Most electrical appliances are connected to the mains electricity using three-core cables.

(a) What is the approximate value of the potential difference of the UK mains electricity supply?

Tick one box.

- 23 V
- 230 V
- 300 V
- 350 V

(b) Figure 1 shows a three-core cable.

![Figure 1](image_url)

Use answers from the box to label the wires and complete Figure 1.

<table>
<thead>
<tr>
<th>Earth</th>
<th>Negative</th>
<th>Neutral</th>
</tr>
</thead>
</table>

(1) (2)
In the UK the three wires in a three-core cable are always the same colours.

Why are the wires always the same colours?

Tick one box.

- Each wire is made by a different company.
- It is easy to identify each wire.
- They are cheaper to manufacture.

Touching the live wire is dangerous.

Use answers from the box to complete the sentences.

<table>
<thead>
<tr>
<th>current</th>
<th>resistance</th>
<th>shock</th>
<th>force</th>
<th>voltage</th>
</tr>
</thead>
</table>

Touching the live wire causes a large potential difference to exist across the body.

This causes a ......................................................... through the body, which results in an electric .........................................................

What is the approximate frequency of the UK mains electricity supply?

Tick one answer.

- 50 Hz
- 75 Hz
- 100 Hz
- 150 Hz
Figure 2 shows how power stations transfer electrical power to consumers using the National Grid.

The power station generates electricity at a voltage of 25 kV.

Transformer A increases the voltage by a factor of 16.

What is the voltage output of transformer A?

Output voltage = .......................................... kV

(2)

(g) Why is the voltage increased by transformer A?

Tick one box.

To reduce the energy lost due to heating

To increase the power

To increase the current

(1)
(h) Why is it important that the voltage is decreased by transformer B?

Tick one box.

- Less energy is used by consumers
- It is safer for consumers
- It reduces consumers’ electricity bills

(1)

We use mains electricity in our homes.

(a) What is the frequency of the UK mains electricity supply?

Tick one box.

- 23 Hz
- 50 Hz
- 230 Hz
- 500 Hz

(1)
(b) Many appliances in the home use three-core electrical cable.

Look at the figure below.

Label the wires in the cable in the figure above.

Use words from the box.

<table>
<thead>
<tr>
<th>Earth</th>
<th>Negative</th>
<th>Neutral</th>
<th>Positive</th>
</tr>
</thead>
</table>

(c) The sentences explain how touching the live wire in a cable can cause an electric shock.

Complete the sentences.

Use words from the box.

<table>
<thead>
<tr>
<th>current</th>
<th>force</th>
<th>resistance</th>
<th>potential difference</th>
</tr>
</thead>
</table>

Touching the live wire causes a large ......................... to exist across the body.

This causes a ......................... through the body, which results in an electric shock.

(2)

(d) A heater has a power rating of 2500 W.

The heater is turned on for 180 seconds.

Calculate the energy transferred by the heater.

Use the equation:

\[
\text{energy transferred} = \text{power} \times \text{time}
\]

Give your answer in kilojoules (kJ).

..................................................................................................................................................

..................................................................................................................................................

..................................................................................................................................................

Energy transferred = ......................... kJ

(3)
(e) Write down the equation that links charge flow, energy transferred and potential difference.

.........................................................................................................................................................

(1)

(f) The mains electricity supply is at 230 V.

A different heater transfers 4200 J of energy.

Calculate the charge flow through the heater.

.........................................................................................................................................................

.........................................................................................................................................................

.........................................................................................................................................................

Charge flow = ................................. C

(3)

(Total 12 marks)

(a) The diagram shows the traces produced on an oscilloscope when it is connected across different electricity supplies.

![Diagrams A, B, C](image)

Which of the traces could have been produced by the mains electricity supply?

.........................................................................................................................................................

Give a reason for your answer.

.........................................................................................................................................................

.........................................................................................................................................................

(2)
(b) The picture shows two adaptors being used to plug five electrical appliances into the same socket.

Explain why it is dangerous to have all five appliances switched on and working at the same time.

..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

(2)
(Total 4 marks)
(a) Figure 1 shows the inside of a three-pin plug and a length of three-core cable.

The cable is to be connected to the plug.

Figure 1

(i) Complete Table 1 to show which plug terminal, A, B or C, connects to each of the wires inside the cable.

<table>
<thead>
<tr>
<th>Wire</th>
<th>Plug terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Name a material that could be used to make the case of the plug.

.............................................................................................................................................
(b) **Figure 2** shows an electric drill and an extension lead. The drill is used with the extension lead.

![Electric drill](image1)

**Figure 2**

![Extension lead](image2)

(i) The drill is used for 50 seconds.

In this time, 30 000 joules of energy are transferred from the mains electricity supply to the drill.

Calculate the power of the drill.

\[
\text{Power} = \frac{30000 \text{ joules}}{50 \text{ seconds}}
\]

\[
\text{Power} = 600 \text{ W}
\]

\[2\]
A second drill is used with the extension lead. The power of this drill is 1200 W.

The instructions for using the extension lead include the following information.

When in use the lead may get hot:

DO NOT go over the maximum power
- lead wound inside the case: 820 watts
- lead fully unwound outside the case: 3100 watts

It would not be safe to use this drill with the extension lead if the lead was left wound inside the plastic case.

Explain why.

...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................
...............................................................................................................

(3)
(c) **Table 2** gives information about three different electric drills.

**Table 2**

<table>
<thead>
<tr>
<th>Drill</th>
<th>Power input in watts</th>
<th>Power output in watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>640</td>
<td>500</td>
</tr>
<tr>
<td>Y</td>
<td>710</td>
<td>500</td>
</tr>
<tr>
<td>Z</td>
<td>800</td>
<td>500</td>
</tr>
</tbody>
</table>

A person is going to buy one of the drills, X, Y or Z. The drills cost the same to buy.

Use only the information in the table to decide which one of the drills, X, Y or Z, the person should buy.

Write your answer in the box.  

Give a reason for your answer.

........................................................................................................................
........................................................................................................................
........................................................................................................................

(1)  
(Total 9 marks)

An electric current is a flow of electrical charge through a circuit.

(a) Complete the sentence.

Use a word from the box.

| atoms | electrons | ions | molecules |

Metals are good conductors of electricity because electrical charge is transferred by delocalised ............................................

(1)
(b) Draw one line from each symbol to the name of the component.

<table>
<thead>
<tr>
<th>Standard symbol</th>
<th>Name of component</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Battery symbol" /></td>
<td>Battery</td>
</tr>
<tr>
<td><img src="image" alt="Lamp symbol" /></td>
<td>Lamp</td>
</tr>
<tr>
<td><img src="image" alt="LED symbol" /></td>
<td>LED</td>
</tr>
<tr>
<td><img src="image" alt="Resistor symbol" /></td>
<td>Resistor</td>
</tr>
<tr>
<td><img src="image" alt="Switch symbol" /></td>
<td>Switch</td>
</tr>
</tbody>
</table>
A student plugs all four of the appliances into one multi-way socket.

The mains electricity is 230 V.

The highest safe current in the socket is 30 A.

Explain why it is not safe to use all four appliances at the same time.

In your answer you should:

• calculate the total power needed

• use the equation

\[
\text{current} = \frac{\text{power}}{\text{potential difference}}
\]

• to calculate the total current needed.
(d) The figure below shows how electrical power is transferred from power stations to consumers using the National Grid.

Transformer 1 is a step-up transformer.

Explain why step-up transformers are used in the National Grid.

(e) What is the purpose of Transformer 2?

(f) In a power station 900 MJ of thermal energy were released by burning natural gas.

Write down the equation that links efficiency, useful input energy transfer and useful output energy transfer.
(g) In a power station 900 MJ of thermal energy were released by burning natural gas. Only 405 MJ was generated.

Calculate the efficiency of this energy transfer.

Efficiency = ........................................

(Total 15 marks)

(a) Describe the difference between an alternating current (a.c.) and a direct current (d.c.).

Efficiency = ........................................

(Total 15 marks)
(b) The diagram shows how the electric supply cable is connected to an electric kettle. The earth wire is connected to the metal case of the kettle.

If a fault makes the metal case live, the earth wire and the fuse inside the plug protect anyone using the kettle from an electric shock.

Explain how.

.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................

(2)  
(Total 4 marks)

Solar panels are often seen on the roofs of houses.

(a) Describe the action and purpose of a solar panel.

.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................

(2)
Photovoltaic cells transfer light energy to electrical energy.

In the UK, some householders have fitted modules containing photovoltaic cells on the roofs of their houses.

Four modules are shown in the diagram.

The electricity company pays the householder for the energy transferred.

The maximum power available from the photovoltaic cells shown in the diagram is $1.4 \times 10^3$ W.

How long, in minutes, does it take to transfer 168 kJ of energy?

$\frac{168 \text{ kJ}}{1.4 \times 10^3 \text{ W}} = 0.12 \text{ h} = 0.12 \times 60 \text{ min} = 7.2 \text{ min}$

Time = 7.2 minutes
When the modules are fitted on a roof, the householder gets an extra electricity meter to measure the amount of energy transferred by the photovoltaic cells.

(i) The diagram shows two readings of this electricity meter taken three months apart. The readings are in kilowatt-hours (kWh).

<table>
<thead>
<tr>
<th>21 November</th>
<th>0 0 0 4 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 February</td>
<td>0 0 1 9 4</td>
</tr>
</tbody>
</table>

Calculate the energy transferred by the photovoltaic cells during this time period.

Energy transferred = ........................................ kWh

(ii) The electricity company pays 40p for each kWh of energy transferred.

Calculate the money the electricity company would pay the householder.

Money paid = ........................................

(iii) The cost of the four modules is £6000.

Calculate the payback time in years for the modules.

Payback time = ........................................ years

(iv) State an assumption you have made in your calculation in part (iii).

Assumption: ____________________________

Assumption: ____________________________

Assumption: ____________________________

Assumption: ____________________________
(d) In the northern hemisphere, the modules should always face south for the maximum transfer of energy.

State one other factor that would affect the amount of energy transferred during daylight hours.

........................................................................................................................................

........................................................................................................................................

(1)
(Total 13 marks)
Mark schemes

(a) 230 V

(b) Earth
   must be in the correct order
   Neutral

(c) It is easy to identify each wire.

(d) current
   must be in the correct order
   shock

(e) 50 Hz

(f) output = 25 × 16
   400 (kV)
   allow 400 (kV) with no working shown for 2 marks

(g) It reduces the energy lost due to heating

(h) It is safer for consumers

[11]

(a) 50 Hz

(b) Top: Earth
    Bottom: Neutral

(c) potential difference

(d) energy = 2500 × 180
(a) A

only scores if A chosen

it is alternating / a.c.

accept because B and C are d.c.

or

it changes direction/p.d.

accept voltage for p.d.

it goes up and down is insufficient

it is constantly changing is insufficient

an answer B and/or C with the reason because it is direct

current/d.c scores 1 mark

(b) too much current (through socket)

accept electricity for current

accept too much power

accept socket/circuit overloaded

do not accept voltage/p.d for current

(e) energy transferred = charge flow × potential difference

allow \( E = QV \)

(f) \( 4200 = Q \times 230 \)

\[
Q = 4200 \div 230
\]

\[
= 18.3 \text{ (C)}
\]

allow 18.3 with no working shown for 3 marks

\[= 450000 = 450 \text{ kJ}
\]

allow 450 with no working shown for 3 marks

[12]
wiring / socket gets hot
accept melts for gets hot
accept risk of fire
risk of fire in appliances is insufficient
ignore reference to sparking
overloaded plugs and plugs getting hot or fuses melting is insufficient
(a) (i) Wire Plug terminal
<table>
<thead>
<tr>
<th>Wire</th>
<th>Plug terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live</td>
<td>C</td>
</tr>
<tr>
<td>Neutral</td>
<td>A</td>
</tr>
<tr>
<td>Earth</td>
<td>B</td>
</tr>
</tbody>
</table>

_all 3 correct for 2 marks_
_allow 1 mark for 1 correct_

(ii) plastic
    or rubber
    accept:
    ABS
    UF / urea formaldehyde
    nylon
    PVC

(b) (i) 600

_allow 1 mark for correct substitution,_

\[ \text{ie } P = \frac{30000}{50} \]

_provided no subsequent step_

(ii) power is greater than 820 (W)
    power is 1200 W is insufficient

_the lead /cable / wire will overheat / get (too) hot_
    accept lead / cable will melt
    _may overheat / get hot is insufficient_

_so there is a risk of fire_
    accept causing a fire

(c) X

_any one from:_

- most / more efficient
- smallest energy input (per second)
- cheapest to operate
mark only scores if X is chosen
mark is for the reason
accept smallest input (power) for same output (power)
accept wastes least energy
smallest (power) input is insufficient
uses least electricity is insufficient

(a) electrons

(b) extra lines from a symbol negate the mark

(c) the total power = 7360 watts

\[
\text{current} = \frac{7360}{230}
\]

= 32 A

*allow 32 with no working shown for 3 marks*

so the current is greater than 30 A

(d) to increase the voltage (across the cables) or to decrease the current (through the cables)

reducing energy losses (in the cables)

*do not allow electricity for energy*

*do not allow no energy loss*

increasing the efficiency of transmission

(e) to decrease the potential difference for domestic use
(f) \[ \text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}} \]

(g) \[ \frac{405}{900} = 0.45 \]

\[ \text{accept 45%} \]

\[ \text{allow 0.45 or 45% with no working shown for 2 marks} \]

6

(a) d.c. flows in (only) one direction

a.c. changes direction (twice every cycle)

\[ \text{accept a.c. constantly changing direction} \]

\[ \text{ignore references to frequency} \]

(b) a current flows through from the live wire / metal case to the earth wire

\[ \text{accept a current flows from live to earth} \]

\[ \text{do not accept on its own if the current is too high} \]

this current causes the fuse to melt

\[ \text{accept blow for melt} \]

\[ \text{do not accept break / snap / blow up for melt} \]

7

(a) water heated by radiation (from the Sun)

\[ \text{accept IR / energy for radiation} \]

water used to heat buildings / provide hot water

\[ \text{allow for 1 mark heat from the Sun heats water if no other marks given} \]

\[ \text{references to photovoltaic cells / electricity scores 0 marks} \]

(b) 2 (minutes)

\[ 1.4 \times 10^3 = \frac{168 \times 10^3}{t} \]

\[ \text{gains 1 mark} \]

\[ \text{calculation of time of 120 (seconds) scores 2 marks} \]

(c) (i) 150 (kWh)
(ii) £60.00 or 6000 (p)
   an answer of £6000 gains 1 mark
   allow 1 mark for 150 \times 0.4(0) 150 \times 40
   allow ecf from (c)(i)

(iii) 25 (years)
   an answer of 6000 / 240
   or
   6000 / their (c)(ii) \times 4
   gains 2 marks
   an answer of 6000 / 60
   or
   6000 / their (c)(ii) gains 1 mark, ignore any other multiplier of (c)(ii)

(iv) any one from:
   • will get £240 per year
     accept value consistent with calculated value in (c)(iii)
   • amount of light is constant throughout the year
   • price per unit stays the same
   • condition of cells does not deteriorate

(d) any one from:
   • angle of tilt of cells
   • cloud cover
   • season / shade by trees
   • amount of dirt