) The grid ✅

(c) The fluorescent screen

(d) The Y-plates

18. The function of the anode in a C.R.O is to:

(a) Repel electrons

(b) Control brightness

(**c**) Accelerate electrons ✅

(d) Absorb electrons

19. Which part of the C.R.O is responsible for vertical deflection of the electron beam?

(a) Vertical plates

(**b**) Horizontal plates ✅

(c) Electron gun

(d) Horizontal plates (X-axis)

20. The screen of a C.R.O glows due to:

(a) Heating by cathode

(b) Electric sparks

(c) Magnetic deflection

(**d**) Bombardment by fast-moving electrons ✅

21. Which of the following is an example of an analogue quantity?

(a) Number of books

(**b**) Temperature of air ✅

(c) Number of cars

(d) Binary code

22. Analogue electronics deals with:

(a) Discrete signals

(b) Binary values

(**c**) Continuously varying quantities ✅

(d) Only sound signals

23. Which device converts analogue signals into digital signals?

(a) Loudspeaker

(b) Amplifier

(c) Analogue to Digital Converter (ADC) ✅

(d) Microphone

24. A digital signal uses which two voltage levels?

(a) +10 V and −10 V

(b) +5 V and −5 V

(c) +5 V and 0 V ✅

(d) 3 V and 0 V

25. What is the main function of a Digital to Analogue Converter (DAC)?

(a) To amplify sound

(b) To convert analogue to digital signal

(c) To produce binary data

(d) To convert digital signal into analogue form ✅

26. A variable that has only two possible states is called a:

(a) Decimal variable

(b) Binary variable ✅

(c) Real variable

(d) Voltage variable

27. Which two digits are used in Boolean algebra?

(a) 2 and 4

(b) 9 and 1

(c) 1 and 0 ✅

(d) 0 and 2

28. The algebra that deals with logic variables is called:

(a) Linear algebra

(b) Vector algebra

(c) Boolean algebra ✅

(d) Matrix algebra

29. What is the output of an AND gate when both inputs are '1'?

(a) 0

(b) 1 ✅

(c) Depends on input

(d) Cannot be determined

30. Which logic gate gives output '1' only when all inputs are '1'?

(a) OR gate

(b) NOT gate

(c) NAND gate

(d) AND gate ✅

31. What is the output of an OR gate when both inputs are 0?

(a) 1

(b) 0 ✅

(c) 2

(d) Undefined

32. OR operation is represented by which symbol?

(a) ×

(b) .

(c) + ✅

(d) −

33. The output of an OR gate is 1 if:

(a) Both inputs are 0

(b) Only one input is 1 ✅

(c) All inputs are 0

(d) None of the above

34. Which gate inverts the input signal?

(a) AND gate

(b) OR gate

(c) NOT gate ✅

(d) NAND gate

35. What is the output of a NOT gate if the input is 1?

(a) 0 ✅

(b) 1

(c) 2

(d) Undefined

36. What is the Boolean expression of a NAND gate?

(a) X = A + B

(b) X = A · B

(c) X = A · B (with NOT) ✅

(d) X = A

37. What is the output of a NAND gate if both inputs are 1?

(a) 1

(b) 0 ✅

(c) Cannot be determined

(d) Same as input

38. A NOR gate gives output 1 only when:

(a) Both inputs are 1

(b) One input is 1

(c) Both inputs are 0 ✅

(d) All inputs are high

39. The Boolean expression for NOR gate is:

(a) X = A + B

(b) X = A + B (with NOT) ✅

(c) X = A · B

(d) X = A – B

40. Which logic gate is commonly used in burglar alarm systems?

(a) OR gate

(b) NOT gate

(c) NAND gate ✅

(d) NOR gate

Important Short Questions:

1. What is electronics?

Answer:

Electronics is the branch of applied physics that deals with the control of motion of electrons in different devices for useful purposes.

2. What is thermionic emission?

Answer:

The process of emission of electrons from the surface of a hot metal is called thermionic emission.

3. What are cathode rays?

Answer:

Cathode rays are electrons emitted from the hot cathode surface that move toward the anode due to potential difference.

4. How can the path of a beam of electrons be changed?

Answer:

A beam of electrons can be deflected by applying electric or magnetic fields.

5. What is a cathode-ray oscilloscope (CRO)?

Answer:

A CRO is an instrument used to display the magnitudes of rapidly changing current or potential.

6. What are the main parts of CRO?

Answer:

- The three main parts of CRO are:

1. Electron gun

2. Deflecting plates

3. Fluorescent screen

7. What are analogue quantities?

Answer:

Quantities that change continuously with time are called analogue quantities.

8. What are digital quantities?

Answer:

Quantities that change in discrete steps are known as digital quantities.

9. What is a logic gate?

Answer:

A logic gate is a digital circuit that performs logic operations and has one or more inputs but only one output.

10. What is a truth table?

Answer:

A truth table shows the inputs and corresponding outputs of logic gates or their combinations.

11. What is thermionic emission?

Answer:

The process of emission of electrons from a hot metal surface is called thermionic emission.

12. Why can't electrons escape from the metal surface at room temperature?

Answer:

At room temperature, the attractive forces of atomic nuclei prevent electrons from escaping the metal surface.

13. How can electrons escape from a metal surface?

Answer:

When the metal is heated to a high temperature, electrons gain enough energy to overcome attractive forces and escape.

14. Which material is commonly used for thermionic emission and what are the typical values of voltage and current?

Answer:

A tungsten filament is used. Typical values: Voltage = 6V, Current = 0.3A.

15. Who discovered cathode rays and what did he conclude?

Answer:

J.J. Thomson discovered cathode rays in 1897 and concluded that they consist of negatively charged particles (electrons).

16. What are cathode rays made of?

Answer:

Cathode rays are made of electrons, which are negatively charged particles.

17. What is the function of an electron gun in experiments?

Answer:

An electron gun emits a narrow beam of high-speed electrons to investigate their properties.

18. How does an electric field affect an electron beam?

Answer:

The electron beam gets deflected towards the positive plate due to the attractive force.

19. Write the formula for the force acting on an electron in an electric field.

Answer:

The force is given by the formula: F = qE, where

F = force

q = charge of the electron

E = electric field strength

20. What happens to an electron beam when a magnetic field is applied at a right angle?

Answer:

The beam gets deflected, and if the magnetic field's direction is reversed, the deflection also reverses.

21. Define thermionic emission.

Answer:

The process of emission of electrons from a heated metal surface is called thermionic emission.

22. What are cathode rays?

Answer:

Cathode rays are streams of electrons emitted from the cathode in a vacuum tube.

23. Name the particle discovered by J.J. Thomson.

Answer:

J.J. Thomson discovered the electron.

24. What is the function of the control grid in an electron gun?

Answer:

It controls the brightness of the electron beam by varying its negative potential.

25. What is the function of deflecting plates in a C.R.O?

Answer:

They deflect the electron beam in vertical and horizontal directions.

26. What is a fluorescent screen in a C.R.O?

Answer:

It is a screen coated with a material that glows when hit by electrons.

27. Differentiate between analogue and digital quantities.

Answer:

Analogue quantities vary continuously, while digital quantities have discrete values (0 or 1).

28. What is the function of an ADC (Analog-to-Digital Converter)?

Answer:

It converts analogue signals into digital form.

29. Define a logic gate.

Answer:

A logic gate is an electronic circuit that performs a logical operation on one or more binary inputs.

30. What is Boolean algebra?

Answer:

It is the branch of algebra used to simplify logic circuits using binary values.

31. What is the Boolean expression for AND operation?

Answer:

- **The Boolean expression for AND operation is:**

$X = A \cdot B$,

which is read as "X equals A AND B".

32. When does the output of an AND gate become '1'?

Answer:

The output of an AND gate becomes '1' only when all of its inputs are at logic '1'.

33. Write any two conditions when the lamp is OFF in AND operation.

Answer:

- i. When both switches S_1 and S_2 are open.
- ii. When one switch is open and the other is closed.

34. What is the Boolean expression for OR operation?

Answer:

- **The Boolean expression for OR operation is:**

X = A + B,

which is read as "X equals A OR B".

35. When does the output of an OR gate become '0'?

Answer:

The output of an OR gate is '0' only when all of its inputs are at logic '0'.

36. What is the function of a NOT gate?

Answer:

A NOT gate inverts the input signal: it gives output 1 when input is 0, and output 0 when input is 1.

37. Why is a NOT gate called an inverter?

Answer:

Because it reverses or complements the logic level of the input.

38. How many inputs and outputs does a NOT gate have?

Answer:

- A NOT gate has one input and one output.

39. What is a NAND gate?

Answer:

- A NAND gate is the combination of an AND gate followed by a NOT gate.

40. What is the Boolean expression for NAND gate?

Answer:

- $X = \overline{(A \cdot B)}$, read as "X equals A AND B NOT".

41. What is the output of a NAND gate when both inputs are 1?

Answer:

- The output is 0.

42. What is the Boolean expression for NOR gate?

Answer:

- $X = \overline{(A + B)}$, read as "X equals A OR B NOT".

43. What is the output of a NOR gate when both inputs are 0?

Answer:

- The output is 1.

44. Which logic gate is used in a burglar alarm system?

Answer:

- NAND gate is used in the burglar alarm system.

Important Long Questions:

🌟 **Q1: What is thermionic emission? Explain the process and conditions necessary for it to occur.**

❖ **Definition of Thermionic Emission:**

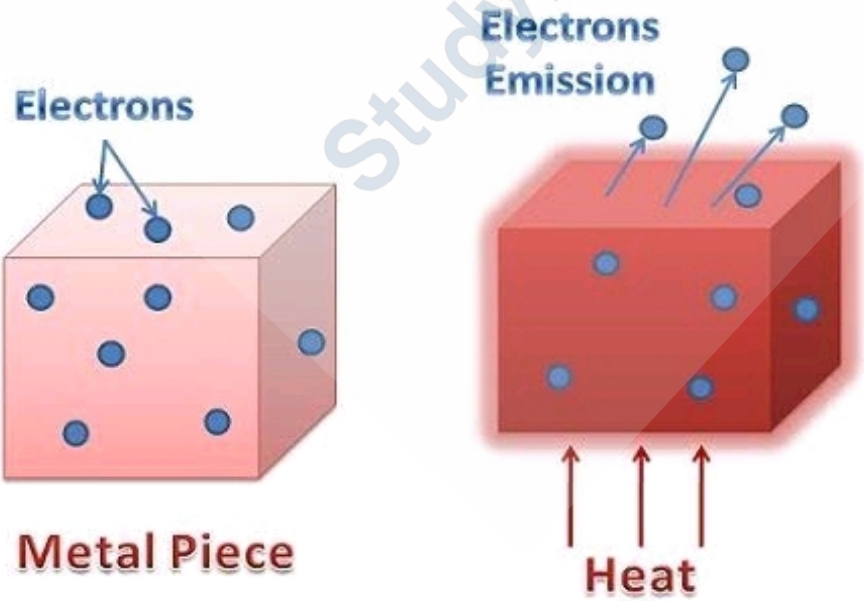
- Thermionic emission is the process in which electrons are emitted from the surface of a hot metal when it is heated to a high temperature.
- "The emission of electrons from a heated metal surface is called thermionic emission."

🔹 **Explanation of the Process:**

- Metals contain a large number of free electrons

that are free to move within the metal.

- However, at room temperature, these electrons do not have enough energy to escape the metal surface due to the attractive forces of the atomic nucleus.
- When the metal is heated, the free electrons gain kinetic energy.
- If the temperature is high enough, some electrons acquire sufficient energy to overcome the attractive forces and escape from the surface of the metal.
- This escape of electrons is called thermionic emission.



Conditions Necessary for Thermionic Emission:

Conditions	Explanation
High Temperature	Provides energy to free electrons to escape the metal surface.
Vacuum or low pressure	Prevents collision of emitted electrons with air molecules.
Metal with low work function	Metals like tungsten, which release electrons at high temperature.
Electric Supply	Required to heat the filament (e.g., using a battery or power source).

- **Example:** Tungsten Filament
  - Tungsten is commonly used for thermionic

emission because it has a high melting point.

- A fine tungsten filament is electrically heated.

Typical values used:

Voltage = 6V

Current = 0.3A

🔸 This setup is used in electron guns and cathode ray tubes.

🌟 **Q2: Explain J.J. Thomson's experiment for the discovery of electron using cathode rays.**

❖ **Introduction:**

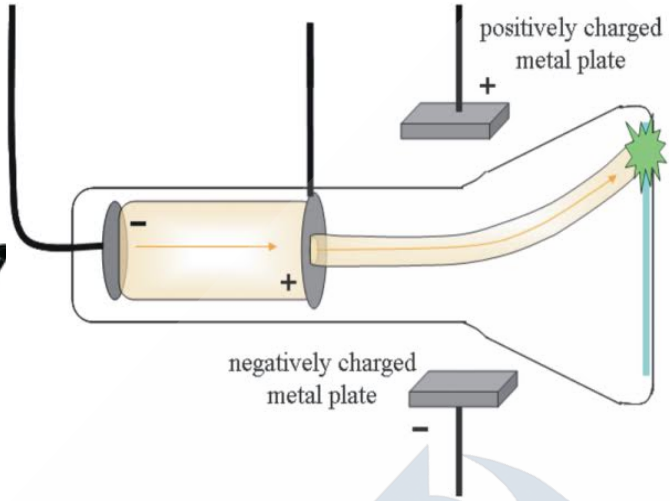
In 1897, Sir J.J. Thomson, a British physicist, performed a famous experiment using cathode rays.

His experiment proved the existence of electrons, the first discovered subatomic particle.

🔹 **Apparatus Used:**

- A discharge tube (glass tube with low-pressure gas inside)
- Two electrodes: cathode (–) and anode (+)
- High voltage power supply

- Electric and magnetic fields applied externally
- Fluorescent screen to detect ray position



Procedure & Observations:

1. When high voltage is applied across the electrodes, cathode rays (invisible beam) are emitted from the cathode and travel towards the anode.

2. These rays hit the fluorescent screen and produce a bright spot.

3. When electric field is applied:

- The rays are deflected towards the positive plate, showing that the rays are negatively charged.

4. When magnetic field is applied:

- The rays are also deflected, confirming they are charged particles, not light.

🔹 **Summary by J.J. Thomson:**

- Cathode rays are made of tiny particles carrying negative charge.
- These particles are much lighter than atoms.
- He named these particles electrons.

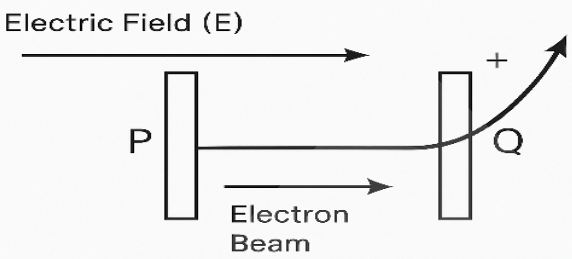
🔹 **Significance of the Experiment:**

- This was the first experimental proof that atoms are not indivisible.
- Discovery of electron laid the foundation of atomic structure and modern physics.

🌟 **Q3: How can we investigate the deflection of an electron beam using an electric field?**

❖ **Introduction:**

An electron beam can be deflected by applying an external electric field. This experiment helps us understand the charge and behavior of electrons under electric forces.



Deflection of Cathode Rays by Electric Field

Setup and Working:

- A narrow beam of electrons is produced using an electron gun inside an evacuated glass tube.
- Two parallel metal plates (P and Q) are placed horizontally, and a potential difference is applied across them.
- This setup creates a uniform electric field between the plates.

Direction of Deflection:

When the electron beam passes between these plates, it gets deflected towards the positive plate.

This shows that electrons carry a negative charge and are attracted towards positive charges and repelled by negative charges.

🔸 Force on Electrons:

The force acting on electrons in the electric field is given by:

$F = qE$

Where:

✅ F = force on electron

✅ q = charge of electron

✅ E = strength of electric field

The stronger the electric field (larger voltage), the greater the deflection.

🌟 Q4: How can we investigate the deflection of an electron beam using a magnetic field?

❖ Introduction:

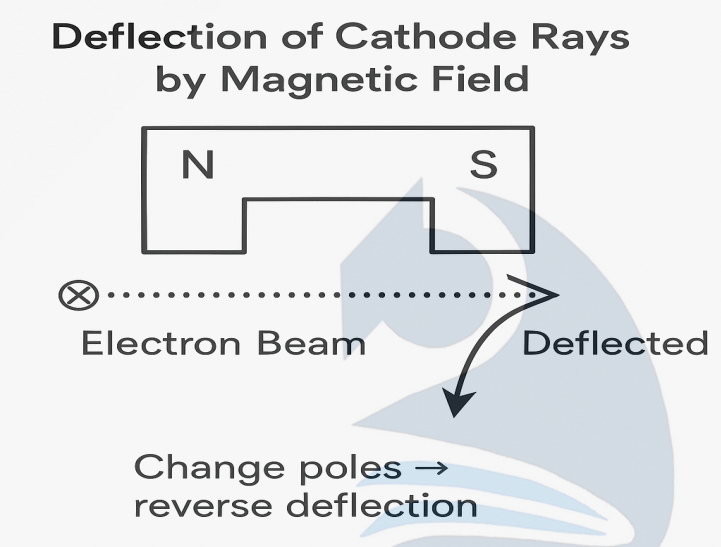
An electron beam can also be deflected by applying a magnetic field. This experiment helps us further investigate the properties of moving electrons and their interaction with magnetic forces.

🔸 Setup and Working:

- A beam of electrons is produced using an

electron gun.

- A horseshoe magnet is placed near the electron beam such that the magnetic field is perpendicular to the direction of motion of electrons.



Direction of Deflection:

The magnetic field exerts a force on the moving electrons, causing the electron beam to deflect from its original path.

If we reverse the direction of the magnetic field, the direction of deflection of the beam also reverses.

Magnetic Force Explanation:

The force on a moving charged particle in a

magnetic field is given by:

$$F = qvB\sin\theta$$

Where:

✅ F = magnetic force

✅ q = charge of electron

✅ v = velocity of electron

✅ B = magnetic field strength

✅ θ = angle between v and B (90° in this case)

Since the direction of force is always perpendicular to both velocity and magnetic field, it causes the electron beam to curve.

🌟 **Q5: What is a Cathode-Ray Oscilloscope (C.R.O)? Explain its main components with working.**

❖ **Definition:**

A Cathode-Ray Oscilloscope (C.R.O) is an electronic instrument used to display the magnitudes of changing electric currents or voltages as a

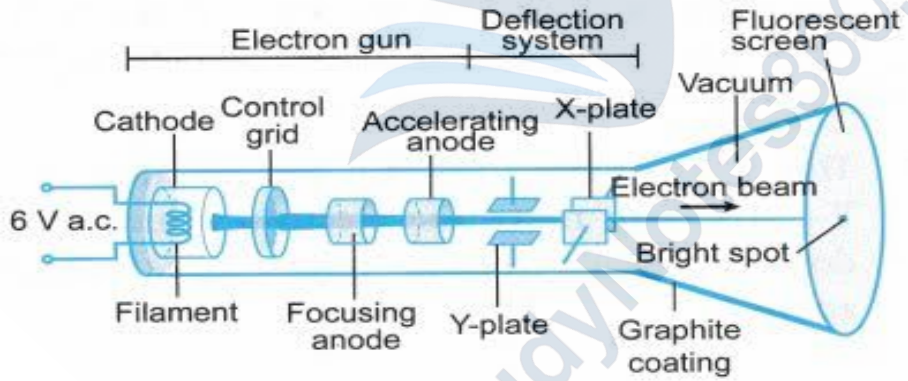
waveform on a screen. It works using a Cathode Ray Tube (CRT).

Purpose of C.R.O:

- To visualize changing electrical signals.
- To measure voltage and current.
- To observe waveforms in real-time.

Diagram of C.R.O:

[Electron Gun] ⇒ [Deflecting Plates] ⇒ [Fluorescent Screen]



Main Components of C.R.O:

1. Electron Gun:

- It consists of a heated cathode that emits electrons via thermionic emission.
- A control grid (G) controls the brightness of the

beam by adjusting the number of electrons.

- An anode accelerates and focuses the electron beam into a narrow stream.

2. Deflecting Plates:

- Vertical (Y-axis) plates move the beam up and down (voltage measurement).
- Horizontal (X-axis) plates move the beam left and right (time base).
- The movement of the beam across these plates forms the waveform.

3. Fluorescent Screen:

- Made of phosphor material.
- When struck by the fast-moving electron beam, it glows and forms a visible spot.
- The spot moves according to the applied signal, forming patterns or waves.

Working Principle:

- Electrons are emitted from the cathode, accelerated by the anode, and passed between

deflecting plates.

- The electric signals control the deflection of the beam.
- The beam hits the screen and forms a waveform representing the input signal.

🌟 **Q6: Write five important uses of C.R.O in daily life and science.**

❖ **Answer:**

🔹 **1. Displaying Waveforms:**

- C.R.O is widely used to display alternating current (AC) waveforms, such as sine waves, square waves, etc.

🔹 **2. Measuring Voltage and Current:**

- It helps in measuring peak-to-peak voltage and time period of electrical signals accurately.

🔹 **3. Radar and Range-Finding:**

- Used in radar systems to measure the distance of objects by analyzing the time taken by reflected signals.

🔹 4. Echo Sounding (Seabed Depth):

- Used in ships to measure ocean depth by detecting sound wave reflections from the seabed.

🔹 5. Heartbeat Display (Medical Use):

- C.R.O is used in ECG (Electrocardiogram) machines to display the electrical activity of the heart.

🌟 **Q7: What are binary variables? Explain their importance in digital electronics with suitable examples.**

❖ **Definition of Binary Variables:**

A binary variable is a quantity that can have only two possible states or values. These are typically represented by:

1 (True / ON / High voltage)

0 (False / OFF / Low voltage)

🔹 Example (Switch and Lamp Circuit):

Consider a simple circuit with:

- A battery, a switch, and a lamp.

Switch (input)	Lamp (output)	Binary From
Open	Off	0
Closed	On	1

- **When the switch is open:** No current ⇒ lamp is OFF ⇒ Output = 0
- **When the switch is closed:** Current flows 'n lamp is ON ⇒ Output = 1

Input-Output Relation in Binary Form:

- **Input (Switch)** = Binary variable (0 or 1)
- **Output (Current or Lamp)** = Binary variable (0 or 1)
- Thus, both input and output behave as binary variables.

Importance in Digital Electronics:

- All digital circuits work on binary logic (0 and 1).
- Devices like computers, calculators, mobile phones, etc., operate using binary variables.

- Decision making and logical processing in digital systems depend on binary inputs and outputs.

🌟 **Q8: What is Boolean Algebra? Discuss its role in the working of digital circuits.**

Answer:

❖ **Introduction to Boolean Algebra:**

Boolean Algebra is a branch of mathematics developed by George Boole. It deals with logic values:

- True / False
- Represented as 1 / 0

It is also known as Algebra of Logic.

🔸 **Use of Logic Variables:**

- In Boolean algebra, variables only have two possible states: 0 or 1.
- These variables represent logical decisions rather than numerical values.

🔸 **How Boolean Algebra Helps:**

🔹 Used to create logic circuits.

🔸 Simplifies complex logical problems using symbols like:

- AND (·)
- OR (+)
- NOT ($\bar{}$ or !)

Example:

- A + B means A OR B
- A · B means A AND B
- $\bar{A}$ means NOT A

📌 Comparison with Traditional Algebra:

Feature	Traditional Algebra	Boolean Algebra
Variable types	Numeric (1, 2, 3, ...)	Logic (0 or 1)
Operations	+, -, ×, ÷	AND, OR, NOT
Results	Range of values	Only 0 or 1
Application	Math, physics,	Digital

area	etc.	electronics, logic

🔹 **Role in Modern Electronics:**

Forms the basis of logic gates and digital circuits.

🔸 **Helps design:**

- Computers
- Calculators
- Microcontrollers
- Digital watches

🔸 Used in control systems and artificial intelligence logic.

🌟 **Q9: Define a logic gate. Explain how basic logic gates (AND, OR, NOT) work with the help of truth tables.**

❖ **Definition of Logic Gate:**

A logic gate is a basic digital circuit that performs logical operations on one or more binary inputs and produces a single binary output.

It works with only two voltage levels:

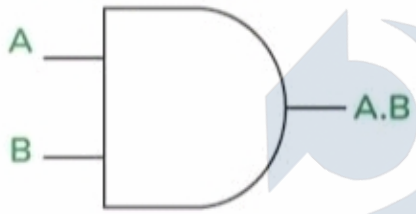
- High (1)
- Low (0)

Each logic gate implements a Boolean function.

🔹 Types of Basic Logic Gates:

🔹 1. AND Gate:

➤ Symbol:



➤ **Truth Table:**

A B A · B (Output)

0 0 0

0 1 0

1 0 0

1 1 1

➤ **Explanation:**

The output is 1 only when both inputs are 1.

🔹 2. OR Gate:

➤ **Symbol:**

2 input OR gate

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

➤ **Truth Table:**

A B A + B (Output)

0 0 0

0 1 1

1 0 1

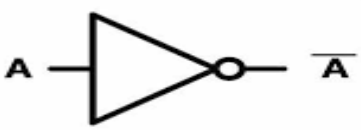
1 1 1

➤ **Explanation:**

The output is 1 if at least one input is 1.

3. NOT Gate:

➤ **Symbol:**



2 input NOT gate

A	$\overline{A}$
0	1
1	0

➤ **Truth Table:**

A	$\bar{A}$ (Output)
0	1
1	0

➤ **Explanation:**

The NOT gate inverts the input.

- If input is 0 ⇒ Output is 1
- If input is 1 ⇒ Output is 0

🌟 **Q10: What is an AND Operation? Explain the working of AND Gate with the help of Boolean expression, truth table, and circuit examples.**

❖ **Definition:**

The AND operation is a basic logic operation in which the output is high (1) only if all inputs are high (1). If even one input is low (0), the output will be low (0).

🔹 **Working of AND Operation:**

Imagine a circuit with a lamp connected to a battery using two switches in series — named S_1 and S_2.

The lamp will only glow if both switches are closed. This is because current can pass through only when there's no break in the path.

- If both switches are open ⇒ lamp remains OFF
- If only one switch is closed ⇒ lamp remains OFF
- If both switches are closed ⇒ lamp turns ON

This behavior is similar to AND operation, where both inputs must be ON (1) to get output ON (1).

📘 Boolean Expression:

AND operation is written as:

> X = A . B

This means "X equals A AND B".

💻Truth Table (Explained in words):

- If A = 0 and B = 0, then X = 0
- If A = 0 and B = 1, then X = 0
- If A = 1 and B = 0, then X = 0
- If A = 1 and B = 1, then X = 1

💡 Real-life Example:

Think of a security door that requires two keys. If both keys are inserted (closed switches), the door opens (output = 1). If one or both keys are missing, the door remains locked (output = 0).

☐ Symbol of AND Gate:

The symbol has two inputs on the left and one output on the right, shaped like a half-circle.

🌟 Q10: What is an OR Operation? Describe the working of OR Gate with Boolean expression, truth table, and suitable example.

❖ Definition:

The OR operation gives an output of high (1) if at least one of the inputs is high (1). Only when all inputs are low (0), the output will be low (0).

🔧 Working of OR Operation:

Imagine a lamp connected to a battery through two parallel switches — S_1 and S_2. If any one of the switches is closed, the circuit completes and the lamp glows.

- If both switches are open ⇒ lamp remains OFF
- If only one switch is closed ⇒ lamp turns ON
- If both switches are closed ⇒ lamp turns ON

This is how OR operation works: it only needs one input to be ON.

📘 Boolean Expression:

OR operation is written as:

> X = A + B

This means "X equals A OR B".

🖥️ Truth Table (Explained in words):

- If A = 0 and B = 0, then X = 0
- If A = 0 and B = 1, then X = 1
- If A = 1 and B = 0, then X = 1
- If A = 1 and B = 1, then X = 1

💡 Real-life Example:

Imagine a room with two doors. If any one door is open, you can enter. Similarly, if either input is 1, output is 1.

☐ Symbol of OR Gate:

The OR gate symbol has two curved inputs entering a pointed shape with one output on the right.

🌟 Q11: What is NOT Operation? Explain its working with Boolean expression, truth table, and suitable circuit.

❖ Definition:

The NOT operation is also known as inversion. It reverses the logic state of the input. If the input is 1, the output becomes 0, and vice versa.

🔹 Working of NOT Operation:

Consider a lamp and a switch connected in a special way. When the switch is open, current flows and the lamp glows. But when the switch is closed, current is diverted and the lamp turns off.

This represents NOT logic, where the output is opposite to the input.

📘 Boolean Expression:

NOT operation is written as:

> $X = \bar{A}$

This means "X equals NOT A" or "X is the complement of A".

🖥️**Truth Table (Explained in words):**

- If A = 0, then X = 1
- If A = 1, then X = 0

💡 **Real-life Example:**

Consider a lamp that turns on only when a person is NOT present. When presence (input = 1) is detected, the light turns OFF (output = 0). When no presence is detected (input = 0), the light turns ON (output = 1).

🔲 **Symbol of NOT Gate:**

The NOT gate has one input and one output. The symbol is a triangle with a small circle at the tip, indicating inversion.

🌟 **Q12: Define Logic Gates. Explain the working of basic logic gates (AND, OR, NOT) with Boolean expressions, symbols, and truth tables.**

❖ **Definition:**

A Logic Gate is an electronic circuit that performs a specific logical operation on one or more binary inputs to produce a binary output. Logic gates are the building blocks of digital electronics.

🟢 AND Gate:

- Inputs must all be 1 for the output to be 1.
- Boolean Expression: X = A . B
- Behavior: If any input is 0, the output is 0.
- Symbol: Half-circle with two inputs and one output.

🔵 OR Gate:

- At least one input must be 1 for the output to be 1.
- **Boolean Expression:** X = A + B
- **Behavior**: Only 0+0 gives 0; all other combinations give 1.
- **Symbol**: Curved input lines joining into a pointed output.

🔴 NOT Gate:

- Only one input and one output.
- **Boolean Expression**: $X = \bar{A}$
- **Behavior**: Input 0 gives output 1, and input 1 gives output 0.
- **Symbol**: Triangle with a small circle on its tip.

Exercise Questions:

REVIEW QUESTIONS

🌟 **Q16.1: Describe, using one simple diagram in each case, what happens when a narrow beam of electrons is passed through (a) a uniform electric field, (b) a uniform magnetic field. What do these results indicate about the charge on electron?**

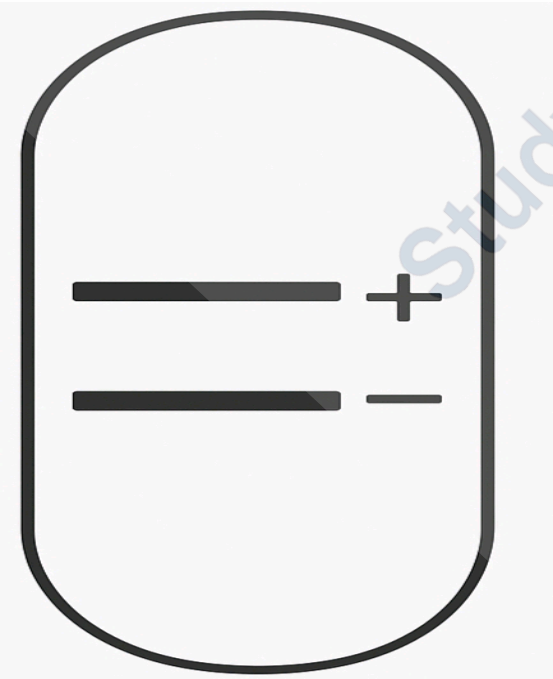
🔹 (a) Electron Beam in Electric Field:

- When a narrow beam of electrons is passed between two parallel metal plates—one

positively charged and one negatively charged—an electric field is created between them.

- As electrons enter this field, they experience an electric force.
- Since electrons are negatively charged, they are attracted towards the positive plate and repelled from the negative plate.
- As a result, the path of the electron beam bends upward (if positive plate is on top), forming a curved trajectory.

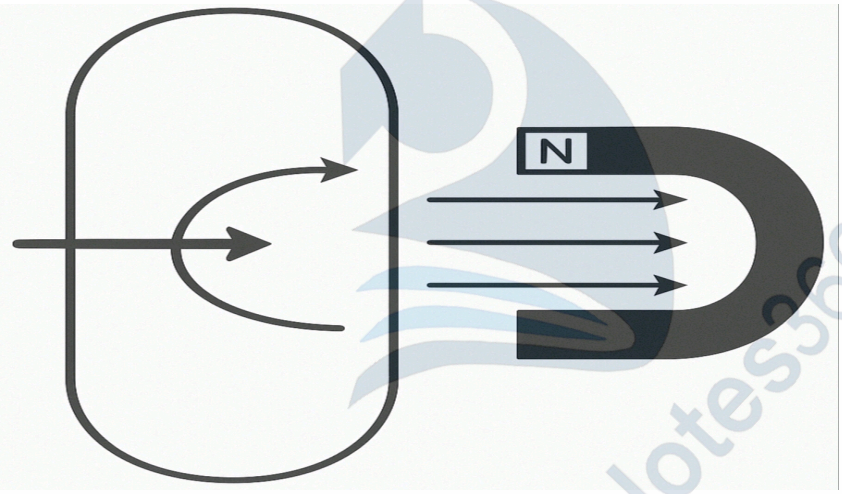
Diagram:



Observation:

- The beam deflects towards the positive plate, confirming that electrons carry a negative charge.
- The greater the voltage (field strength), the greater the deflection.

(b) Electron Beam in Magnetic Field:



- Now suppose a magnetic field is applied perpendicular to the direction of the moving electron beam. For example, using a horseshoe magnet, we create a magnetic field into or out of the plane.
- As the electron beam enters this field, it experiences a magnetic force due to its motion.

- The force acts perpendicularly to both the direction of motion and the magnetic field (Right-Hand Rule).
- As a result, the electron beam follows a curved path, forming a circular or spiral arc.

🔹 **Observation:**

The beam deflects sideways, indicating that moving charges are affected by magnetic fields, and since electrons bend in a certain direction, it confirms their negative charge.

🌟 **Q16.2: Explain the working of different parts of oscilloscope.**

❖ **Answer:**

A Cathode Ray Oscilloscope (C.R.O.) is an electronic device used to display electrical signals as waveforms. It shows how voltage changes with time and helps visualize AC/DC signals, pulses, or other wave patterns.

🔹 **Main Parts of C.R.O. and Their Working:**

1. Cathode Ray Tube (CRT)

- It is the heart of the C.R.O. and consists of a vacuum tube with several key components:

2. Electron Gun

- It includes a heated cathode that emits electrons via thermionic emission.
- These electrons are accelerated and focused into a narrow beam.
- The beam is directed toward the screen.

🔹 **Purpose:** Produces and focuses electron beam to hit the screen.

3. Deflecting Plates

There are two sets of metal plates:

📍 X-plates (Horizontal Deflection)

- Connected to Time Base Circuit.
- Moves the electron beam left to right across the screen.

📍 Y-plates (Vertical Deflection)

- Connected to the input signal.
- Moves the beam up or down based on voltage.

- **Working:**

The combination of X and Y deflection causes the electron beam to move in waveform pattern, representing how signal voltage varies with time.

4. Fluorescent Screen

- Coated with phosphor material.
- When hit by the electron beam, it glows and shows a visible trace.
- The trace forms the graph of the signal.

Purpose: Converts invisible electron beam into visible waveform.

- **Time Base Circuit**

- Produces a saw-tooth waveform.
- It controls the horizontal movement (X-direction) of the electron beam to sweep across the screen at a constant speed.

Function: Enables time-based display of signals.

- **Input System**

- It accepts electrical signals (AC or DC) and

feeds them to the Y-plates.

- Signal is amplified and conditioned before use.

🔎 **Summary:**

C.R.O. converts electric signals into visual traces.

It allows precise observation of:

- Waveforms
- Signal frequencies
- Voltage amplitudes
- Time intervals

🧪 **Applications:**

Used in electronics, television, radar, medical ECG, engineering labs, and signal testing.

🌟 **Q16.3: Name some uses of oscilloscope.**

❖ **Answer:**

The Cathode Ray Oscilloscope (C.R.O.) is a very useful electronic instrument used for observing the waveform of electrical signals.

✅ **Uses of Oscilloscope:**

1. Measurement of Voltage (AC/DC)

- C.R.O. can measure the peak value, rms value, and instantaneous value of both alternating and direct voltages.
- The vertical deflection on the screen is proportional to the input voltage.

2. Measurement of Frequency

- The number of complete waveforms seen on the screen per second allows frequency calculation.
- Useful for tuning electronic circuits.

3. Study of Waveforms

It helps visualize electrical signals as waves, making it easier to analyze:

- Sinusoidal waves
- Square waves
- Pulse waves

4. Testing of Electronic Equipment

Engineers and technicians use CROs to test

components like:

- Amplifiers
- Oscillators
- Transformers

5. Medical Applications

- In Electrocardiograms (ECG), oscilloscopes are used to display heartbeats as wave patterns.
- Also used in brainwave analysis (EEG).

6. Radar and Communication Systems

- C.R.O. is used in radar systems to display distance, direction, and movement.
- It also helps in signal transmission testing in communication devices.

7. Measurement of Phase Difference

By using Lissajous Figures, CRO helps measure the phase difference between two signals.

🌟 **Q16.4: Considering an oscilloscope, explain:**

❖ **Answer:**

(i) How is the filament heated?

- The filament in the cathode ray tube (CRT) is heated by passing an electric current through it.
- The filament is connected to a low voltage power supply (often AC), which heats it up.

Key Point: The heating is done electrically, just like a light bulb filament.

(ii) Why is the filament heated?

- Heating the filament causes it to emit electrons through a process called thermionic emission.
- When the filament becomes hot, the electrons in the metal gain enough energy to escape from its surface.

Key Point: The purpose is to produce a stream of free electrons needed for the electron beam.

(iii) Why is the anode potential kept positive with respect to the cathode potential?

- The anode is kept positive to attract the negatively charged electrons emitted from the cathode.

- This positive potential accelerates the electrons toward the screen.

Key Point: Positive anode pulls electrons forward, forming a focused high-speed beam.

(iv) Why is a large potential applied between anode and cathode?

- A large potential (thousands of volts) is applied to give electrons high kinetic energy.
- This ensures that the electrons strike the fluorescent screen with enough energy to produce a bright visible spot.

Key Point: More voltage = brighter and sharper display.

(v) Why is the tube evacuated?

The CRT is evacuated (i.e., air is removed) to create a vacuum.

- In vacuum:
- Electrons can travel without colliding with air molecules.

- Beam remains focused, and display is clear.

Key Point: Vacuum ensures smooth and uninterrupted electron flow.

🌟 **Q16.5: What is an Electron Gun? Describe the process of Thermionic Emission.**

❖ **Definition: Electron Gun**

- An electron gun is a device used in a Cathode Ray Tube (CRT) to produce a narrow and high-speed beam of electrons.
- It is the starting part of the oscilloscope or television tube, and it directs the electrons towards the screen.

🔹 **Main Parts of Electron Gun:**

1. Filament (Heater):

- A thin wire that is heated by an electric current.
- It produces heat needed for thermionic emission.

2. Cathode:

- A metal electrode placed near the filament.

- When heated, it emits electrons.

3. Control Grid:

- It controls the number of electrons in the beam.
- It can increase or decrease the brightness of the spot on the screen.

4. Anodes:

Positively charged electrodes that accelerate and focus the electron beam towards the screen.

✅ What is Thermionic Emission?

Thermionic emission is the process in which electrons are emitted from the surface of a heated metal.

🔹 Explanation:

- When the filament is heated, it provides thermal energy to the cathode.
- The electrons in the cathode metal gain enough energy to overcome the attractive forces holding them inside.
- These free electrons are then emitted from the

surface of the cathode.

- This stream of electrons forms the electron beam which is accelerated by the anode.

🌟 **Q16.6: What do you understand by Digital and Analogue Quantities?**

❖ **Answer:**

✅ **Analogue Quantities:**

An analogue quantity is a type of signal or measurement that can vary continuously over time.

It can have infinite values within a given range.

🔹 **Examples of Analogue Quantities:**

- Temperature
- Speed
- Sound waves
- Voltage in a battery

🔹 **Characteristics of Analogue Quantities:**

- Smooth and continuous change
- Represented by curved or sloped lines on

graphs

- Sensitive to noise and signal distortion

✅ Digital Quantities:

- A digital quantity is a signal or measurement that can take only specific and discrete values.
- It uses binary form (0 and 1) for representation.

🔹 Examples of Digital Quantities:

- Data in a computer
- Digital clock time
- Binary code
- Number of people (1, 2, 3...)

🔹 Characteristics of Digital Quantities:

- Change in steps or jumps
- Represented by square or pulse-like waves
- Less affected by noise
- Easy to store, process, and transmit

🌟 Q16.7: Differentiate between Analogue Electronics and Digital Electronics. Also write

names of five analogue and five digital devices used in daily life.

❖ **Answer:**

🔹 Analogue Electronics:

- Analogue electronics is a branch of electronics that deals with continuous signals. In analogue systems, the input and output values can vary smoothly over a range. These signals are not restricted to just two states—they can take any value between minimum and maximum.
- For example, when we increase the volume of a radio gradually, the signal changes continuously. This is a feature of analogue electronics.
- However, analogue circuits are more affected by noise and less accurate compared to digital systems.

🔹 Digital Electronics:

- Digital electronics works on signals that are discrete or binary in nature. This means that

the signals can have only two values: 0 and 1, or OFF and ON. These are also called logic signals.

- Digital systems are used in modern devices like computers, calculators, and digital clocks. They are more accurate, fast, and less affected by noise. Most modern machines use digital circuits due to their reliability.

✅ Main Difference:

- The key difference between analogue and digital electronics is that analogue deals with continuous signals, whereas digital deals with binary signals (0 and 1).

🔹 Examples of Analogue Devices in Daily Life:

1. Thermometer (with a mercury column)
2. Old radios (with manual tuning)
3. Microphones
4. Analogue wall clocks
5. Tape recorders

- **Examples of Digital Devices in Daily Life:**

1. Digital watches
2. Computers
3. Calculators
4. Digital thermometers
5. Mobile phones

🌟 **Q16.8: State and explain for each case whether the information given by the following devices is in analogue or digital form.**

❖ **Answer:**

➤ **(a) A moving-coil voltmeter measuring the e.m.f of a cell**

- **Type of Signal: Analogue**
- **Explanation:**

A moving-coil voltmeter gives a continuously varying reading on a dial based on the voltage of the cell. The pointer can take any position within the scale, which means the signal is continuous, not limited to fixed steps. Therefore, the output is

analogue.

➤ (b) A microphone generating an electric current

- **Type of Signal: Analogue**
- **Explanation:**

When a microphone picks up sound waves, it converts them into a continuously varying electric current that matches the shape of the sound wave. Since this current changes smoothly over time, it is an analogue signal.

➤ (c) A central heating thermostat controlling the water pump

- **Type of Signal: Digital**
- **Explanation:**

The thermostat works on the principle of turning the pump ON or OFF based on a temperature limit. These are two distinct states (either ON or OFF), so the output is in digital form.

➤ (d) Automatic traffic lights controlling the flow of traffic

- **Type of Signal: Digital**
- **Explanation:**

Traffic lights operate using preset signals such as red, yellow, and green. These signals represent fixed, discrete states and are not continuous. Hence, the control system uses digital signals to manage the light changes.

🌟 **16.9. Write down some benefits of using digital electronics over analogue electronics.**

❖ **Answer:**

Digital electronics offer several advantages over analogue electronics, especially in terms of accuracy, efficiency, and processing. Some key benefits are:

- **1. Higher Accuracy and Reliability**

Digital systems work with binary signals (0 and 1), which are less affected by noise, temperature, or signal degradation. This ensures more accurate and reliable results compared to analogue signals, which can vary continuously and be distorted.

2. Easy Storage and Processing

Digital signals can be easily stored in memory devices (like USB, CDs, or computers) and processed using computers and microprocessors. Analogue signals require more complex methods for storage and are harder to process.

3. Noise Immunity

Digital circuits are less sensitive to electrical noise and interference. This makes them suitable for long-distance data transmission and communication without much distortion.

4. Compact and Low Power

Digital components are often smaller in size and consume less power, making devices like smartphones, calculators, and digital watches more efficient.

5. Easy Error Detection and Correction

Digital systems can use error-checking codes and logic to detect and correct transmission errors, which is difficult in analogue systems.

6. Reproducibility and Consistency

A digital signal can be exactly reproduced every time, while an analogue signal may slightly change every time it's copied or transmitted.

🌟 **16.10. What are the three universal Logic Gates? Give their symbols and truth tables.**

❖ **Answer:**

The three universal logic gates are:

1. NAND Gate

Definition: The NAND (Not AND) gate gives an output of 0 only when all inputs are 1. In all other cases, it gives 1.

Boolean Expression: X = (A . B)' (NOT of A AND B)

Working:

- If both inputs are 1 ⇒ Output is 0
- If any input is 0 ⇒ Output is 1

2. NOR Gate

Definition: The NOR (Not OR) gate gives an output of 1 only when all inputs are 0. If any input is 1, the

output becomes 0.

Boolean Expression: X = (A + B)' (NOT of A OR B)

Working:

If both inputs are 0 ⇒ Output is 1

If any input is 1 ⇒ Output is 0

🔹 3. NOT Gate

Definition: The NOT gate is also called an inverter. It reverses the input signal:

- If input is 0 ⇒ Output is 1
- If input is 1 ⇒ Output is 0

Boolean Expression: X = $\bar{A}$

✅ **Why Are NAND and NOR Called Universal Gates?**

NAND and NOR gates are called universal because you can use them to build any other logic gate (AND, OR, NOT, XOR, etc.) using just combinations of NAND or NOR gates.

CONCEPTUAL QUESTIONS

🌟 **16.1. Name two factors which can enhance thermionic emission.**

❖ **Answer:**

Thermionic emission is the process in which electrons are emitted from a metal surface when it is heated. Two main factors that enhance this emission are:

🔹 **1. Increase in Temperature of the Filament:**

When the filament (usually made of tungsten) is heated to a high temperature, the thermal energy provides electrons enough energy to overcome the attractive forces of the metal, allowing them to escape.

👉 Higher the temperature ⇒ Greater the thermionic emission.

🔹 **2. Use of a Low Work Function Material:**

Materials with a low work function (i.e., the minimum energy required to release an electron)

emit electrons more easily. Metals like tungsten, barium, or cesium oxide are often used for this reason.

👉 Lower the work function ⇒ Easier electron emission.

🌟 **16.2. Give three reasons to support the evidence that cathode rays are negatively charged electrons.**

❖ **Answer:**

Cathode rays are proven to be made of negatively charged electrons based on the following experimental observations:

- **1. Deflection by Electric and Magnetic Fields:**
  - When cathode rays are passed through a uniform electric field, they are deflected towards the positive plate, indicating that the rays carry a negative charge.
  - Similarly, they are also deflected by a magnetic field, confirming their charged nature.
- **2. Mechanical Effect (Paddle Wheel**

Experiment):

Cathode rays can move a small paddle wheel placed in their path inside a discharge tube. This proves that they consist of particles with mass (not just energy), and their ability to push the wheel shows they possess momentum.

🔹 3. Production of Shadow and Fluorescence:

- When an object (like a metal cross) is placed in the path of cathode rays, it casts a shadow on the fluorescent screen, proving that cathode rays travel in straight lines.
- Moreover, they cause fluorescence when they strike certain materials, which is a property of high-energy charged particles like electrons.

🌟 **16.3. When electrons pass through two parallel plates having opposite charges, they are deflected towards the positively charged plate. What important characteristic of the electron can be inferred from this?**

❖ **Answer:**

When electrons pass through two oppositely charged plates, they are deflected toward the positively charged plate. This behavior clearly indicates an important property of the electron:

➡ **Electrons carry a negative charge.**

Explanation:

- Opposite charges attract. Since the electron is attracted towards the positive plate, it must have a negative electric charge. This deflection proves that:
- Electrons are negatively charged particles.
- They respond to electric fields and experience electrostatic force.

🌟 **16.4. When a moving electron enters the magnetic field, it is deflected from its straight path. Name two factors which can enhance electron deflection.**

❖ **Answer:**

When a moving electron enters a magnetic field, it is deflected due to the magnetic force acting on it.

The deflection increases with the following two factors:

- **1. Increase in Magnetic Field Strength (B):**

A stronger magnetic field applies a greater force on the moving electron, causing more curvature in its path.

- **2. Increase in Electron Velocity (v):**

The faster the electron moves, the greater the magnetic force it experiences. This leads to a larger deflection from its original path.

🧲 Magnetic Force Formula:

$$F = qvB\sin\theta$$

- F = Magnetic force
- q = Charge of electron
- v = Velocity of electron
- B = Magnetic field strength
- θ = Angle between v and B (maximum when 90°)

🌟 Q16.7. Show that the circuit given below acts

as OR gate.

❖ **Answer:**

- **Definition of OR Gate:**

An OR gate gives an output of 1 when any one or both inputs are 1.

Input A	Input B	Output (A + B)
0	0	0
0	1	1
1	0	1
1	1	1

- **Assume Circuit Description:**

Suppose the given circuit has:

Two input switches: A and B

- One lamp or LED as output
- A battery connected through the switches
- Both switches connected in parallel

🔹 Explanation of Circuit Working:

- In a parallel circuit, current flows if any one path is completed.
- So, if A is ON or B is ON, current will flow ’n Lamp will glow (Output = 1)
- Lamp will not glow only when both A and B are OFF (Output = 0)

🔹 Truth Table of the Circuit:

Switch A	Switch B	Lamp (Output)
OFF (0)	OFF (0)	OFF (0)
OFF (0)	ON (1)	ON (1)
ON (1)	OFF (0)	ON (1)
ON (1)	ON (1)	ON (1)

🔍 Summary:

Since the output behavior matches the OR Gate truth table,

- 🔹 This circuit behaves like an OR Gate.

🌟 Q16.8. Show that the circuit given below acts as AND gate.

❖ **Answer:**

🔹 **Definition of AND Gate:**

An AND gate gives output 1 (ON) only if both inputs are 1 (ON).

Otherwise, output is 0 (OFF).

Input A	Input B	Output (A · B)
0	0	0
0	1	0
1	0	0
1	1	1

🔹 **Assumed Circuit Description:**

Two switches: A and B

- One bulb or LED connected in series
- Power source (battery) connected through the switches

➤ **Both switches are connected in series with the lamp.**

🔹 Explanation of Circuit Working:

- In a series connection, current flows only if both switches are closed (ON).
- If either A or B is OFF, the current cannot flow ⇒ bulb stays OFF.

The lamp glows only when both A and B are ON.

🔹 Truth Table of Series Circuit:

Switch A	Switch B	Lamp (Output)
OFF (0)	OFF (0)	OFF (0)
OFF (0)	ON (1)	OFF (0)
ON (1)	OFF (0)	OFF (0)
ON (1)	ON (1)	ON (1)

🔍 Summary:

Since the lamp glows only when both switches are ON,

- 🔹 This circuit behaves exactly like an AND Gate.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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