AQA (GCSE Notes)

Chapter 7: Magnetism and Electromagnetism

Q1. What happens when two like poles of a magnet are brought close together?
Answer: They repel each other.
Solution: Like poles, such as two north poles or two south poles, push away from each other because the magnetic field lines from each pole move in the same direction, creating a repulsive force. This repulsion is a non-contact force, meaning the magnets don't need to touch to feel the effect.

Q2. What happens when two unlike poles of a magnet are brought close together?
Answer: They attract each other.
Solution: Unlike poles, such as a north pole and a south pole, pull towards each other because their magnetic field lines move toward one another, creating an attractive force. This interaction happens even without the magnets touching, showing a non-contact force.

Q3. Why is attraction and repulsion between magnets considered a non-contact force?
Answer: Because it occurs even when the magnets are not touching.
Solution: Magnetic forces act through space without any direct contact. When two magnets are near each other, they can either attract or repel depending on their poles. This action without physical contact defines it as a non-contact force.

Q4. What is meant by the term 'permanent magnet'?
Answer: A magnet that produces its own magnetic field all the time.
Solution: A permanent magnet is made from a material that remains magnetised even when not in a magnetic field. It has fixed north and south poles and always produces a magnetic field without needing an external influence.

Q5. What is meant by the term 'induced magnet'?
Answer: A material that becomes a magnet when placed in a magnetic field.
Solution: Induced magnets are not always magnetic. They become magnetised only when inside a magnetic field and lose most or all of their magnetism once removed. They are useful for temporary magnetism.

Q6. How does an induced magnet behave when placed in a magnetic field?
Answer: It becomes magnetised and attracts to the magnet.
Solution: When a material like iron is placed in a magnetic field, it temporarily becomes a magnet itself. The field causes the domains inside the material to align, turning it into an induced magnet that attracts to the source.

Q7. What happens to an induced magnet when it is removed from a magnetic field?
Answer: It loses most or all of its magnetism quickly.

Solution: Induced magnets are temporary. As soon as the external magnetic field is removed, the material's magnetic domains return to random positions, and the magnetism fades away.

Q8. Why does an induced magnet always produce a force of attraction?
Answer: Because its poles align in such a way that it is always attracted to the permanent magnet.
Solution: An induced magnet will always have its poles arranged to attract the source magnet. It never repels because it takes on opposite polarity to the nearby permanent magnet's pole, resulting in attraction.

Q9. How can you tell the poles of a magnet?
Answer: By using a compass or another magnet.
Solution: If a known north pole is brought near an unknown pole and attraction occurs, the unknown pole is south. If repulsion occurs, it is also north. A magnetic compass can also help as its needle points towards the magnetic south (Earth's north).

Q10. What is the region around a magnet where it can exert a force called?
Answer: The magnetic field.
Solution: A magnetic field is the area around a magnet where magnetic forces can be felt. It is invisible but can be detected using a compass or iron filings, and its strength decreases with distance from the magnet.

Q11. Which materials are considered magnetic materials?
Answer: Iron, steel, nickel, and cobalt.
Solution: These materials can be attracted to magnets and can be magnetised. Iron and steel are commonly used in electromagnets and permanent magnets because they respond strongly to magnetic fields.

Q12. What is the direction of magnetic field lines?
Answer: From the north pole to the south pole outside the magnet.
Solution: Field lines show the direction a north pole would move if placed in the field. They always go out from the north pole and into the south pole, forming closed loops through the magnet itself.

Q13. Why is the magnetic field strongest at the poles of a magnet?
Answer: Because the field lines are most concentrated at the poles.
Solution: At the poles, magnetic field lines are closer together, meaning the magnetic force is stronger in those regions. This is where the attraction or repulsion between magnets is strongest.

Q14. How does the strength of a magnetic field change with distance?
Answer: It decreases as distance from the magnet increases.
Solution: Magnetic fields spread out from the source, so as you move further away, the field lines become less dense and the force gets weaker. That's why magnetic effects are strongest near the magnet.

Q15. What kind of force exists between a magnet and a magnetic material?
Answer: A force of attraction.

Solution: A magnetic material is always attracted to a magnet, regardless of the pole it's near. This attraction is due to induced magnetism, which always causes the magnetic material to align opposite to the magnet's pole.

Q16. Why can magnets exert forces without touching objects?
Answer: Because magnetic fields can act through space.
Solution: Magnetic fields are invisible regions around a magnet that exert forces on other magnets or magnetic materials within range. This allows interaction without physical contact, making it a non-contact force.

Q17. How can you show the direction of a magnetic field?
Answer: By using a magnetic compass.
Solution: A compass contains a small magnet that aligns with the magnetic field. By placing it in different positions around a magnet, you can mark the direction the needle points and draw the magnetic field lines.

Q18. What is the role of a magnetic compass?
Answer: To show the direction of a magnetic field.
Solution: A magnetic compass aligns itself with the magnetic field it's in. It helps detect the direction of field lines and is used to navigate using Earth's magnetic field.

Q19. How does a magnetic compass work?
Answer: It contains a small bar magnet that aligns with the magnetic field.
Solution: The needle inside a compass is a magnet. When placed near another magnet or on Earth, it rotates to point in the direction of the magnetic field, with the north pole of the needle pointing to magnetic south.

Q20. Why does a magnetic compass point north?
Answer: Because it aligns with the Earth's magnetic field.
Solution: The compass needle's north pole is attracted to the Earth's magnetic south pole, which is near the geographic North Pole. This makes the needle appear to point north.

Q21. What does the compass needle align with?
Answer: The direction of the magnetic field.
Solution: The needle points along the lines of magnetic force, showing the direction from the north pole to the south pole of a magnetic field, including the Earth's.

Q22. What is the evidence that the Earth has a magnetic field?
Answer: A compass needle aligns with it.
Solution: The Earth behaves like a giant magnet with a magnetic field surrounding it. A compass needle aligns with this field, pointing towards the magnetic poles, proving the field exists.

Q23. How is the Earth's magnetic field related to its core?
Answer: It is believed to be caused by movements in the liquid outer core.
Solution: The Earth's core contains molten iron and nickel. The movement of these conductive

materials creates electric currents, which generate the Earth's magnetic field through the dynamo effect.

Q24. How can plotting the field lines help understand a magnet's field?
Answer: It shows the shape and direction of the magnetic field.
Solution: By marking compass directions around a magnet and connecting the points, you can create a map of the field lines. This helps visualise how the magnetic force behaves in space.

Q25. What pattern do magnetic field lines form around a bar magnet?
Answer: They form loops from north to south outside the magnet.
Solution: The field lines go from the north pole to the south pole outside the magnet, and continue inside from south to north, forming continuous closed loops. This shows the direction and shape of the magnetic field.

Q26. How can a magnetic field be mapped using a compass?
Answer: By placing the compass at different points around the magnet and marking the direction the needle points.
Solution: To map a magnetic field, place a magnetic compass near a magnet and draw a small arrow in the direction the needle points. Move the compass to several different positions around the magnet and repeat. Connecting the arrows will show the shape and direction of the magnetic field lines.

Q27. What happens to the direction of a compass needle near a magnet?
Answer: It aligns with the local magnetic field direction.
Solution: The needle of the compass is a small magnet. When near another magnet, it rotates to align with the field lines of that magnet, pointing from north to south along the magnetic field.

Q28. How can you describe the magnetic field between the poles of a magnet?
Answer: It is strong and uniform, especially in the central region between the poles.
Solution: Between the poles of a magnet, especially if the poles are flat and close together, the field lines are nearly straight and evenly spaced. This shows a strong, nearly uniform magnetic field in that area.

Q29. What do closely spaced magnetic field lines represent?
Answer: A stronger magnetic field.
Solution: Where magnetic field lines are close together, the force is stronger. The denser the lines, the greater the magnetic force in that area. This is typically near the poles of a magnet.

Q30. What do widely spaced magnetic field lines represent?
Answer: A weaker magnetic field.
Solution: As the distance from a magnet increases, the field lines spread out. Widely spaced lines show the magnetic field is weaker in those regions compared to where the lines are denser.

Q31. How can you show the direction of magnetic field lines in a diagram?
Answer: By drawing arrows pointing from the north pole to the south pole.

Solution: Field lines are drawn with arrows to show direction. They start at the north pole and end at the south pole of a magnet, giving a clear picture of how the field behaves in space.

Q32. What is the difference between a magnetic field and a gravitational field?
Answer: Magnetic fields act on magnetic materials, gravitational fields act on all masses.
Solution: A magnetic field affects only certain materials like iron and magnets. A gravitational field affects all objects with mass. Also, magnetic fields have direction and polarity, while gravitational fields only attract.

Q33. Can magnetic materials become permanently magnetised? Explain.
Answer: Yes, some magnetic materials can become permanent magnets if magnetised strongly enough.
Solution: Materials like steel can retain magnetism after being exposed to a magnetic field. Their internal magnetic domains stay aligned, making them permanent magnets even after removing the external field.

Q34. How does distance from the magnet affect magnetic force?
Answer: The magnetic force becomes weaker as the distance increases.
Solution: Magnetic fields spread out as you move away from a magnet, and the force felt by another object reduces. This is why magnets have the strongest effect when objects are close.

Q35. Why does the force between a magnet and magnetic material not change with the poles?
Answer: Because magnetic materials are always attracted, regardless of the pole.
Solution: Magnetic materials become induced magnets when near a magnet. This always leads to attraction, no matter which pole is involved, because the material aligns opposite to the nearby pole.

Q36. How do you test which end of a magnet is the north pole?
Answer: Use a compass; the needle's north end will point toward the magnet’s south pole.
Solution: A compass can help determine polarity. The north-seeking end of the needle points to the magnetic south pole of a magnet, so by observing this, you can identify the magnet’s poles.

Q37. Why do magnetic field lines never cross?
Answer: Because the direction of the magnetic field at any point must be unique.
Solution: If field lines crossed, it would mean the magnetic force at that point has two directions, which is not possible. Therefore, magnetic field lines never intersect.

Q38. What happens when you break a bar magnet in two?
Answer: Each piece becomes a magnet with its own north and south poles.
Solution: Magnetic domains inside the material realign in each piece. Instead of separating the poles, you get two smaller magnets, each with a north and south pole.

Q39. How can you make a magnet lose its magnetism?
Answer: By heating it or hitting it hard.
Solution: Heating shakes the atoms and disrupts the alignment of magnetic domains. Similarly,

hitting a magnet causes vibrations that can also misalign domains, reducing or removing the magnetism.

Q40. Why do field lines go from north to south?
Answer: That's the convention based on the direction a compass needle points.
Solution: By definition, magnetic field lines go from a magnet's north pole to its south pole outside the magnet. This follows the direction a compass needle (north-seeking end) points.

Q41. What happens to iron filings around a magnet?
Answer: They arrange themselves along magnetic field lines.
Solution: Iron filings become tiny induced magnets in the field. They align along the invisible lines of magnetic force, making the field pattern visible.

Q42. What does the shape of the field lines indicate about a magnet's influence?
Answer: It shows where the magnetic force is strong or weak and its direction.
Solution: The field lines form loops, dense at the poles and spreading out with distance. This tells us the magnet's strength and how its force would affect other materials around it.

Q43. How can magnetic field lines help explain the direction of magnetic forces?
Answer: They show the path a north pole would follow.
Solution: Magnetic field lines point in the direction that a north pole would move if placed in the field. This allows us to predict the force direction on any magnet or magnetic material in that region.

Q44. Why does a compass needle rotate when moved around a magnet?
Answer: Because it aligns with the changing magnetic field direction.
Solution: The compass needle is influenced by the nearby magnetic field. As you move it, the local direction of the field changes, so the needle rotates to stay aligned with the new field direction.

Q45. How does the compass provide evidence for Earth's magnetic field?
Answer: Because the needle always points towards Earth's magnetic north.
Solution: The compass aligns with Earth's magnetic field, just like it would with a bar magnet. This behaviour suggests that the Earth itself has a magnetic field, like a huge magnet inside the planet.

Q46. Why do magnets not attract all metals?
Answer: Only certain metals have magnetic properties.
Solution: Materials like iron, nickel, and cobalt have atoms that can align to form magnetic domains. Other metals like copper or aluminium don't respond to magnetic fields in the same way and are not attracted.

Q47. Why is steel a better choice than iron for permanent magnets?
Answer: Because steel keeps its magnetism for longer.
Solution: Iron magnetises quickly but also loses magnetism quickly. Steel takes longer to magnetise but keeps its magnetism for a longer time, making it suitable for permanent magnets.

Q48. Why can magnets attract objects through paper or plastic?
Answer: Because magnetic fields can pass through non-magnetic materials.
Solution: Paper and plastic do not block magnetic fields. The field lines pass through them easily, so magnetic forces still act on magnetic materials on the other side.

Q49. How does the size of a magnet affect its magnetic field?
Answer: A larger magnet generally has a stronger and wider field.
Solution: Bigger magnets have more magnetic material and can produce stronger magnetic fields. However, shape and material also affect the field's strength and range.

Q50. Can you shield a region from a magnetic field? If so, how?
Answer: Yes, by using materials like soft iron or mu-metal to redirect the field.
Solution: Magnetic shielding doesn't block the field but redirects it. Materials like mu-metal guide the magnetic field lines around the protected area, reducing the field strength inside.

Q51. State two ways to increase the strength of the magnetic field around a straight current-carrying wire.
Answer: The strength of the magnetic field around a straight current-carrying wire can be increased by raising the amount of electric current flowing through the wire and by bringing the point of measurement closer to the wire. A stronger current produces more field lines, and magnetic strength is always greater near the conductor.

Q52. Describe how you could use iron filings to show the magnetic field pattern around a current-carrying wire.
Answer: To show the magnetic field, place a vertical wire through a piece of stiff card and sprinkle iron filings evenly on the surface. When current flows through the wire, gently tapping the card causes the filings to align with the circular magnetic field around the wire, making the field pattern visible.

Q53. Explain why the magnetic field produced by a wire becomes weaker further from the wire.
Answer: Magnetic field strength decreases with distance because the field lines spread out as they move away from the wire. The further you go from the wire, the more dispersed the magnetic effect becomes, resulting in a weaker field.

Q54. Sketch and label the direction of magnetic field lines around a vertical wire carrying current upwards.
Answer: When a vertical wire carries current upwards, the magnetic field lines form concentric circles around the wire, going in an anticlockwise direction when viewed from above. This direction can be confirmed using the right-hand grip rule.

Q55. Why does coiling a wire into a solenoid amplify its magnetic field compared with a straight wire?
Answer: Coiling the wire causes each loop's magnetic field to add up in the centre of the coil,

creating a strong and focused field inside the solenoid. This overlap increases the total magnetic effect compared to a single straight wire.

Q56. Describe the shape and direction of the magnetic field inside and outside a solenoid.
Answer: Inside the solenoid, the field lines are parallel, evenly spaced, and go from the back to the front, showing a strong and uniform magnetic field. Outside the solenoid, the field lines loop around from one end to the other, similar to a bar magnet's field.

Q57. How does inserting an iron core into a solenoid affect its magnetic field strength, and why?
Answer: An iron core increases the strength of the magnetic field because iron is a magnetic material that becomes magnetised when placed in the solenoid. This induced magnetism reinforces the magnetic field, making the solenoid act as a much stronger electromagnet.

Q58. Give two advantages of using an electromagnet instead of a permanent magnet in industrial machinery.
Answer: Electromagnets can be turned on and off with the current, allowing better control in machinery. Also, their strength can be adjusted by changing the current, which is useful for lifting or holding objects with variable magnetic needs.

Q59. A solenoid has 500 turns and carries 2 A. State two changes you could make to double the magnetic field at its centre.
Answer: To double the magnetic field strength, you could either double the current to 4 A or double the number of turns to 1000. Both methods increase the total magnetic effect, enhancing the field at the solenoid's centre.

Q60. Why is the magnetic field inside a long solenoid considered uniform?
Answer: In a long solenoid, the magnetic field lines are straight, parallel, and evenly spaced across the central region. This indicates the field has the same strength and direction throughout, making it uniform.

Q61. Outline a method to reverse the polarity of an electromagnet quickly.
Answer: You can reverse the polarity of an electromagnet by switching the direction of the electric current. This can be done using a double-pole double-throw (DPDT) switch or by reversing the battery connections supplying the solenoid.

Q62. Explain how a relay uses the magnetic effect of a current to switch a high-current circuit.
Answer: A small current in the control circuit energises a coil, turning it into an electromagnet. This magnet attracts a metal arm that closes a switch in a separate high-current circuit, allowing it to operate safely without direct contact with the user.

Q63. What factors determine the magnetic flux density inside a solenoid?
Answer: The flux density inside a solenoid depends on the current through the wire, the number of turns of the coil per unit length, and whether it has an iron core. All these factors influence how concentrated the magnetic field is.

Q64. Describe how Fleming's left‑hand rule helps predict the direction of force on a current‑carrying conductor in a magnetic field.
Answer: Fleming's left-hand rule uses the thumb, first finger, and second finger placed at right angles to each other. The first finger shows the magnetic field direction, the second shows current direction, and the thumb shows the direction of the force acting on the conductor.

Q65. Identify the finger assignment for force, field, and current in Fleming's left‑hand rule.
Answer: In Fleming's left-hand rule: the **Thumb** represents the **Force**, the **First finger** represents the **Field**, and the **Second finger** represents the **Current**.

Q66. State the condition under which the equation F = B I l applies to a conductor in a magnetic field.
Answer: The equation applies when the conductor is placed at right angles (perpendicular) to the magnetic field. If the wire is not at right angles, the full force is not experienced, and the equation will not give an accurate result.

Q67. Why does the force on a current‑carrying wire become zero when the wire is parallel to the magnetic field?
Answer: When the wire is parallel to the magnetic field, there is no component of force perpendicular to the field lines, so no sideways force is produced. The magnetic field does not push the wire in any direction.

Q68. How does doubling the current in a conductor affect the force it experiences in a uniform magnetic field?
Answer: The force is directly proportional to the current. If you double the current, the force experienced by the conductor will also double, assuming the magnetic field strength and wire length stay the same.

Q69. A straight wire 0.08 m long carries 3 A at right angles to a 0.5 T field. Calculate the force on the wire.
Answer: Using the formula $F = B \times I \times l$:
$F = 0.5\ T \times 3\ A \times 0.08\ m = 0.12\ N$.
So, the force on the wire is 0.12 newtons.

Q70. Explain why iron cores are laminated in transformer electromagnets.
Answer: Laminating the iron core (slicing it into thin layers separated by insulating material) reduces energy losses caused by eddy currents. This helps maintain the magnetic efficiency of the electromagnet.

Q71. Describe how reversing the current direction in a motor coil affects the force on each side of the coil.
Answer: Reversing the current direction reverses the direction of the force on each side of the coil. This causes the coil to spin in the opposite direction, which is how motor direction is controlled.

Q72. Why is soft iron preferred over steel for the core of an electromagnet used in MRI scanners?
Answer: Soft iron becomes magnetised easily and loses its magnetism quickly when the current is turned off. This is useful in devices like MRI scanners where the magnetic field needs to be controlled accurately.

Q73. How can you experimentally verify that the magnetic field strength around a solenoid is proportional to current?
Answer: You can measure the deflection of a magnetic compass near the solenoid while varying the current using an ammeter. As the current increases, the deflection increases, showing a stronger magnetic field.

Q74. Explain the role of commutators in a simple d.c. electric motor.
Answer: The commutator reverses the direction of current in the motor coil every half turn. This ensures that the force on each side of the coil remains in the same direction, allowing continuous rotation.

Q75. A conductor in a magnetic field experiences a constant force but does not move. Give two possible reasons.
Answer: One reason could be that the conductor is fixed in place and cannot move. Another reason could be that the magnetic force is being balanced by an equal and opposite force, such as tension or friction.

Q76. Describe how a loudspeaker converts electrical signals into sound using electromagnetism.
Answer: A loudspeaker works by passing an alternating current through a coil placed in a magnetic field. The current causes the coil to experience a force due to the motor effect. As the current changes direction, the force also changes direction, making the coil and attached cone vibrate. These vibrations create pressure waves in the air, which we hear as sound.

Q77. Why must the magnetic field and current be perpendicular for maximum motor effect?
Answer: The motor effect is strongest when the current is at right angles to the magnetic field because this orientation allows the magnetic field to exert the maximum force on the conductor. If the current is parallel to the field, there is no sideways force, and the conductor does not move.

Q78. Give one industrial application that relies on the force exerted on a current-carrying conductor in a magnetic field.
Answer: One industrial application is the electric motor used in machines such as conveyor belts, fans, or drills. These devices rely on the motor effect to convert electrical energy into mechanical motion through the force exerted on current-carrying conductors in magnetic fields.

Q79. Explain why increasing the length of wire in the magnetic field increases the force on the conductor.
Answer: The force on the conductor is directly proportional to the length of wire within the magnetic

field, as shown by the formula F = B × I × l. A longer wire means a greater part of the current interacts with the field, resulting in a larger overall force.

Q80. How would you plot the magnetic field pattern around a solenoid using a small plotting compass?
Answer: Place a plotting compass near one end of the solenoid and mark the direction the needle points. Move the compass in small steps around the solenoid, marking its direction at each step. Join the marks with smooth curves to create magnetic field lines, which should form loops around the solenoid from north to south.

Q81. Describe what would happen to the force on a conductor if the magnetic flux density were halved.
Answer: Since the force is directly proportional to the magnetic flux density (F = B × I × l), halving the flux density would halve the force acting on the conductor. The interaction between the magnetic field and the current would be weaker, reducing the overall magnetic force.

Q82. Suggest a safety precaution when demonstrating the magnetic effect of a large current in a laboratory.
Answer: A safety precaution is to use a low-voltage power supply with a fuse or circuit breaker to prevent overheating or short circuits. Also, avoid touching exposed wires and use heat-resistant gloves if components may get hot due to high current.

Q83. Explain how an electric bell uses an electromagnet to produce sound.
Answer: In an electric bell, closing the circuit sends current through an electromagnet, which attracts a metal arm attached to a hammer. The hammer hits the bell, producing sound, and breaks the circuit at the same time. This allows the arm to spring back and repeat the process rapidly, creating a continuous ringing.

Q84. What happens to the magnetic field inside a solenoid if alternating current is used instead of direct current?
Answer: If alternating current (AC) is used, the direction of the current changes repeatedly. This causes the magnetic field inside the solenoid to continuously reverse direction, producing a magnetic field that alternates in polarity at the same frequency as the AC.

Q85. Why does the iron core of an electromagnet remain magnetised only while current flows?
Answer: Iron is a soft magnetic material, meaning it is easily magnetised but also loses its magnetism quickly when the current stops. This property ensures the electromagnet can be turned on and off as needed without retaining residual magnetism.

Q86. State two similarities between the magnetic field of a solenoid and that of a bar magnet.
Answer: Both have field lines that emerge from a north pole and enter a south pole, forming closed loops. Also, both produce a uniform magnetic field inside and a curved field outside, making their field patterns appear very similar.

Q87. Describe how magnetic field strength varies along the axis outside the ends of a solenoid.
Answer: Outside the solenoid, along its axis, the magnetic field strength decreases with distance from the ends. It is strongest near the poles and weakens the further away you move because the field lines spread out and become less concentrated.

Q88. Explain why a wire loop carrying current experiences a torque in a uniform magnetic field.
Answer: In a wire loop, opposite sides carry current in opposite directions. When placed in a magnetic field, each side experiences a force in opposite directions, creating a turning effect or torque that causes the loop to rotate, which is the basis of how motors work.

Q89. How can you increase the turning force in an electric motor without changing the current?
Answer: You can increase the number of turns in the coil, increase the magnetic field strength using a stronger magnet, or increase the length of wire within the field. All of these changes enhance the force acting on the coil, resulting in a stronger turning effect.

Q90. A 0.12 m conductor experiences a 0.36 N force in a 0.6 T field. Calculate the current flowing.
Answer: Use the formula F = B × I × l.
0.36 = 0.6 × I × 0.12
I = 0.36 / (0.6 × 0.12)
I = 5 A
So, the current flowing is 5 amperes.

Q91. Why does reversing both the field direction and current direction leave the force direction unchanged?
Answer: According to Fleming's left-hand rule, if both the magnetic field and current directions are reversed, the force direction remains the same because the reversal cancels out. The relative orientation stays the same, keeping the motion unchanged.

Q92. Give one reason why superconducting coils are used in high-field electromagnets.
Answer: Superconducting coils offer zero electrical resistance, which allows them to carry large currents without energy loss as heat. This makes them ideal for generating strong, stable magnetic fields in medical equipment or particle accelerators.

Q93. Explain how magnetic levitation trains use electromagnetic forces to reduce friction.
Answer: Maglev trains use electromagnets to lift the train above the track, eliminating physical contact. This magnetic levitation reduces friction and allows for smooth and high-speed travel, improving efficiency and reducing wear on components.

Q94. Describe the effect on magnetic field strength when two identical solenoids are placed end-to-end with currents in opposite directions.

Answer: If the solenoids are arranged with opposing currents, the magnetic fields between them cancel out, weakening the field in that region. This can result in a near-zero field at the junction and reduced overall magnetic strength.

Q95. Why does adding more turns per metre on a solenoid increase its magnetic flux density?
Answer: More turns per metre mean that more loops of wire contribute to the total magnetic field in a given length. This increases the density of magnetic field lines inside the solenoid, strengthening the magnetic field.

Q96. How can Fleming's left-hand rule be used to verify the correct wiring of a motor?
Answer: By applying the left-hand rule with the known directions of magnetic field and current, the expected force direction can be predicted. If the motor turns in the opposite direction, the wiring may be incorrect and needs to be checked or reversed.

Q97. Suggest one design change to reduce eddy currents in an iron core used with an electromagnet.
Answer: A common design solution is to laminate the iron core by making it from thin, insulated layers. This limits the formation of circular eddy currents, reducing energy loss and heat generation within the core.

Q98. Explain why the force on a current-carrying conductor is greatest at the poles of the magnet producing the field.
Answer: The magnetic field is strongest at the poles, which means the magnetic flux density (B) is highest there. Since force depends on magnetic field strength, the conductor experiences the greatest force in regions where the field is most concentrated.

Q99. What feature of an electromagnet allows it to be switched on and off rapidly in industrial sorting machines?
Answer: Electromagnets can be controlled using an electric current. When the current is turned on, the magnet becomes active, and when turned off, it loses its magnetism quickly, allowing fast and repeated operations in sorting or lifting machinery.

Q100. Why is magnetic flux density measured in tesla rather than newtons per ampere-metre in practical calculations?
Answer: Tesla is a convenient unit that directly represents magnetic field strength in practical applications. Although it is equivalent to N/(A·m), using "tesla" simplifies communication and calculations in scientific and engineering contexts.

Q101. What causes a coil to rotate in an electric motor?
Answer: When a coil carrying current is placed in a magnetic field, each side of the coil experiences a force in opposite directions due to the motor effect. These forces act as a couple and produce a turning effect, or torque, causing the coil to rotate.

Q102. How does the motor effect create motion in an electric motor?
Answer: The motor effect happens when a current-carrying conductor is placed in a magnetic field.

The magnetic field interacts with the electric current, producing a force on the conductor. In a motor, this force acts on the sides of the coil, causing it to spin.

Q103. Why does a coil in a magnetic field experience a turning force when current flows?
Answer: Each side of the coil has current flowing in opposite directions. The magnetic field interacts with these currents, creating forces that act in opposite vertical directions on either side of the coil. This produces a turning force that causes the coil to rotate.

Q104. How does the commutator help maintain continuous rotation in a simple electric motor?
Answer: The commutator is a split ring that reverses the direction of current in the coil every half turn. This ensures that the side of the coil experiencing an upward force continues to do so, maintaining the coil's continuous rotation in one direction.

Q105. What happens to the direction of rotation if the current in a motor coil is reversed?
Answer: If the current in the motor coil is reversed, the direction of the force on each side of the coil also reverses due to the motor effect. This causes the coil to rotate in the opposite direction.

Q106. Why does only one side of a coil move up while the other moves down in a magnetic field?
Answer: The two sides of the coil carry current in opposite directions. When placed in a magnetic field, the motor effect causes the two sides to experience forces in opposite directions—one upward and one downward—leading to rotation.

Q107. What role do brushes play in a basic electric motor?
Answer: Brushes are in contact with the spinning commutator. They allow current to pass from the external power source to the rotating coil. They also help reverse the current direction in the coil to maintain continuous rotation.

Q108. How can you increase the speed of rotation in an electric motor?
Answer: You can increase the motor speed by increasing the current, using a stronger magnetic field, adding more turns to the coil, or reducing friction in the motor. Each of these increases the force or reduces resistance to rotation.

Q109. Why is the force strongest on a coil when it is at 90° to the magnetic field?
Answer: The force on a current-carrying conductor in a magnetic field is given by $F = BIL \sin\theta$. When the angle θ between the current and magnetic field is 90°, $\sin\theta$ is 1, and the force is at its maximum.

Q110. What would happen if there were no magnetic field in a motor circuit?
Answer: Without a magnetic field, the motor effect cannot take place. The current in the coil would not experience any force, so the coil would not rotate and the motor would not work.

Q111. How does a loudspeaker convert an electric signal into sound?
Answer: A loudspeaker uses a coil placed in a magnetic field. When an electric signal flows through

the coil, the motor effect causes it to move. The coil is attached to a cone that moves with it, causing air vibrations that produce sound.

Q112. What causes the cone in a loudspeaker to vibrate?
Answer: The cone is connected to a coil inside a magnetic field. When an alternating current passes through the coil, the direction and size of the magnetic force constantly change, causing the cone to move back and forth and create sound vibrations.

Q113. How do changes in current affect the sound produced by a loudspeaker?
Answer: The changing current alters the force on the coil, which moves the cone. The frequency of the current controls the pitch of the sound, and the amplitude controls the loudness. Faster changes produce higher-pitched sounds; larger currents produce louder sounds.

Q114. What part of the loudspeaker is responsible for producing pressure waves?
Answer: The cone or diaphragm of the loudspeaker produces pressure waves. As it moves in and out due to the motion of the coil, it pushes and pulls on surrounding air particles, creating compressions and rarefactions that form sound waves.

Q115. Why must the wire coil in a loudspeaker be placed in a magnetic field?
Answer: The magnetic field is necessary for the motor effect to occur. When the electric current flows through the coil, the interaction with the magnetic field produces a force that moves the coil and the cone to create sound.

Q116. How does the frequency of the current affect the movement of a loudspeaker cone?
Answer: The frequency of the current determines how fast the direction of current changes. A higher frequency causes the coil and cone to vibrate more quickly, producing a higher-pitched sound. A lower frequency causes slower vibrations and a lower pitch.

Q117. What would happen if the loudspeaker coil was fixed and could not move?
Answer: If the coil could not move, the motor effect could not cause motion, so the cone wouldn't vibrate. As a result, no sound would be produced, because sound depends on the vibration of the cone to generate pressure waves in the air.

Q118. What is the function of the diaphragm in a headphone?
Answer: The diaphragm in a headphone moves back and forth in response to the movement of the coil, which is affected by the current. This movement creates sound waves that travel through the air or into the ear canal, allowing us to hear sound.

Q119. Why is the motor effect essential for a loudspeaker to function?
Answer: The motor effect causes the force on the coil that results in movement. This movement makes the cone vibrate and push air to create sound waves. Without the motor effect, the coil would not move and no sound would be generated.

Q120. How does increasing the current through the coil affect the loudness of the sound?
Answer: Increasing the current increases the force on the coil, which makes the cone move more

strongly. This increases the amplitude of the sound wave produced, resulting in a louder sound. So, higher current means louder sound output.

Q121. What is meant by the generator effect?
Answer: The generator effect is when a potential difference (voltage) is induced across a conductor due to a change in magnetic field or because the conductor is moving through a magnetic field. If the circuit is complete, this causes a current to flow.

Q122. How is a potential difference induced in a wire?
Answer: A potential difference is induced in a wire when it moves through a magnetic field or when the magnetic field around it changes. This motion or change cuts across magnetic field lines and creates a voltage across the ends of the wire.

Q123. What two things can cause an induced current in a conductor?
Answer: An induced current can be caused by moving the conductor through a magnetic field, or by changing the magnetic field around a stationary conductor. Both methods cut magnetic field lines and produce a voltage and current.

Q124. Why is a current induced only when there is movement or change in the magnetic field?
Answer: Current is only induced when magnetic field lines are cut, which happens during motion or field change. If nothing changes, there's no movement of field lines relative to the conductor, and therefore no potential difference or current is produced.

Q125. What happens when a magnet is pushed into a coil of wire?
Answer: When a magnet is pushed into a coil, the magnetic field through the coil changes. This change induces a potential difference across the ends of the wire. If the coil is connected in a circuit, a current will flow. The faster the magnet moves, the greater the current.

Q126. How does moving a conductor through a magnetic field generate electricity?
Answer: When a conductor moves through a magnetic field, the magnetic field causes the electrons inside the conductor to move. This movement of electrons creates an electric current, which is known as electromagnetic induction. The movement must be across the magnetic field lines, not parallel to them, for current to be induced.

Q127. What is needed for an induced current to flow in a conductor?
Answer: To induce a current in a conductor, you need a magnetic field, relative motion between the conductor and the magnetic field, and a complete circuit for the current to flow. Without movement or a closed circuit, even if a voltage is induced, current will not flow.

Q128. How does the direction of motion affect the direction of the induced current?
Answer: The direction of the motion of the conductor through the magnetic field affects the direction of the induced current. If the direction of movement is reversed, the direction of the induced current also reverses. This relationship is explained by Fleming's Right-Hand Rule.

Q129. What rule can be used to determine the direction of the induced current?
Answer: Fleming's Right-Hand Rule is used to find the direction of the induced current. If you point your thumb in the direction of motion, your first finger in the direction of the magnetic field, then your second (middle) finger will point in the direction of the induced current.

Q130. Why does an induced current oppose the motion that caused it?
Answer: An induced current opposes the motion that caused it due to Lenz's Law. This law states that the induced current will always flow in a direction that opposes the change that produced it. This is a result of the conservation of energy and ensures that work must be done to move the conductor.

Q131. How does Lenz's Law explain the direction of an induced current?
Answer: Lenz's Law says that the direction of the induced current is such that it creates a magnetic field that opposes the change in the original magnetic field. If the magnetic field through the conductor increases, the induced current will create a field to reduce it, and vice versa. This opposes the cause and resists the motion.

Q132. What happens to the induced current if the speed of movement is increased?
Answer: If the conductor moves faster through the magnetic field, the induced current increases. This is because a greater rate of change of magnetic field is experienced by the conductor, which increases the induced voltage, and hence a larger current flows, assuming resistance stays the same.

Q133. Why is a complete circuit required to produce an induced current?
Answer: A complete circuit is needed because, without a closed loop, the induced potential difference cannot push charges around, so no current flows. You may get an induced voltage in an open circuit, but current only flows if there is a path for electrons to move through the circuit.

Q134. What would happen if a conductor moved parallel to a magnetic field?
Answer: If a conductor moves parallel to the magnetic field lines, no current is induced. This is because there is no change in the magnetic field experienced by the conductor. To induce current, the conductor must cut across the magnetic field lines, not move along them.

Q135. How does the strength of the magnetic field affect the size of the induced current?
Answer: A stronger magnetic field increases the size of the induced current. This is because the change in magnetic flux is greater when the field is stronger, which results in a higher induced voltage and thus a larger current, provided the circuit resistance remains constant.

Q136. What is the difference between the generator effect and the motor effect?
Answer: The generator effect is when movement in a magnetic field induces a current in a conductor. The motor effect is when a current in a magnetic field produces a force and causes motion. So, one converts motion into electricity, while the other converts electricity into motion.

Q137. Why does the generator effect not occur when the conductor is stationary in a steady magnetic field?
Answer: If the conductor is stationary and the magnetic field is not changing, then there is no

change in magnetic flux. Since electromagnetic induction requires a change in magnetic field through the conductor, no current is induced unless there is movement or a changing magnetic field.

Q138. How does a coil rotating in a magnetic field produce alternating current?
Answer: As the coil rotates in a magnetic field, the direction of the coil's motion relative to the magnetic field changes continuously. This causes the direction of the induced current to reverse every half turn, resulting in alternating current (AC), where the current changes direction repeatedly.

Q139. What changes in a coil's movement cause changes in the size of the induced potential difference?
Answer: The speed of rotation and the angle between the coil and magnetic field affect the size of the induced potential difference. Faster rotation and positions where the coil cuts magnetic lines more directly increase the induced voltage. Maximum voltage is induced when the coil moves perpendicularly to the magnetic field lines.

Q140. What is the basic principle behind an alternator?
Answer: An alternator works on the principle of electromagnetic induction. It has a coil that rotates in a magnetic field, which induces an alternating current as the coil continuously changes its orientation relative to the magnetic field. The faster the rotation, the higher the voltage and frequency of the AC.

Q141. How does a dynamo differ from an alternator?
Answer: A dynamo generates direct current (DC), while an alternator generates alternating current (AC). The main difference is in how the current is collected. A dynamo uses a commutator to keep the current flowing in one direction, whereas an alternator uses slip rings which allow the current to alternate.

Q142. Why does a dynamo produce direct current?
Answer: A dynamo uses a commutator, which is a split-ring device that reverses the connection to the external circuit every half turn. This ensures that the output current always flows in the same direction, producing direct current (DC) instead of alternating current (AC).

Q143. Why does an alternator produce alternating current?
Answer: An alternator produces alternating current because it uses slip rings instead of a commutator. As the coil rotates, the direction of the induced current reverses every half turn, and since slip rings do not reverse the connection, the output remains alternating.

Q144. What kind of graph shows the output from an alternator?
Answer: The output from an alternator is shown as a sine wave on a graph. The graph shows the voltage or current rising and falling in a regular pattern and changing direction repeatedly, which represents the alternating nature of the current.

Q145. What does the graph of a dynamo's output look like?
Answer: The graph of a dynamo's output looks like a series of bumps that are all on the same side of the axis. The voltage rises and falls, but since the direction is the same, the graph does not go below the horizontal axis. This represents direct current with changing voltage.

Q146. How can you increase the output voltage of an alternator?
Answer: You can increase the output voltage of an alternator by rotating the coil faster, increasing the strength of the magnetic field, or increasing the number of turns in the coil. Each of these increases the rate of change of magnetic flux, which increases the induced voltage.

Q147. What part of an alternator rotates to produce an induced potential difference?
Answer: In an alternator, it is usually the coil that rotates within a fixed magnetic field. As the coil spins, it cuts through magnetic field lines, and this movement induces a voltage across the ends of the coil, which leads to the generation of alternating current.

Q148. What happens to the output if the coil in a generator spins faster?
Answer: If the coil in a generator spins faster, the output voltage increases and the frequency of the alternating current also increases. This is because the rate at which the coil cuts the magnetic field lines is higher, leading to a greater and more frequent change in magnetic flux.

Q149. Why does reversing the rotation of a generator coil reverse the output polarity?
Answer: Reversing the rotation of a generator coil changes the direction in which the coil cuts through the magnetic field lines. This changes the direction of the induced current, resulting in a reversal of the polarity of the output voltage.

Q150. How does the number of turns in a coil affect the output from a generator?
Answer: Increasing the number of turns in a coil increases the induced voltage. This is because each loop of wire experiences the magnetic field, and more loops mean more induced voltages adding up, which increases the total output from the generator.

Q151. Explain how a moving-coil microphone uses the generator effect to produce an electrical signal.
Answer: A moving-coil microphone works by converting sound waves into an electrical signal using the generator effect. When sound waves hit the diaphragm, it vibrates. This diaphragm is connected to a coil of wire placed within a magnetic field. As the diaphragm moves due to the pressure of the sound waves, the coil moves within the magnetic field. This motion cuts the magnetic field lines and induces a voltage across the coil. This induced voltage varies with the sound pressure, creating an electrical signal that matches the original sound wave.

Q152. Describe what happens inside a moving-coil microphone when sound waves hit the diaphragm.
Answer: When sound waves reach the moving-coil microphone, they strike the diaphragm and cause it to vibrate. The diaphragm is attached to a small coil of wire that is placed inside a magnetic field. As the diaphragm vibrates, it moves the coil back and forth within the magnetic field. This movement changes the magnetic flux through the coil, which induces a voltage in the coil. The changing voltage represents the sound wave and can be sent through an electrical circuit.

Q153. Why is an iron core used in a transformer?
Answer: An iron core is used in a transformer because iron is a magnetic material that is easily

magnetised. It helps to carry the changing magnetic field from the primary coil to the secondary coil efficiently. This makes the transformer more effective at transferring energy between the coils. The iron core concentrates the magnetic field and improves the efficiency of induction between the coils.

Q154. What is meant by the term "step-up transformer"?
Answer: A step-up transformer is a transformer that increases the voltage from the primary coil to the secondary coil. It has more turns on the secondary coil than on the primary coil. This type of transformer is used when we need to increase the voltage for transmission over long distances, helping to reduce energy losses in the cables.

Q155. What is meant by the term "step-down transformer"?
Answer: A step-down transformer is a transformer that decreases the voltage from the primary coil to the secondary coil. It has fewer turns on the secondary coil than on the primary coil. Step-down transformers are used to reduce high voltages to safer, usable levels for homes and businesses.

Q156. What happens to the voltage when a step-up transformer is used?
Answer: When a step-up transformer is used, the voltage in the secondary coil becomes greater than the voltage in the primary coil. This happens because the secondary coil has more turns than the primary coil. The transformer increases the potential difference to make the transmission of electricity over long distances more efficient.

Q157. What happens to the voltage when a step-down transformer is used?
Answer: When a step-down transformer is used, the voltage in the secondary coil becomes lower than the voltage in the primary coil. This is because the secondary coil has fewer turns. Step-down transformers reduce voltage to levels that are safe and suitable for use in homes and electrical appliances.

Q158. State the equation that links the potential differences and number of turns in the coils of a transformer.
Answer: The equation that links the potential differences and the number of turns in a transformer is:
$V_p / V_s = N_p / N_s$
Where V_p is the potential difference in the primary coil, V_s is the potential difference in the secondary coil, N_p is the number of turns on the primary coil, and N_s is the number of turns on the secondary coil.

Q159. A transformer has more turns on the secondary coil than on the primary. What effect does this have on the output voltage?
Answer: If a transformer has more turns on the secondary coil than on the primary, the output voltage will be greater than the input voltage. This is a step-up transformer. The increased number of turns in the secondary coil means that the coil cuts through more magnetic field lines, which induces a higher voltage.

Q160. A transformer has fewer turns on the secondary coil than on the primary. What type of transformer is it?

Answer: If a transformer has fewer turns on the secondary coil than on the primary coil, it is a step-down transformer. This means it reduces the input voltage to a lower output voltage, which is useful for making electricity safe for home or appliance use.

Q161. Describe how an alternating current in the primary coil of a transformer induces a current in the secondary coil.
Answer: An alternating current in the primary coil creates a changing magnetic field around the coil. This changing magnetic field passes through the iron core and links to the secondary coil. Because the magnetic field is continuously changing, it induces an alternating voltage in the secondary coil. If the secondary coil is part of a complete circuit, this voltage causes an alternating current to flow.

Q162. Why must the current in the primary coil of a transformer be alternating?
Answer: The current in the primary coil must be alternating because only a changing magnetic field can induce a current in the secondary coil. Direct current does not change direction and produces a constant magnetic field, so it cannot induce a continuous voltage in the secondary coil. Alternating current ensures the magnetic field is always changing, which is needed for electromagnetic induction.

Q163. Explain what would happen if direct current was used in the primary coil of a transformer.
Answer: If direct current (DC) was used in the primary coil of a transformer, it would create a steady magnetic field that does not change over time. Since a changing magnetic field is needed to induce a voltage in the secondary coil, no continuous current would be induced. Only a small, brief current might occur when the DC is first switched on or off, but it would quickly stop.

Q164. State the equation used to calculate the power in a transformer.
Answer: The equation used to calculate power in a transformer is:
$V_p \times I_p = V_s \times I_s$
Where V_p is the voltage in the primary coil, I_p is the current in the primary coil, V_s is the voltage in the secondary coil, and I_s is the current in the secondary coil. This equation assumes the transformer is 100% efficient.

Q165. What assumption must be made about a transformer in order to use the equation $V_p \times I_p = V_s \times I_s$?
Answer: To use the equation $V_p \times I_p = V_s \times I_s$, we must assume that the transformer is 100% efficient. This means that all the electrical power from the primary coil is transferred to the secondary coil with no energy lost as heat, sound, or other forms of energy.

Q166. Explain why transformers are used in the transmission of electricity across long distances.
Answer: Transformers are used in electricity transmission because they allow us to increase the voltage using step-up transformers. High voltage means lower current for the same power. Since energy loss in wires is caused by current (as heat), reducing the current minimises energy losses. This makes power transmission over long distances more efficient.

Q167. How does using a high voltage reduce energy losses during power transmission?
Answer: Energy loss in transmission lines is mainly due to heating and is proportional to the square of the current ($P = I^2R$). By increasing the voltage, the current needed to transmit the same amount of power decreases. Lower current results in less energy lost as heat in the wires, making transmission more efficient.

Q168. What is the role of a step-up transformer in the national grid?
Answer: The role of a step-up transformer in the national grid is to increase the voltage of electricity generated at power stations before it is sent through transmission lines. This high voltage allows electricity to travel long distances with minimal energy loss, improving the efficiency of the power delivery system.

Q169. What is the role of a step-down transformer in the national grid?
Answer: The role of a step-down transformer in the national grid is to reduce the high transmission voltage to a lower, safer voltage before the electricity reaches homes and businesses. This ensures that the electrical appliances we use operate safely and within their voltage ratings.

Q170. Describe the energy changes that take place in a transformer.
Answer: In a transformer, electrical energy is supplied to the primary coil. This energy is converted into magnetic energy as the coil produces a changing magnetic field. This magnetic energy is transferred through the iron core to the secondary coil, where it is converted back into electrical energy. In an ideal transformer, all the input electrical energy is transferred to the output.

Q171. Why is the core of a transformer made from a magnetic material?
Answer: The core of a transformer is made from a magnetic material like iron because it can easily become magnetised and demagnetised. This allows it to carry the changing magnetic field from the primary coil to the secondary coil efficiently, which improves the transformer's performance by increasing the strength of the induced voltage.

Q172. What is meant by the term "magnetic field"?
Answer: A magnetic field is a region around a magnet, electric current, or changing electric field where magnetic forces can be felt. In a transformer, the magnetic field produced by the primary coil is used to induce a voltage in the secondary coil. The strength and direction of the field affect how much voltage is induced.

Q173. Why is it important that the core of a transformer is not made of a non-magnetic material?
Answer: If the core of a transformer was made from a non-magnetic material, it would not be able to carry the magnetic field effectively from the primary to the secondary coil. This would result in a weak or incomplete transfer of energy between the coils, reducing the efficiency of the transformer and the voltage output.

Q174. A transformer has a primary voltage of 230V and a secondary voltage of 23V. What type of transformer is this?

Answer: This transformer is a step-down transformer because the secondary voltage (23V) is lower than the primary voltage (230V). It reduces the input voltage to a safer and more usable level for devices and appliances.

Q175. How can you increase the voltage output of a transformer?
Answer: To increase the voltage output of a transformer, you can increase the number of turns on the secondary coil compared to the primary coil. This increases the ratio of turns, which increases the voltage induced in the secondary coil. You can also use a stronger magnetic field or reduce energy losses to make it more efficient.

Q176. If a transformer has 100 turns on the primary coil and 500 on the secondary, what kind of transformer is it?
Answer: Because the secondary coil has five times as many turns as the primary coil, the induced voltage on the secondary is five times larger than the supply voltage on the primary. Any transformer that raises the voltage in this way is called a step-up transformer. Step-up transformers are used where high voltage with lower current is needed, for example at the start of a transmission line, because the higher voltage means less current is required for the same power, which cuts resistive heating losses in the cables and improves overall efficiency.

Q177. What happens to the current in the secondary coil of a step-up transformer if the voltage increases?
Answer: In an ideal transformer the electrical power in equals the electrical power out, so $V_p \times I_p = V_s \times I_s$. When a step-up transformer raises the secondary voltage, V_s becomes larger, yet the product $V_s \times I_s$ must stay equal to the constant power supplied by the primary. To keep the product unchanged, the secondary current I_s must fall in proportion to the voltage rise. Therefore the current becomes smaller as the voltage rises, which is why high-voltage transmission lines carry relatively low currents while still delivering large amounts of power.

Q178. Why does increasing the current in power lines lead to energy loss?
Answer: The resistance of the transmission cables turns some electrical energy into heat at a rate given by $P = I^2R$. That formula shows the power wasted as heat grows with the square of the current; doubling the current multiplies the heating losses by four. Heating not only wastes energy that customers must ultimately pay for but also warms the conductors, making them sag and threatening safety clearances. Because resistance cannot be made zero over hundreds of kilometres, reducing current is the only practical way to cut these I^2R losses, which is why power networks raise the voltage instead.

Q179. Describe how transformers help reduce the cost of electricity transmission.
Answer: Power stations first feed their output to step-up transformers that boost the voltage to hundreds of kilovolts. The high voltage allows the same power to be moved with a much lower current, slashing resistive heating losses in the long transmission cables. Near cities substations use step-down transformers to make the voltage safe for distribution. By cutting losses en route, less fuel must be burned at the power station for the same delivered energy, lowering operating costs and

carbon emissions. The hardware cost of the transformers themselves is quickly recovered through the continual savings in reduced energy waste.

Q180. Explain why power stations use step-up transformers before sending electricity into the national grid.
Answer: A step-up transformer increases the generator's output voltage from a few tens of kilovolts to several hundred kilovolts. Since transmitted power P equals V × I, raising V lets engineers deliver the same power with a proportionally smaller current. Line losses depend on I^2R, so cutting current dramatically reduces the energy lost as heat. This improves the overall efficiency of the grid, means thinner (and cheaper) cables can be used for a given power level, and allows generators that may be hundreds of kilometres away from consumers to supply electricity economically without excessive waste.

Q181. Why are step-down transformers necessary before electricity enters homes?
Answer: Domestic wiring and appliances are designed for modest voltages, typically 230 V in the UK or 120 V in North America. The hundreds of kilovolts carried on transmission lines would instantly damage household equipment and pose extreme shock hazards. Step-down transformers at local substations reduce the high transmission voltage to a level that standard insulation, switches and plugs can safely handle. They also limit fault currents to values domestic circuit breakers can interrupt. Without these transformers, the final stage of the electricity supply would be unsafe, unreliable and far more expensive to install and maintain.

Q182. In terms of energy transfer, why do we assume an ideal transformer has 100 % efficiency?
Answer: The "ideal transformer" is a convenient model that lets us apply simple power and turns-ratio equations without complicating factors. By assuming no energy is lost as heat in the coils, as eddy currents in the core, or as stray magnetic fields, we can state that electrical power in the primary exactly equals electrical power out of the secondary. This 100 % efficiency assumption gives $V_p \times I_p = V_s \times I_s$, making problem-solving straightforward. Real transformers approach high efficiencies—often above 98 %—so the ideal model provides accurate results for most classroom calculations while illustrating the underlying principles clearly.

Q183. How does the number of turns in a coil affect the voltage in that part of a transformer?
Answer: The induced voltage in a transformer coil is directly proportional to the number of turns that coil has. Each turn of wire "cuts" the changing magnetic flux in the core; more turns mean the changing flux links with the conductor more times per cycle, so the induced electromotive force adds up. The fundamental equation $V \propto N \times (\Delta\Phi/\Delta t)$ shows this relationship. Therefore, doubling the turns roughly doubles the voltage, provided the magnetic flux change remains the same. Engineers exploit this by choosing appropriate turn ratios to obtain the desired step-up or step-down voltage for any given application.

Q184. What safety advantages are there in reducing voltage before electrical energy enters homes?
Answer: Lowering the voltage reduces the risk of fatal electric shock because the current that can

flow through a person's body at a given contact resistance falls with voltage. It also limits the energy released in arcs or short circuits, minimising fire hazards and allowing affordable protective devices such as fuses and circuit breakers to disconnect faults quickly. Domestic insulation, sockets and appliance components need withstand only a few hundred volts, making them cheaper and easier to manufacture. Additionally, lower voltages simplify building regulations by allowing cables to be run in walls without special high-voltage conduits.

Q185. A transformer supplies a device that needs 12 V. What must be true about the transformer's secondary coil?
Answer: The secondary coil must have a turns count—and therefore a turns ratio relative to the primary—that produces 12 V across its terminals when the rated primary voltage is applied. If the mains is 230 V, the turns ratio Ns/Np must equal 12 / 230, roughly 1 : 19.2. That means the secondary must have about one-twentieth the turns of the primary. By selecting the wire gauge for the expected current, the designer ensures the coil delivers both the correct voltage and sufficient current to run the device safely without excessive heating or voltage drop under load.

Q186. If Vs is greater than Vp, what must be true about ns and np?
Answer: For the induced voltage in the secondary coil Vs to exceed the primary voltage Vp the turns ratio must favour the secondary, meaning Ns > Np. The transformer equation Vp/Vs = Np/Ns shows that if Ns is larger, the fraction on the right becomes less than one, so Vs exceeds Vp. In practical terms, engineers wind many more turns of thinner wire on the secondary core limb while using fewer turns of thicker wire on the primary so that the device acts as a step-up transformer, increasing voltage and proportionally reducing current.

Q187. A transformer is needed to power a 100 W device from a 230 V supply. What current must the transformer draw if it's 100 % efficient?
Answer:
Answer: The primary current must be low enough that the input power equals the 100 W required by the device, assuming no losses.
Solution:
Power input = Power output
Vp × Ip = 100 W
Ip = 100 W / 230 V = 0.4348 A
So the transformer must draw approximately 0.43 A from the 230 V mains. Because we assumed ideal efficiency, this current supplies the full 100 W without additional losses; in a real transformer the current would be slightly higher to cover heat and core losses.

Q188. What effect does increasing the number of turns on the secondary coil have in a step-up transformer?
Answer: Raising the number of secondary turns increases the turns ratio Ns/Np, which raises the secondary voltage according to Vs = Vp × (Ns/Np). For a fixed power transfer the higher voltage means the secondary current decreases, reducing resistive losses in any cables connected to the secondary side. However, more turns require longer wire, raising the coil's resistance and leakage

inductance. Designers must balance the benefits of higher voltage against these drawbacks and the physical space limits on winding the coil.

Q189. How does a changing magnetic field in the transformer core induce voltage?
Answer: According to Faraday's law of electromagnetic induction, an emf is induced in a conductor whenever the magnetic flux linking the conductor changes with time. In a transformer, the alternating current in the primary coil produces a sinusoidally varying magnetic field in the iron core. This field threads through the secondary coil. As the flux increases and decreases, it continuously changes the number of field lines that cut each turn of the secondary. The rate of change of flux ($d\Phi/dt$) multiplied by the number of turns (N) gives the induced emf, which appears as the secondary voltage.

Q190. Why is it important that the magnetic field in a transformer constantly changes?
Answer: A steady magnetic field cannot induce a continuous voltage because induction depends on change. If the field were constant, the flux linkage in the secondary coil would not vary, so Faraday's law would yield zero emf except for a brief moment when the field first appeared. By driving the primary with an alternating current, the magnetic field continually rises, falls and reverses. This constant change keeps inducing a voltage cycle after cycle, allowing the transformer to transfer energy efficiently from the primary to the secondary as long as the a.c. supply continues.

Q191. Why does a transformer not work with a battery?
Answer: A battery supplies direct current, which produces a static magnetic field after the initial connection transient. Without a time-varying field there is no ongoing change in magnetic flux through the secondary coil, so no emf is induced and no power is transferred. Only when the circuit is first closed or opened does the flux change briefly, causing a momentary spark or pulse. Transformers therefore require an alternating supply to function; connecting them to a d.c. source merely wastes energy as heat in the primary winding without delivering useful output.

Q192. If a transformer is 100 % efficient, how does the power input compare to the power output?
Answer: For an ideal transformer with no losses, all the power supplied to the primary appears at the secondary. Mathematically, $P_{input} = V_p \times I_p$ equals $P_{output} = V_s \times I_s$. No energy is converted into unwanted forms such as heat or sound, so the efficiency $\eta = P_{out}/P_{in} \times 100\%$ equals exactly 100 %. In practice real transformers have small copper losses, core hysteresis losses and eddy current losses that make η slightly less than unity, but for many classroom calculations assuming perfect efficiency provides results very close to the truth.

Q193. What is the relationship between current and voltage in an ideal transformer?
Answer: In an ideal transformer the power balance $V_p \times I_p = V_s \times I_s$ leads to the inverse relationship $I_p/I_s = V_s/V_p$. This means that if the voltage is stepped up by a certain factor, the current is stepped down by the same factor, and vice versa. The product of voltage and current—power—remains constant (ignoring phase differences in a.c. analysis). This inverse proportionality underpins why transmission systems raise voltage to cut current and losses, and why distribution networks then lower the voltage to increase current to usable levels.

Q194. What happens to current when voltage is increased by a step-up transformer?
Answer: Because power must stay the same in an ideal transformer, increasing the secondary voltage forces the secondary current to drop proportionally. For example, doubling the voltage halves the current. This current reduction lowers I^2R losses in the conductors connected to the secondary, which is the principal reason high-voltage, low-current transmission is efficient. Conversely, stepping voltage down inside homes increases current so that ordinary cables and appliance heating elements can consume useful amounts of power at safe voltages.

Q195. A transformer increases voltage from 12 V to 120 V. What does this mean for the current in the secondary coil?
Answer: The voltage has been stepped up by a factor of ten. In an ideal transformer that means the secondary current is one-tenth of the primary current: $Is = Ip \times (Vp/Vs) = Ip/10$. Power remains the same, so if the primary delivers, say, 2 A at 12 V (24 W), the secondary will supply 0.2 A at 120 V (also 24 W). The reduced secondary current minimises resistive losses in any wiring on the high-voltage side but requires adequate insulation to handle the higher potential difference safely.

Q196. Explain how sound waves are converted into an electrical signal by a microphone.
Answer: In a moving-coil microphone sound waves strike a lightweight diaphragm causing it to vibrate. The diaphragm is attached to a small coil suspended in a fixed magnetic field from a permanent magnet. As the coil moves back and forth with the diaphragm it cuts through magnetic field lines, inducing an emf across its terminals that mirrors the pressure variations of the sound wave. This tiny analog voltage is then amplified and can be recorded, transmitted or processed. Essentially, the microphone performs energy conversion from acoustic to electrical by exploiting electromagnetic induction.

Q197. What role does the coil play in a moving-coil microphone?
Answer: The coil acts as the conductor in which the voltage is induced. Bonded to the diaphragm, it faithfully follows the diaphragm's motion in response to sound pressure. As it moves inside the radial magnetic field of the microphone's magnet assembly, it experiences a changing magnetic flux that generates an emf proportional to the speed and direction of motion. The coil therefore converts mechanical vibration into an electrical signal while its resistance, inductance and mass are carefully designed to give the microphone the desired sensitivity and frequency response.

Q198. Why does the movement of the coil in a microphone create a current?
Answer: According to Faraday's law, any conductor experiencing a change in magnetic flux will have an emf induced across its ends. When the microphone's diaphragm vibrates, the coil moves within the magnetic field, continually changing the flux linkage. This induces an alternating voltage. If the coil is connected to an external circuit—through the microphone leads—this voltage drives electrons, producing an alternating current that mirrors the diaphragm's motion and therefore the original sound wave. The current is small but can be amplified without losing its detailed time-varying information.

Q199. What causes the coil in a microphone to move?
Answer: The coil is glued or otherwise attached to the diaphragm, a thin, flexible membrane. Incoming sound waves are pressure variations that push and pull on the diaphragm. Because the

diaphragm's mass is extremely low and its compliance high, these pressure changes make it vibrate. The attached coil must therefore follow the diaphragm's motion, sliding within the narrow gap of the magnet structure. The precision suspension allows the coil to move freely while staying centred so that it can consistently cut the magnetic field lines and generate a clean electrical output.

Q200. In what way is a microphone an example of electromagnetic induction?
Answer: Electromagnetic induction is the process in which a changing magnetic flux through a conductor produces an emf. In a moving-coil microphone the conductor is the coil, the magnetic flux comes from the permanent magnet, and the change in flux is caused by the coil's motion with the vibrating diaphragm. This changing flux induces a voltage that is proportional to the diaphragm's velocity and, after amplification, reproduces the pressure variations of the sound. Thus the microphone directly applies the principles discovered by Faraday to transform mechanical energy from sound into an electrical signal.