ELECTROMAGNETS
MARKING SCHEME

1. Comparing permanent magnets and electromagnets

- **Read each of the numbered statements below**
- **Decide if each one applies to permanent magnets, to electromagnets, or to both types of magnet**
- **Write the number of each statement in the correct area of the blank Venn diagram below**

1. Require an electric current to work
2. Are surrounded by an invisible magnetic field
3. Can be switched on and off
4. Have a North Pole and a South Pole
5. Can be made stronger or weaker
6. Remain magnetic all the time
7. Usually have a soft iron core that's inside a solenoid
8. Are found in electric motors
9. Attract magnetic materials
10. Are used in power station generators

PERMANENT MAGNETS

6. Remain magnetic all the time

Both

2. Are surrounded by an invisible magnetic field
4. Have a North Pole and a South Pole
9. Attract magnetic materials

ELECTROMAGNETS

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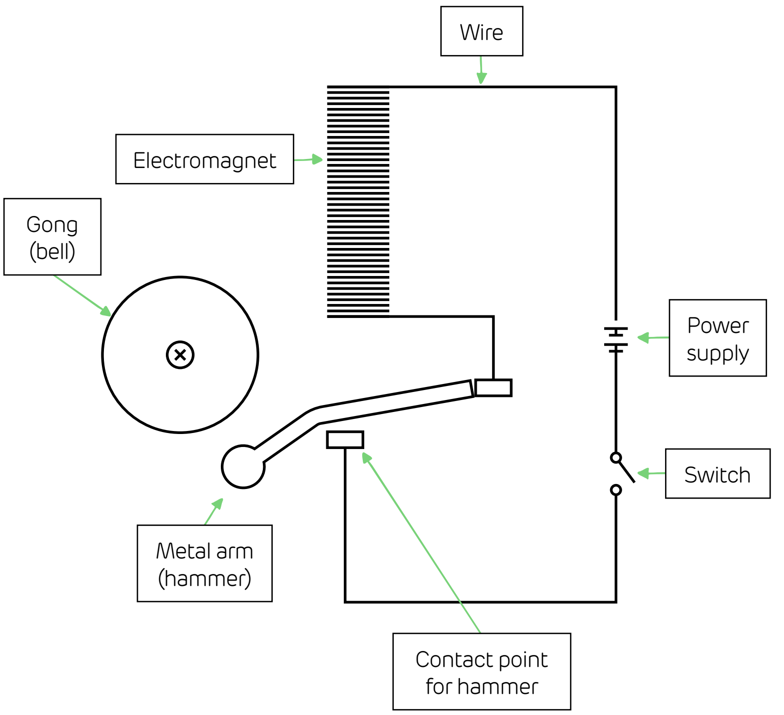
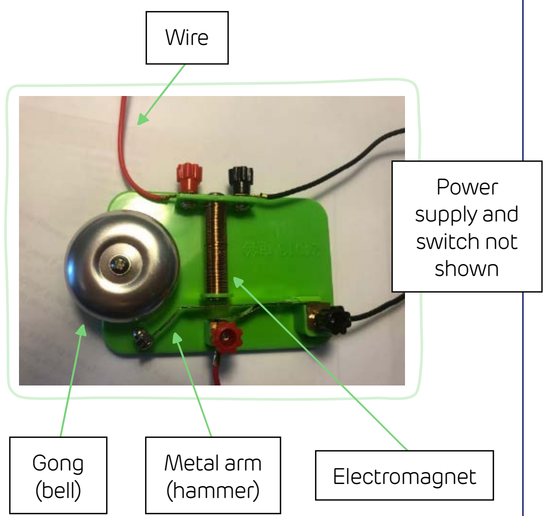
2. How does an electromagnetic bell work?

Correct order	Step
1	G The switch is open and the metal arm is away from the gong.
2	F The switch is closed. An electric current flows through the electromagnet, producing a magnetic field.
3	B The metal arm (hammer) is attracted to the electromagnet.
4	A As the metal arm (hammer) is pulled towards the electromagnet, it's pulled away from its contact with the series circuit.
5	A As the metal arm (hammer) is pulled towards the electromagnet, it's pulled away from its contact with the series circuit.
6	D The circuit is broken, there's no current flowing through the coil, and the electromagnet turns off.
7	I The metal arm (hammer) springs back. The contacts touch and the circuit is complete again.
8	C A current flows through the electromagnet again. The metal arm is attracted again, hitting the gong and making a second single noise.
9	E This process repeats over and over again.
10	H The repeated rapid strikes of the gong are the ringing noise of the bell.





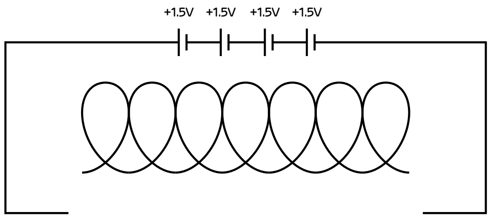
3. Planning a magnetic investigation

Control variables	The number of paperclips that the magnet is able to pick up.
Independent variable	The number of turns of wire on the solenoid (the number of times the wire is wound around the core).
Dependent variable	The number of paperclips that the magnet is able to pick up.

Method

1. Set up a circuit as shown by the circuit diagram. This is a simple series circuit (all components in one loop), with 4 cells, and a long piece of coated wire, connected using crocodile clips.
2. You might want to check that the soft iron nail is not magnetic (does not pick up any of the paperclips), and to check that your circuit is complete with no breaks inside the long coated wire (you would need to add a bulb or other simple component to check you circuit).
3. Wind 5 complete turns of the long wire around the iron nail.
4. Touch the nail onto a pile of unlined paperclips and observe whether any are attracted or not (they are unlikely to be lifted at this point). Record the observation.
5. Wind on another 5 turns of wire and test with the paperclips again. Record the number of paperclips that can be lifted off a surface.
6. Continue adding another 5 turns onto the iron nail, testing with the paperclips, and recording each time.
7. Stop when the whole length of wire has been wound around the nail.

Circuit diagram



Recording Results

An example of a table (you do not have to complete any results, but you could make a prediction about the hypothesis if you want to!):

Number of turns of wire on the electromagnet	Number of paperclips lifted off the table
0	0
5	0
10	0
15	3
20	7
25	10
30	14
35	17
40	20

4. Research challenge

1. Name the British scientist who first discovered that a moving magnetic field could induce an electric current in a wire.

   Michael Faraday

2. What are the main components (parts) of a power station generator?

   A spinning rotor and a stationary stator. The rotor is directly connected to the main turbine and sits inside the stator.

3. How big are the spinning electromagnets in each of the generators at Drax Power Station?

   120 tonnes, 660MW (of which 645MW is exported off site).

4. Most types of electricity generation use a spinning turbine, with a spinning magnet inducing an electrical current inside copper metal around the magnet. Name a type of power generation that doesn't use a spinning turbine.

   Solar power.

5. What's the 'stator' in an electrical generator?

   The copper bars (or wires) surrounding the spinning electromagnet.

6. How long are each of the copper bars in the stators inside the Drax Power Station generators, and how are they kept cool?

   11m; they are cooled with water.

7. What's a 'Kibble balance', and what's it got to do with electromagnets?

   An accurate measuring balance, that uses an electromagnet instead of a counter-weight to measure mass. The strength of the electromagnet can be changed by varying the electrical current through it.

8. All the turbines generating electricity in the UK, regardless of who operates them or what powers them, have to spin at the same speed. How fast do they turn?

   3000rpm, that is, 3000 complete revolutions per minute, or 50 times per second.

9. How does the electricity generated by power stations reach homes and businesses?

   It is transmitted via the National Grid – a system of electrical cables, transformers and lots of pylons used to distribute power throughout the country.

10. In 2016, Drax Power Station carried out work to 'rewind' a copper stator. Why did this work need special, very clean conditions?

    Any small metal particles left inside the stator after the work is completed would be attracted to the powerful electromagnet when it is switched back on – this would damage it.