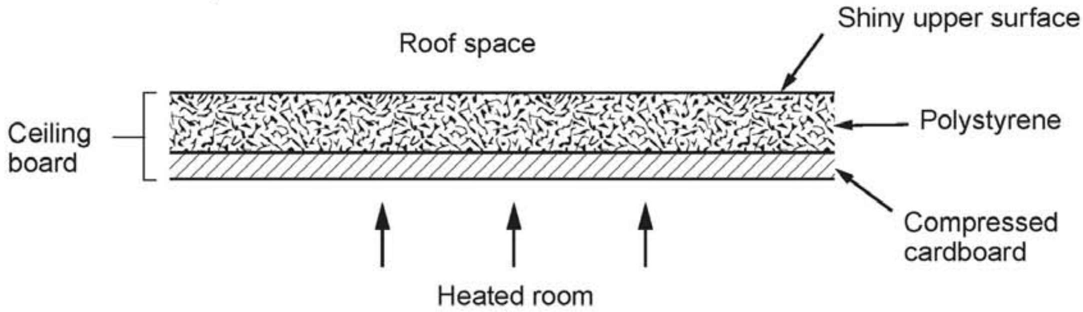
WJEC Physics GCSE
Topic 1.3: Making use of Energy
Questions by topic

1.

Two ways in which new houses are designed to save the owner energy costs are shown below.

(a) The diagram shows a section through a modern ceiling board used to reduce the heat lost into the roof space of a house.



(i) State how the polystyrene reduces heat loss **into** the roof space. [1]

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(ii) Explain how the shiny upper surface reduces convection of air in the roof space. [2]

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(iii) State why the ceiling board reduces heat loss by convection of air **in the roof** space. [1]

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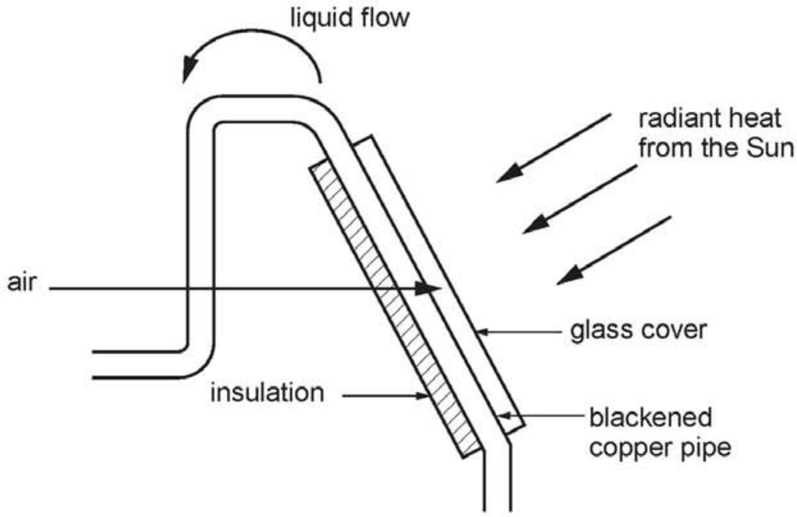
(b) The diagram shows a solar heating panel, which can be installed on a roof. The liquid in the copper pipe becomes heated by energy from the Sun.



(i) Explain why the copper pipe in the solar panel is painted black. [2]

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(ii) Explain why the glass cover reduces heat loss from the solar panel. [2]

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(c) On a sunny day **each square metre** of the solar panel receives 1200 J of energy every second from the Sun. The solar panel has an area of 3 m^2.

(i) Calculate the amount of energy falling on the panel in **one minute**. [2]

energy = ... J

(ii) During this time, the liquid absorbs 86400 J of energy. Use an equation from page 2 to calculate the % efficiency of the solar panel. [2]

% efficiency = ...

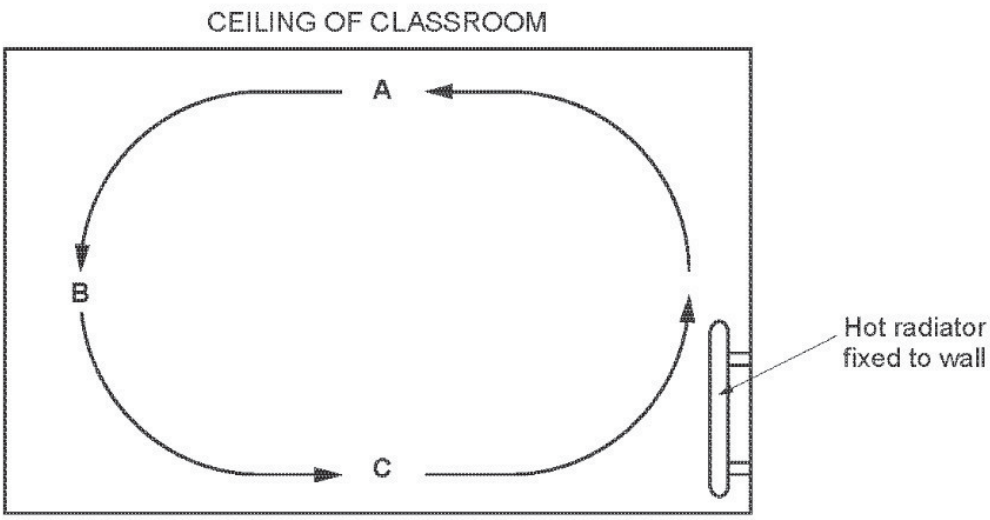
2.

(a) A classroom has a volume of $80\,m^3$ and contains 104 kg of air. Use an equation from page 2 to calculate the density of the air in the room and state the unit. [3]

Density = ...

Unit ....

(b) The classroom is now heated by a radiator. This sets up a convection current in the air as shown in the diagram below.



(i) At which point **A**, **B** or **C** is the air in the classroom the hottest? .... [1]

(ii) At which point **A**, **B** or **C** is the air in the classroom least dense? .... [1]

(iii) Give a reason for your answer to *(b)*(ii). [1]

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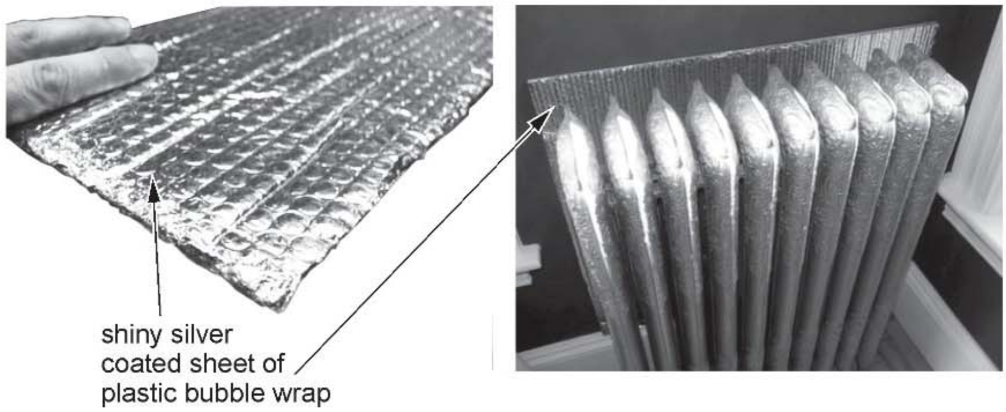
(c) A shiny silver coated sheet of plastic bubble wrap is placed on the wall behind the radiator. Explain how this can reduce heat loss from the classroom by conduction, convection and radiation. [6 QWC]



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3. (Higher)

Use your knowledge of the kinetic theory of matter to explain how heat energy is transferred by conduction in **metals** and by convection in **gases**. [6 QWC]

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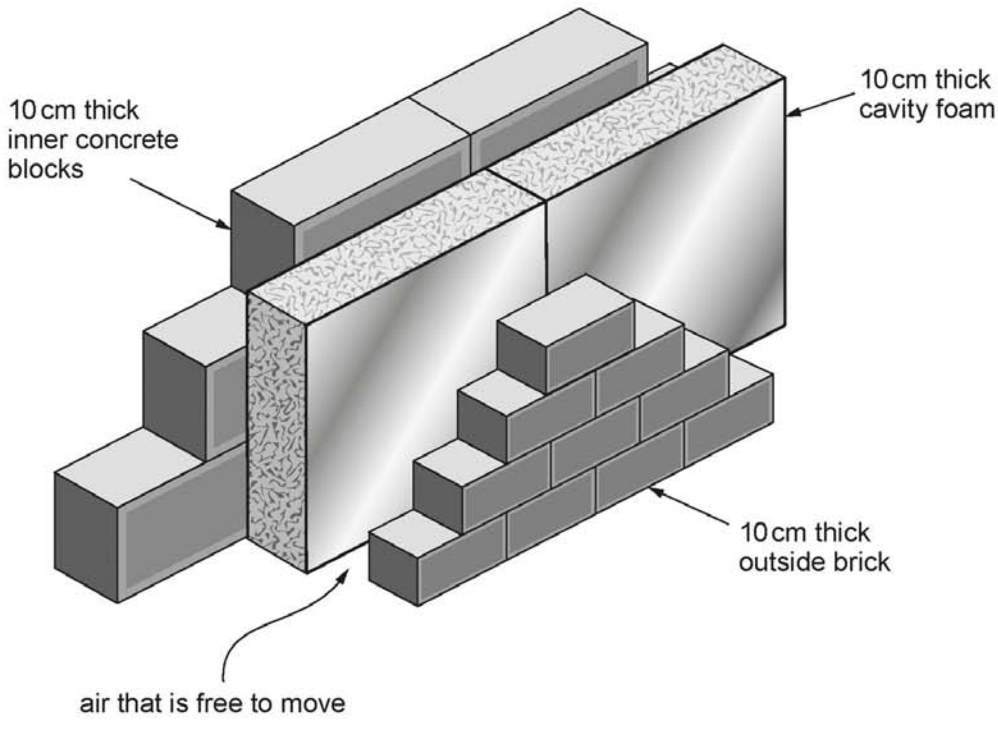
4.

The insulating effectiveness of a material is given by a quantity called its R value. The higher the R value of a section of material, the better it is at resisting the movement of heat energy.

The R values for some common materials are shown in the table below.
Where more than one type of material is used, R values are added together.

Material	R value (units)
Air that is free to move	0.02
A standard 10 cm thick brick	0.30
10 cm cavity wall insulating foam	3.60
10 cm thick inner concrete block	2.08
30 cm of attic foam	2.70

A house wall is built in the way shown below.



(a) Calculate the total R value for the wall shown. [1]

R value for wall = ... units *(b)* The rate at which energy is lost through the wall is given by the following equation:

$$\text{power} = \frac{\text{wall area} \times \text{temperature difference between inside and outside}}{\text{total R value}}$$

A typical house has a total outside wall area of 150 m^2.
On a winter's day, the temperature outside is –4° C and the inside is kept at a comfortable 21° C.

(i) Use the equation above to calculate the rate at which energy is lost from the walls of the house. [2]

power = ... W

(ii) **An extra 475 W is lost** from other parts of the house such as windows, floor, roof and draughts. Use equations from page 2 to calculate the cost of maintaining the inside temperature at 21° C for 16 hours if the cost of a unit of electricity is 15 p. [3]

cost = ...

(iii) Why would a semi-detached house prove to be cheaper to heat than a detached house of a similar size? [1]

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(c) The blocks of foam that are built into the walls are coated on both sides with shiny aluminium foil. Explain how the foil near the inner **warm** wall of the house and the foil on the outer **cooler side** (next to the air in the cavity) reduce heat loss. [3]

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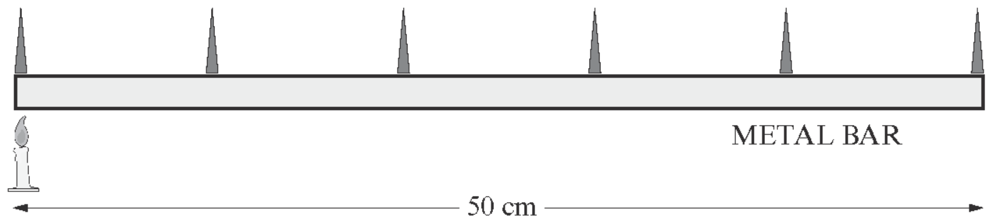
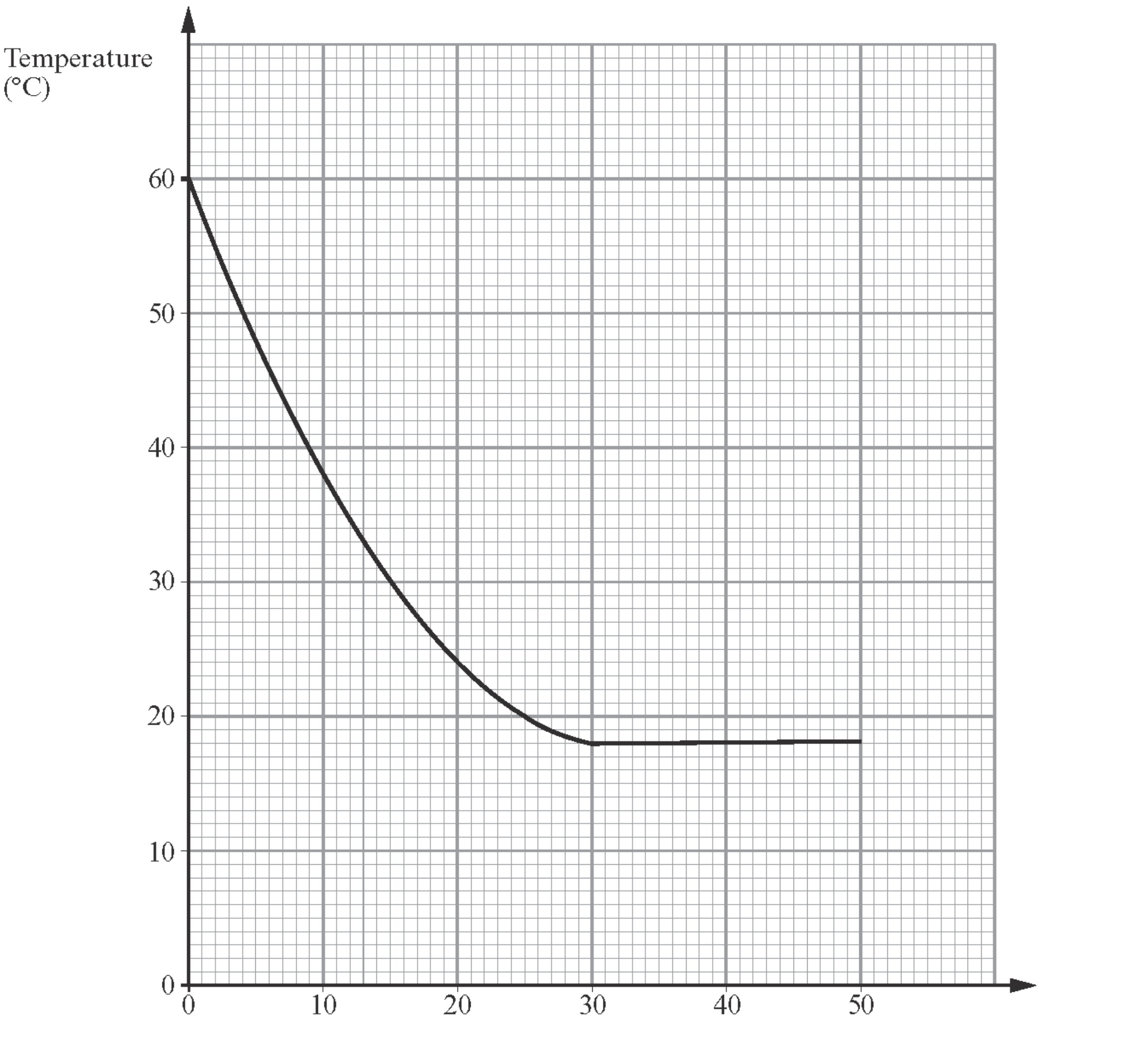
5.

The diagram shows a metal bar which is heated by a candle at one end and has temperature probes attached to it along its length.

Six temperature probes connected to a computer



The graph shows how the temperature falls with distance along the metal bar from the heated end.



(a) (i) Use the graph to calculate the mean temperature drop per cm for the first 20 cm along the metal bar. [2]

.... °C/cm

(ii) The mean temperature drop per cm for the first 10 cm along the bar is 2.2 °C/cm. State how the temperature drop per cm **at the heated end** of the metal bar could be found from the graph. [1]

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(b) **Draw** on the graph a line to show how the temperature change along the bar would look for a metal bar which conducts less well. [2]

(c) Explain, in terms of particles, why metals are better conductors of heat than non-metals. [2]

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6.

A semi-detached house is poorly insulated.
The owner has £3 200 available to spend on improving the insulation.
Information on each type of insulation is shown in the table below.

Part of house	Insulated or not	Heat energy lost per second (W)	Cost of insulation (£)	Payback time (years)	Expected annual saving (£)
LOFT	No insulation	4 200			
	Fibre glass laid on floor of loft	1 500	800	....	200
CAVITY WALL	No insulation	3 000			
	Insulated with foam	1 300	1 200	10	120
DOORS	Wood	1 200			
	PVCu	1 000	1 200	60	....
WINDOWS	Single glazed	1 500			
	Double glazed	1 200	2 400	96	25

(a) Complete the spaces in the last **two** columns of the table. [2]

(b) Use information from the table opposite to advise the owner on how best to spend all the £3 200 on insulation. [6 QWC]

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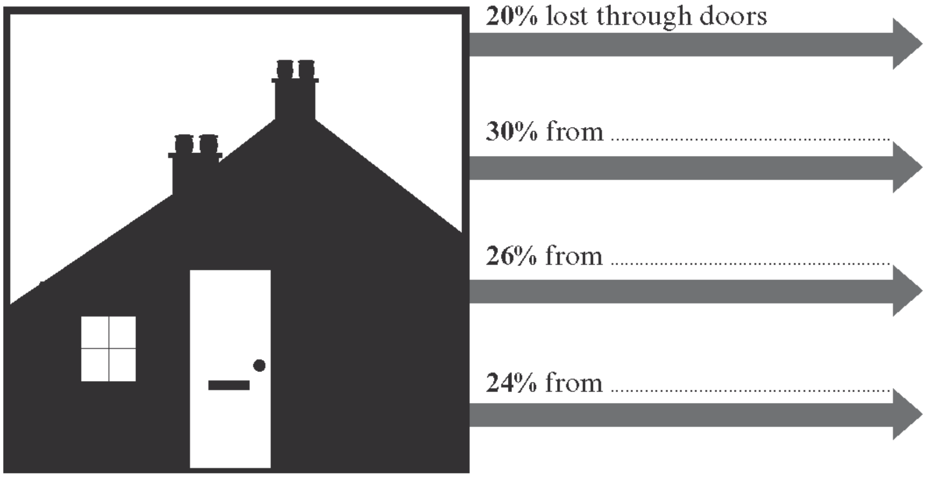
(c) The diagram shows the percentages of energy lost from the house if it is **fully insulated**. Label the arrows to show which part of the house each percentage comes from. *One has been done for you.* You should refer to the table on page 8. [2]



(d) Explain how convection currents are set up in a cavity wall with no insulation. [2]

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(e) The family in the house is advised to reduce the temperature in the main living area in winter time to save money. Explain how this would increase the payback time for the improvements that are undertaken. [2]

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(f) Insulating the cavity wall reduces the energy loss per second by 1 700 W. Use this information to calculate the time taken to save £120. One unit of electricity costs 15 p. [3]

You should use the following equations:

$$\text{Units saved} = \frac{\text{saving}}{\text{cost per unit}} \qquad \text{Time (h)} = \frac{\text{units saved}}{\text{power (kW)}}$$

Time = ... hours

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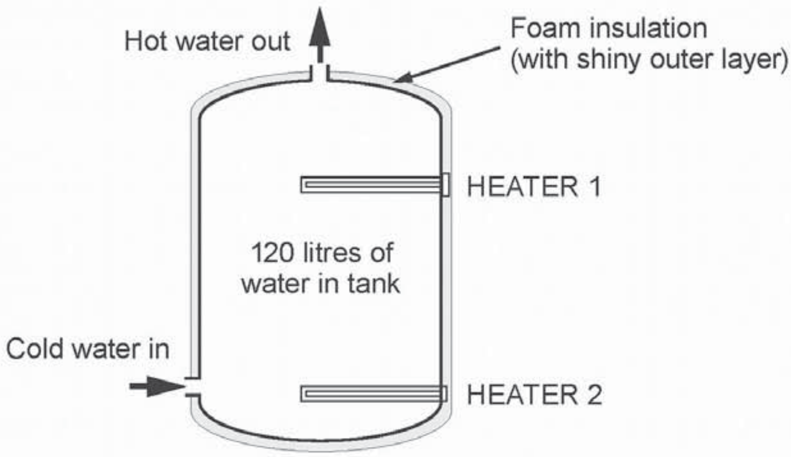
7.

A hot water tank that is covered in foam insulation contains a total of 120 litres of water. It has two electric heaters, either of which may be used to heat water to the same final temperature. Heater **1** is used during the day and heater **2** is used during the night. A simplified diagram is shown below.



(a) Explain why heater **1** does not heat all of the water in the tank. [2]

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(b) (i) Explain why foam is used to cover the hot water tank to reduce heat loss. [2]

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(ii) State how the shiny outer surface of the foam reduces heat loss. [2]

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(c) Explain how the foam covering benefits the environment. [2]

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(d) The following table gives information about heating water by either of the two heaters.

	Electric heater **1**	Electric heater **2**
Volume of water that is heated by the heater (litres)	40	120
Time to heat this volume of water (hours)	0.5	3
Power (kW)	4	2
Cost per unit (p)	16	5

A householder has to decide which heater (**1** or **2**) to use. She will need to use 30 litres of hot water.
Use data from the table and equations from page 2 to compare the two methods of heating in terms of: [6 QWC]

- the number of units used to heat the water;
- the cost of electricity used;
- the impact on the environment;
- advice that should be given to the householder.

Assume the water in the tank is initially cold.

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