Sustainable energy – 2021/20 GCSE 21st Physics Combined Science B

1. Nov 2021/Paper_J260/03/No.4

Amaya makes a bubble machine as shown in **Fig. 4.1**.

The fan blows air through the bubble wand.

A wand motor rotates the bubble wand between the bubble mixture and the moving air to make bubbles.

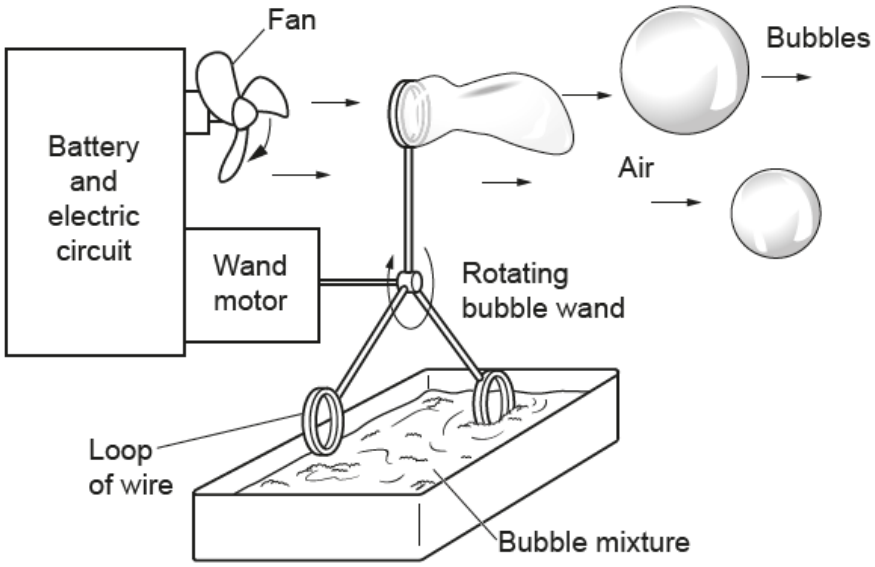


Fig. 4.1

(a) The bubble machine transfers energy to the bubble wand and bubbles.

Complete **Fig. 4.2** to show the energy transfer from the battery to the rotating bubble wand.

Energy store reduced in battery		Energy is transferred by		Energy store increased in rotating wand
	→		→	

Fig. 4.2 **[3]**

(b) **Fig. 4.3** shows an incomplete circuit diagram for the wand motor.

A variable resistor is needed to change the speed of the wand motor.

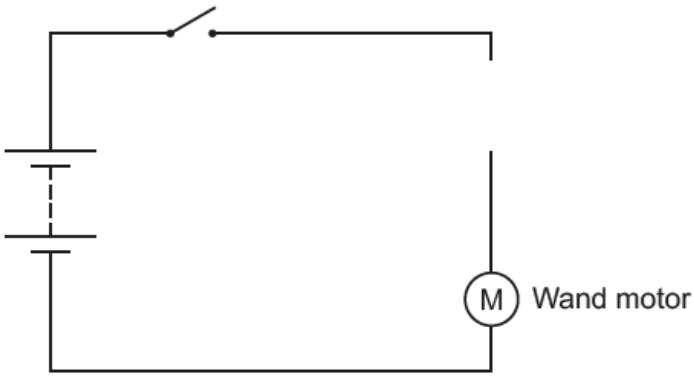


Fig. 4.3

(i) Complete the circuit diagram in **Fig. 4.3** by adding a **variable resistor**. **[1]**

(ii) The resistance of the variable resistor is set to 1.54 Ω and the resistance of the wand motor is 0.56 Ω.

Calculate the total resistance of the variable resistor and the wand motor.

Total resistance = ... Ω **[2]**

(c) Complete the statements to describe what happens to the current and potential difference when the resistance of the variable resistor is increased.

Use the words.

You can use each word once, more than once, or not at all.

increases **decreases** **stays the same**

(i) The current through the variable resistor ..... **[1]**

(ii) The potential difference across the wand motor ..... **[1]**

(iii) The total potential difference across the variable resistor and wand motor

..... **[1]**

2. Nov 2021/Paper_J260/03/No.9

Nina has an electric car. It has a rechargeable battery. She plugs it into a charger at home to recharge it overnight.

(a) The charger has a power rating of 7 kW.

(i) Calculate the total energy transferred when Nina charges the battery for 7.5 hours.

Give your answer in **kWh**.

Total energy transferred = ... kWh **[3]**

(ii) The charging increases the energy stored in the battery by 48.3 kWh.

Calculate the efficiency of the charger.

Give your answer as a percentage.

Efficiency = ... % **[3]**

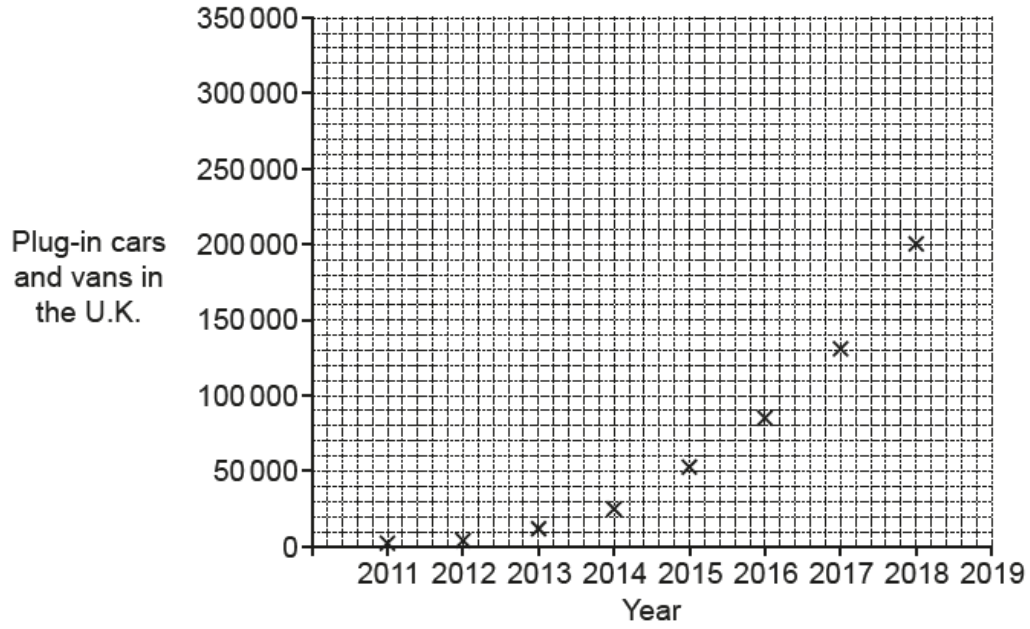
(iii) The domestic electricity supply voltage is alternating voltage, but the battery voltage is direct voltage.

What is the difference between alternating voltage and direct voltage?

.....

..... **[1]**

(b) The graph shows the number of cars and vans in the U.K. that could be plugged in and charged, from 2011 to 2018.



(i) Complete the graph by drawing a curve of best fit. **[1]**

(ii) Use the graph to estimate the number of plug-in cars and vans in the U.K. in 2019.

Estimated number of plug-in cars and vans = ... **[1]**

(c) **(i)** Suggest **one** reason why the number of plug-in cars and vans in the U.K. is increasing.

.....

..... **[1]**

(ii) Suggest **two** problems for the electricity supply industry if all petrol cars in the U.K. are replaced by electric cars that are plugged in overnight.

1 .....

.....

2 .....

.....

[2]

3. Nov 2020/Paper_J260/03/No.9

Jamal has a new television.

Fig. 9.1 shows the Sankey diagram for the energy transferred by the new television in one second.

(a) Complete the Sankey diagram in **Fig. 9.1**.

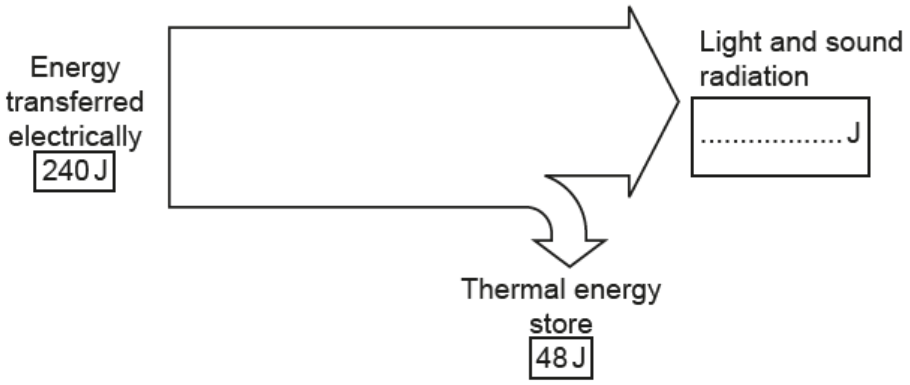


Fig. 9.1

[1]

(b) Jamal wants to work out how long he watches television in one week.

He makes some measurements of the energy transferred by the television.

Energy transferred by the television in one week	5.04 kWh
Power rating of television	240 W

Calculate the time, in **hours**, that the television was used during the week.

Use the equation: energy transferred = power × time

Time ..... hours **[3]**

(c) The energy transferred electrically to the television is supplied by a **nuclear** power station.

Complete **Fig. 9.2** to show the order of electricity generation in a nuclear power station.

Use words from the list.

You can use each word once, more than once, or not at all

reactor **furnace** **generator** **grid** **turbine**

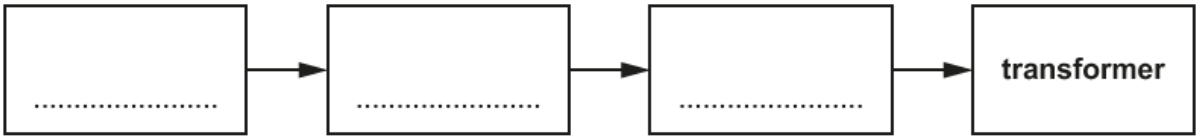


Fig. 9.2

[2]

4. Nov 2020/Paper_J260/04/No.3

(a) **Table 3.1** shows the properties of some materials.

Material	Tensile Strength (MPa)	Density (g/cm^3)	Electrical conductivity	Thermal conductivity	Flexibility	Melting Point (°C)
Aluminium	290	2.7	good	good	medium	660
Low-density polyethylene (LDPE)	17	0.9	poor	poor	high	110
Steel	1020	8.1	good	good	medium	1400

Table 3.1

(i) Which material in **Table 3.1** should be used as an **insulator** around electrical wires found in a plug, as shown in **Fig. 3.1**?

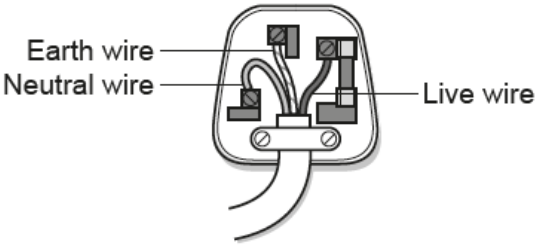


Fig. 3.1

Put a (ring) around the correct answer.

aluminium **LDPE** **steel** **[1]**

(ii) Overhead electrical cables used in the National Grid need to be flexible, and as light as possible.

Which material in **Table 3.1** should be used for overhead electrical cables in the National Grid as shown in **Fig. 3.2**?

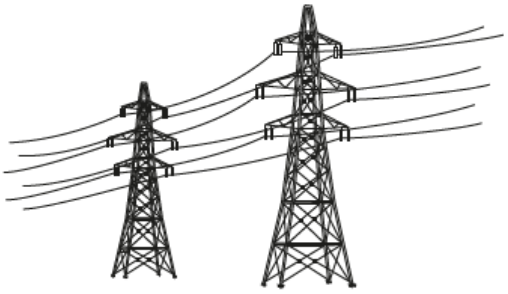


Fig. 3.2

Put a (ring) around the correct answer.

aluminium **LDPE** **steel** **[1]**

(b) Which statements about the materials in **Table 3.1** are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
Aluminium is more likely to bend without breaking than LDPE.		
LDPE is nine times less dense than steel.		
Steel is the strongest material.		

[2]

(c) Suggest which material costs the least to recycle.

Use data from **Table 3.1** to explain your answer.

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.....

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..... **[2]**

(d)* In some professional cycling sports, competitors have to run with their bicycles.

Table 3.2 shows some materials used to make professional cycling bicycles.

Material	Density (g/cm^3)	Strength (MPa)	Brittleness	Cost of frame (£)
Steel	8.1	1020	low	350
Aluminium	2.7	290	low	500
Titanium	4.5	434	low	1000
Carbon fibre	1.8	1600	high	800

Table 3.2

Give the **advantages** and **disadvantages** of using carbon fibre for professional cycling bicycles.

Use the information in **Table 3.2** and calculations to support your answer.

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..... **[6]**

5. Nov 2021/Paper_J260/07/No.1

Nina has an electric car. It has a rechargeable battery. She plugs it into a charger at home to recharge it overnight.

(a) The charger has a power rating of 7 kW.

(i) Calculate the total energy transferred when Nina charges the battery for 7.5 hours.

Give your answer in **kWh**.

Total energy transferred = ... kWh **[3]**

(ii) The charging increases the energy stored in the battery by 48.3 kWh.

Calculate the efficiency of the charger.

Give your answer as a percentage.

Efficiency = ... % **[3]**

(iii) The domestic electricity supply voltage is alternating voltage, but the battery voltage is direct voltage.

What is the difference between alternating voltage and direct voltage?

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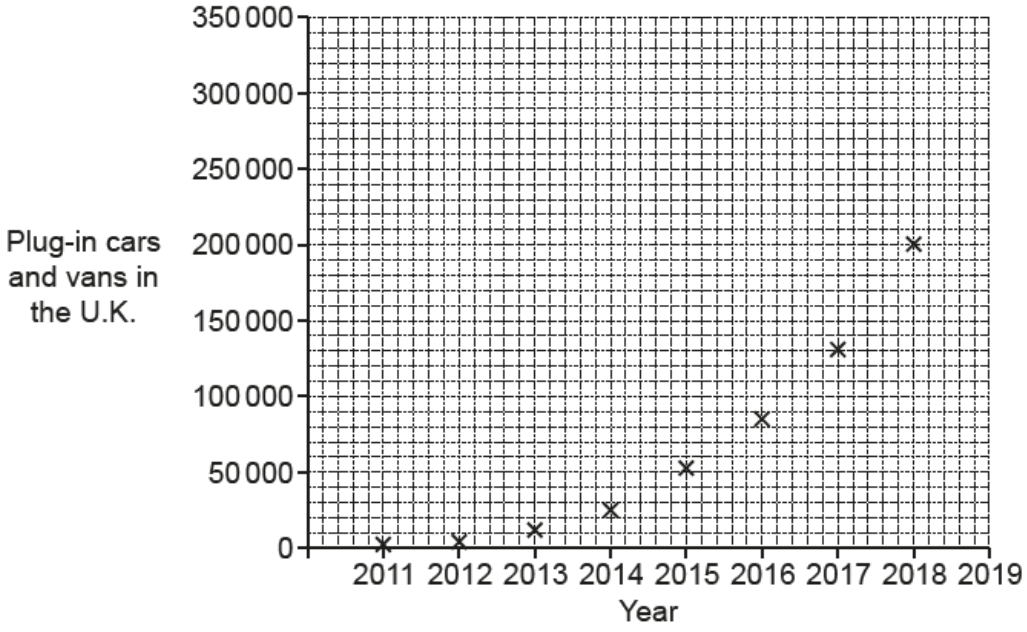
..... **[1]**

(b) The graph shows the number of cars and vans in the U.K. that could be plugged in and charged, from 2011 to 2018.



(i) Complete the graph by drawing a curve of best fit. **[1]**

(ii) Use the graph to estimate the number of plug-in cars and vans in the U.K. in 2019.

Estimated number of plug-in cars and vans = ... **[1]**

(c) **(i)** Suggest **one** reason why the number of plug-in cars and vans in the U.K. is increasing.

.....

..... **[1]**

(ii) Suggest **two** problems for the electricity supply industry if all petrol cars in the U.K. are replaced by electric cars that are plugged in overnight.

1 .....

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2 .....

.....

[2]

6. Nov 2021/Paper_J260/07/No.8

Energy is transmitted from power stations to homes by overhead power cables.

High voltages are used for transmitting electricity long distances because it is a more efficient way to transmit energy.

(a) Explain why it is more efficient to use a high voltage.

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..... **[2]**

(b) This table gives information about the mains electricity.

Voltages used in National Grid distribution network	400 kV 132 kV 33 kV 11 kV
Voltage in homes	230 V
Frequency of supply	50 Hz

Which **one** statement is correct?

Tick (✓) **one** box.

At substations variable resistors are used to step down the voltage to 230 V. ☐

Overhead power cables only transmit energy from fossil fuel power stations. ☐

Radio waves with a frequency of 50 Hz are produced by the overhead power lines. ☐

The mains supply to homes is direct voltage. ☐

[1]

(c) The electricity generated from solar power in the U.K. has increased.

In 2010 it was 33 GW h. In 2017 it was 11 479 GW h.

Calculate how many orders of magnitude it increased in that time.

Orders of magnitude = ... **[2]**

7. Nov 2020/Paper_J260/07/No.7

When an electrical appliance is used, energy is transferred from one energy store to another, so there is a change in stored energy.

The table shows the change in stored energy for different electrical appliances.

Electrical appliance	Power rating (W)	Time used (h)	Change in stored energy (Wh)
shower	7500	0.2	1500
kettle	3000	0.2	600
television	125	1.0	125
cordless vacuum cleaner	125	0.4	50
lamp	9	5.0	45

(a) Explain how the power rating of the appliance, and the time used, affects the change in stored energy.

Use data from the table to support your answer.

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..... **[3]**

(b) **(i)** Calculate the useful energy transferred to the cordless vacuum cleaner motor when it is used for 0.4 hours.

The efficiency of the cordless vacuum cleaner motor is 90%.

Use data from the table.

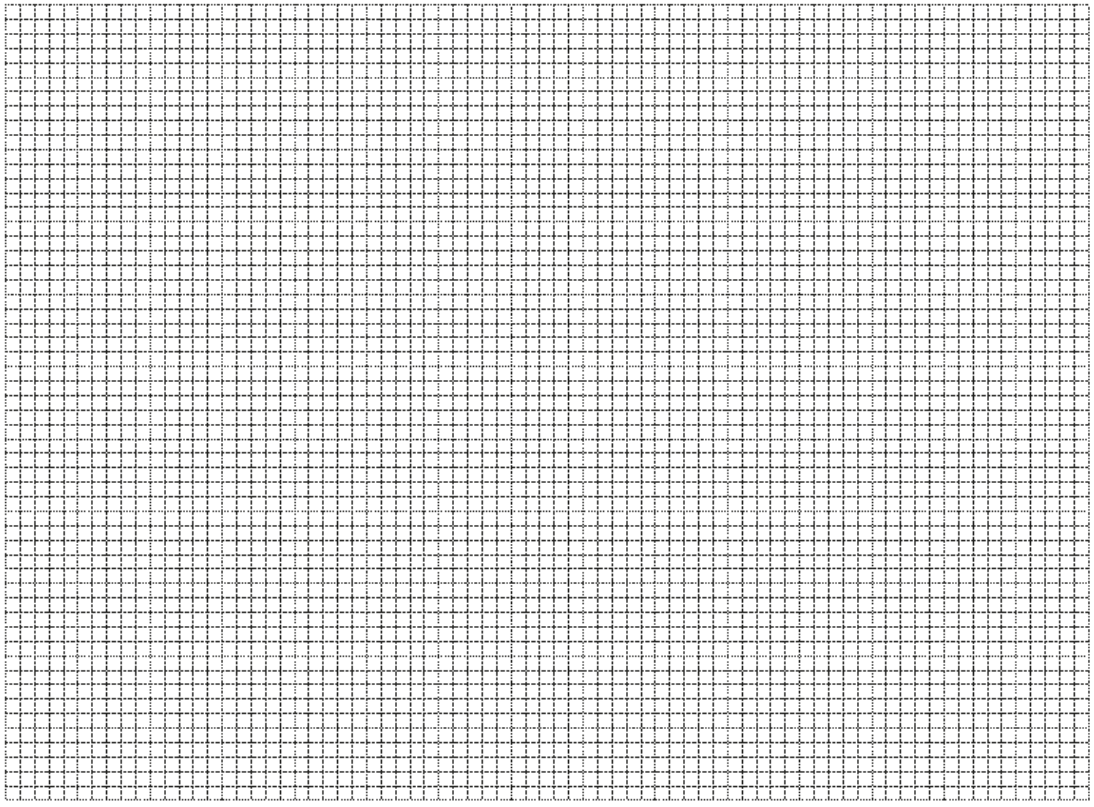
Use the equation: $\text{efficiency} = \frac{\text{useful energy transferred}}{\text{total energy transferred}}$

Useful energy transferred = ... Wh **[3]**

(ii) Draw a labelled Sankey diagram to show the energy transfers that take place when the cordless vacuum cleaner is used for 0.4 hours.

Use information from the table and your answer to **(b)(i)**.

The energy store at the start is the 50 W h chemical energy store of the battery in the cordless vacuum cleaner.



[4]

(c) The kettle uses the mains domestic electricity supply.

Complete **Fig. 7.1** to describe the energy transfers that take place when a kettle heats water, starting with the energy store at the power station.

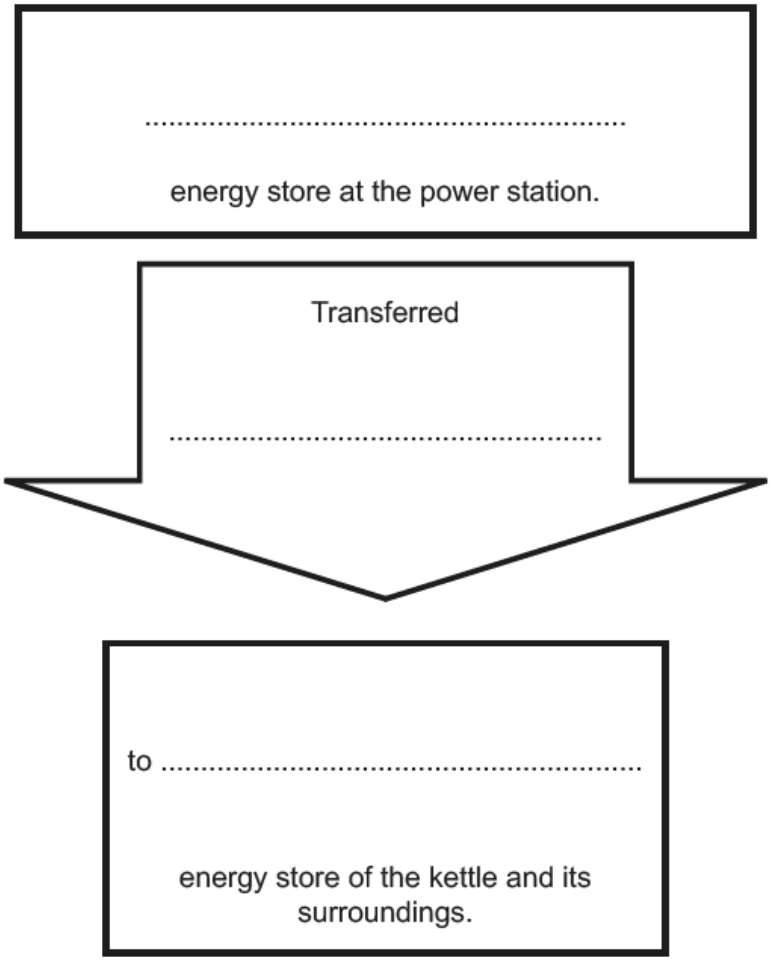


Fig. 7.1

[3]