3.12 Mains Electricity, Power and Energy: 30-minute Pack

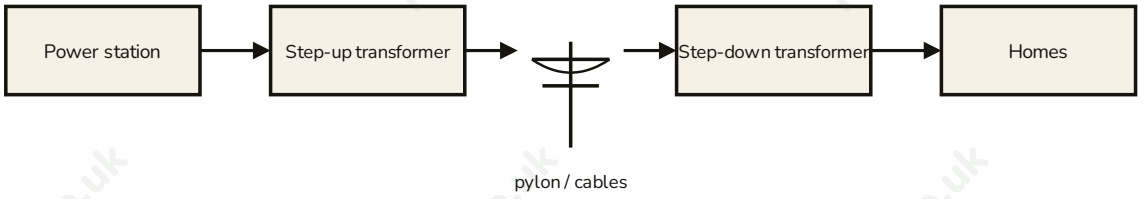
AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Electricity generated at a power station is transmitted around the country by the National Grid at a very high potential difference, before being reduced for use in homes.



(a) State what is meant by the 'National Grid'. **(1)**

(b) Name the type of transformer used to increase the potential difference before transmission. **(1)**

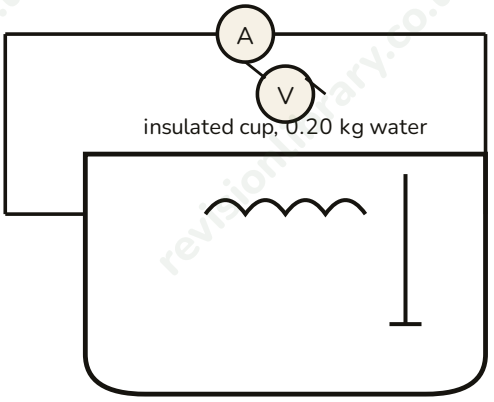
(c) Name the type of transformer used to decrease the potential difference before it reaches homes. **(1)**

(d) State one reason why transmitting electrical power at a high potential difference is more efficient than at a low potential difference. **(1)**

(Total for Question 1 is 4 marks)

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2 Required practical. A student investigates the specific heat capacity of water. She places 0.20 kg of water in an insulated cup and heats it using a low-voltage immersion heater connected to an ammeter and a voltmeter, as shown. The potential difference across the heater and the current through it both stay constant. She switches the heater on for 300 s (5 minutes) and uses a thermometer to record the water's temperature before and after heating. Her results: potential difference = 12.0 V; current = 5.0 A; time = 300 s; initial temperature = 20.0°C; final temperature = 38.0°C.



(a) In addition to the immersion heater, ammeter and voltmeter, state three other pieces of apparatus the student needs to carry out this investigation. **(3)**

(b) Calculate the energy transferred to the water by the immersion heater. Use E = V I t. **(3)**

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(c) The mass of water heated was 0.20 kg and its temperature rose from 20.0°C to 38.0°C. Calculate the specific heat capacity of the water using the student's results. Use E = m c (delta)T and your answer to part (b). **(3)**

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(d) The accepted value for the specific heat capacity of water is 4200 J/(kg °C). Suggest why the student's calculated value is higher than this accepted value. **(1)**

(e) Suggest one improvement to the method that would reduce this source of error. **(1)**

(f) Calculate the percentage difference between the student's calculated specific heat capacity and the accepted value of 4200 J/(kg °C). Give your answer to the nearest 1%. **(2)**

(g) Suggest why the student should stir the water gently while it is being heated. **(1)**

(Total for Question 2 is 14 marks)

3 Evaluate how effectively fuses, circuit breakers and earthing work together to protect a user from electric shock and to protect the wiring from damage due to overheating, in the event of a fault.

(Total for Question 3 is 6 marks)

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Mark scheme · 3.12 Mains Electricity, Power and Energy: 30-minute Pack

Question 1

(a) the system of cables and transformers that transfers/distributes electrical power from power stations to consumers (homes, businesses, etc.) across the country, oe **B1**

(a) Answer: The system of cables and transformers that transfers electrical power from power stations to consumers across the country.

(b) step-up transformer **B1**

(b) Answer: Step-up transformer.

(c) step-down transformer **B1**

(c) Answer: Step-down transformer.

(d) for the same power transmitted, a higher potential difference means a lower current is needed, and a lower current means less energy is wasted (dissipated as heat) in the transmission cables, oe **B1**

(d) Answer: A higher potential difference means a lower current is needed to transmit the same power, so less energy is wasted as heat in the cables.

Question 2

(a) a thermometer (to measure the water's temperature/temperature change) **B1**

(a) a (mass/top-pan) balance (to measure the mass of the water) **B1**

(a) a stopwatch/timer (to measure the heating time); accept an insulated container/lid or a stirrer as alternative correct answers, up to three in total **B1**

(a) Answer: A thermometer, a (mass/top-pan) balance, and a stopwatch/timer.

(b) substitutes: E = 12.0 x 5.0 x 300 **M1**

(b) evaluates the product correctly **M1**

(b) E = 18 000 J (18 kJ) (cao) **A1**

(b) Answer: 18,000 J (18 kJ)

(c) calculates the temperature rise: (delta)T = 38.0 - 20.0 = 18.0°C **M1**

(c) rearranges and substitutes: c = E / (m (delta)T) = 18000 / (0.20 x 18.0), ft from (b) **M1**

(c) c = 5000 J/(kg °C) (cao, ft) **A1**

(c) Answer: 5000 J/(kg °C)

(d) some of the electrical energy supplied was transferred to the surroundings/the cup/the heater and thermometer rather than to the water (heat loss), so the water's actual temperature rise was smaller than it would have been if all the energy had gone into the water; using the full electrical energy in the calculation therefore overestimates the specific heat capacity, oe **B1**

(d) Answer: Some of the electrical energy was lost to the surroundings (not all of it heated the water), so the measured temperature rise was smaller than expected for that energy input, making the calculated specific heat capacity too high.

(e) insulate the cup further (e.g. use a lid and/or lagging/polystyrene) to reduce energy transferred to the surroundings, oe; accept other valid improvements, e.g. using a more powerful heater for a shorter time to reduce the proportion of energy lost **B1**

(e) Answer: Insulate the cup better (e.g. add a lid and lagging) to reduce the energy transferred to the surroundings.

(f) substitutes: percentage difference = (5000 - 4200)/4200 x 100, ft from (c) **M1**

(f) 19% (awrt, ft) **A1**

(f) Answer: 19% (awrt)

(g) stirring ensures the water is heated evenly/reaches a uniform temperature throughout, so the thermometer gives an accurate reading of the whole sample's temperature, oe **B1**

(g) Answer: Stirring spreads the heat evenly through the water so the temperature is uniform, giving an accurate thermometer reading.

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Question 3

Level 3 A clear, logically structured evaluation explaining how the earth wire, fuse and circuit breaker work together: the earth wire provides a low-resistance path so a fault produces a large current; this current is used by the fuse (melting) or circuit breaker (tripping) to disconnect the faulty circuit quickly, before the casing can remain dangerously live or the cables can overheat and start a fire. Includes a reasoned overall judgement on their combined effectiveness (e.g. noting limits, such as needing a correctly rated fuse, or that an RCD gives faster/more sensitive protection). Correct scientific terminology used throughout.	**5-6**
Level 2 Relevant description of how one or two of the features (fuse, circuit breaker, earthing) reduce the risk of shock or fire, with some explanation of the underlying mechanism, but links between the features (or an overall judgement) are missing or unclear. Reasonably logical structure, mostly correct terminology.	**3-4**
Level 1 Basic, isolated statement(s) about one safety feature, with little or no explanation of how it works or why it matters for safety. Limited or no use of correct scientific terminology.	**1-2**
Level 0 No relevant content.	**0**

Indicative content:

- A fault (e.g. a loose live wire) can make an appliance's metal casing live/at a dangerous potential difference.
- The earth wire connects the casing to earth, providing a low-resistance path to earth.
- This causes a large current to flow when a fault occurs.
- The fuse contains a thin wire that heats up (heating effect of a current) and melts once the current exceeds its rating, breaking the live-wire connection.
- A circuit breaker instead uses an electromagnetic switch that trips (opens) once the current exceeds its rating, also breaking the live-wire connection.
- Both the fuse and circuit breaker disconnect the faulty circuit/appliance, isolating it from the mains supply.
- This prevents the casing remaining at a dangerous potential difference, reducing the risk of electric shock to the user.
- It also prevents a sustained excessive current overheating the cables, reducing the risk of fire.
- A circuit breaker can be reset and reused, and typically trips faster, than a fuse (which must be replaced).
- Overall judgement: used together, earthing with a fuse or circuit breaker gives fast, reliable protection at both appliance and circuit level, though protection depends on fitting a fuse of the correct rating, and an RCD would add faster, more sensitive protection against smaller fault/leakage currents than a fuse alone can detect.

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