GCSE

4781/03-A

SCIENCE B
UNIT 1: Space, Energy and Life

P.M. FRIDAY, 6 June 2014

Resource folder (Pre-Release Article)

For use with:

Section B of the foundation tier

Section A of the higher tier

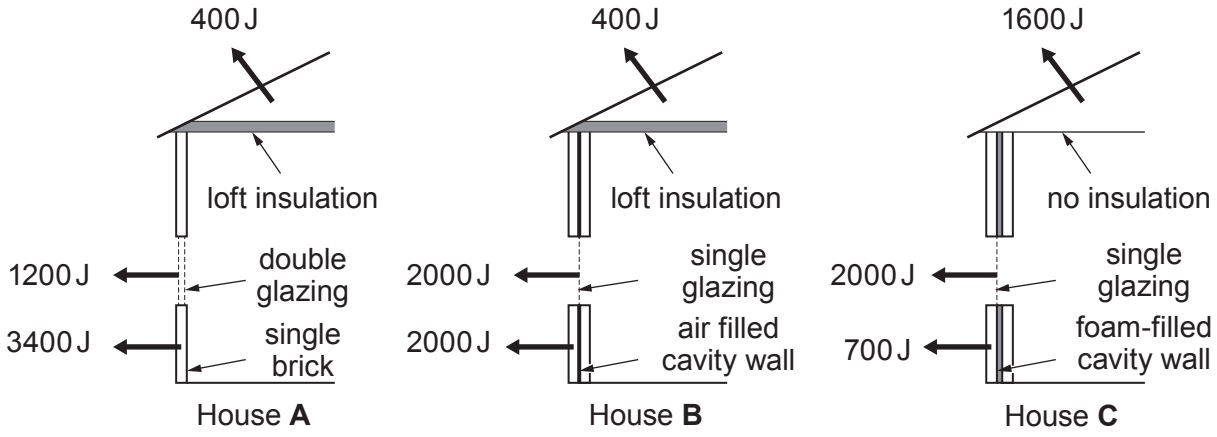
4781
03A001

Pre-Release Article - Home Insulation

Diagram 1 shows three houses of identical size. None of the houses are fully insulated.

Diagram 1 also shows how much heat is lost per second from the windows, walls and roof of each house when there is a temperature difference of 20 °C between the inside and the outside.

Diagram 1



The cost of each type of insulation is shown in **Table 1** below.

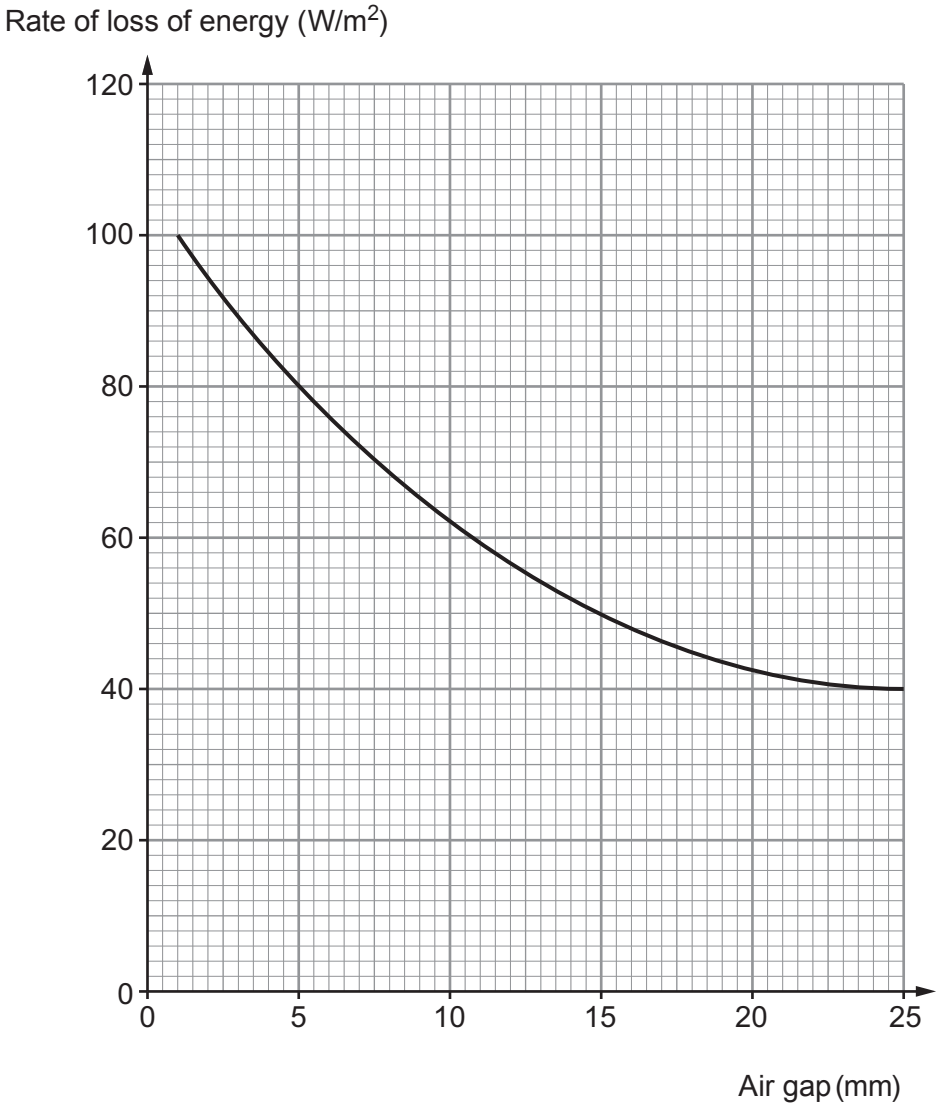
Table 1

Type	Cost (£)
Loft	250
Double-glazing	4 000
Cavity wall insulation	1 200

Double glazing

The graph shows the results of an investigation to see how the rate of loss of energy through a double glazed window is affected by the width of the air gap between the two panes of glass. The investigation used a window of area 1 m^2 and kept a temperature difference of 20 °C between the inside and the outside.

Graph 1

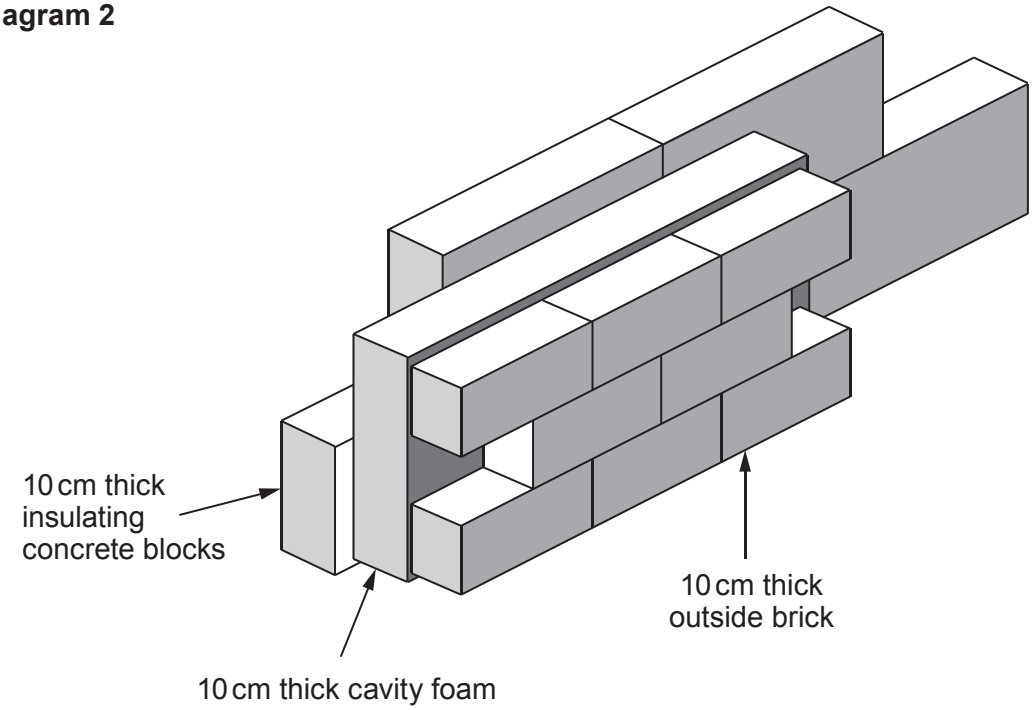


Turn over.

Cavity walls

Diagram 2 shows how a house wall is built. Its cavity is totally filled with foam.

Diagram 2



The insulating effectiveness of a material is given by a quantity called its R value.

R value is a measure of thermal resistance. The higher the R value of any material, the better its ability to resist the transmission of heat.

The R values for some common materials are shown in **Table 2** below.
R values add together to give the total R value.

Table 2

Material	R value (Units)
A standard brick of thickness 10 cm	0.32
10 cm cavity wall insulating foam	3.60
10 cm thick insulating concrete block	2.08

Loft insulation

A **U value** tells us how much energy passes through a material per second.
It tells us the energy per second per square metre for a 1 °C temperature difference between the inside and the outside.

A U value of 1.61 means that 1.61 Joules of energy per second are transferred through 1 square metre of the material if the temperature difference between inside and outside is 1 °C.

U values are calculated using:

$$U = \frac{1}{R}$$

Modern regulations require that the heat loss through a roof should be limited so the U value is no more than 0.16 $W/m^2\,°C$.

Table 3 shows how the U value varies with different thicknesses for two materials, **A** and **B**.

Table 3

Insulation Thickness	U value for **A** $W/m^2\,°C$	U value for **B** $W/m^2\,°C$
100 mm	0.30	0.20
120 mm	0.26	0.19
140 mm	0.23	0.17
160 mm	0.20	0.15
180 mm	0.18	0.14
200 mm	0.16	0.13

Making the most of our energy

The heat loss per second depends on the temperature difference between the inside and outside of the house.

To keep a house at a constant temperature, the energy losses must be balanced by energy produced by the heating system.

Electricity is convenient because it can be used in many ways including providing heating.

Power can be found using the equation:

$$\text{Power} = \frac{\text{energy}}{\text{time}}$$

The cost of electrical heating can be found using the equations:

Units used = power (kW) x time (h)

Total cost = cost of one unit x units used

Examiner only

Answer **all** *questions in the spaces provided.*

Use the information in the separate Resource Folder to answer the following questions.

1. *(a)* Use the information in **Diagram 1** and **Table 1** to answer the following questions.

(i) Arrange the houses **A, B** and **C** in order of amount of energy loss starting with the house that loses least energy. [2]

House ..... House ..... House .....

Loses least energy ⟶ Loses most energy

(ii) Compare the cost effectiveness of loft insulation, double-glazing and cavity wall insulation. [6 QWC]

In your answer you should compare:

- the energy saved by each type of insulation
- the value for money of each type of insulation.

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Examiner only

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(b) Refer to the information about **double-glazing** and **Graph 1** to answer the following questions.

(i) I. Describe how the rate of loss of energy is related to the size of the air gap. [1]

.....

.....

.....

II. Give **one** reason why makers of double-glazing are unlikely to use an air gap larger than 20 mm. [1]

.....

.....

(ii) A house has a window area of 24 m^2. The air gap used in the windows is 15 mm. There is a 20 °C temperature difference between the inside and outside of the house.

Calculate the rate of loss of energy through the windows of the house. [2]

Rate of loss of energy = ... W

Turn over.

Examiner only

(c) Refer to the information about **cavity walls** and **Table 2** to answer the following questions.

(i) I. Which of the materials used in the wall will be most effective at reducing heat loss? ..... [1]

II. Give **one** reason for your answer. [1]

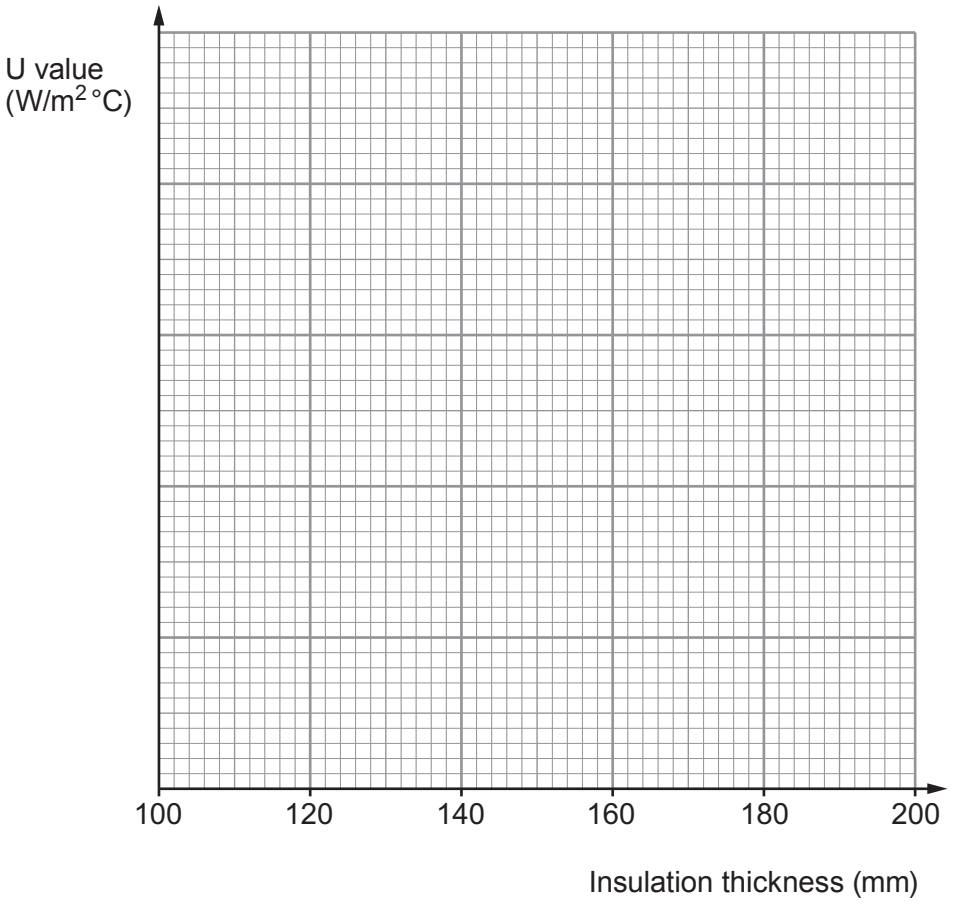
.....

(ii) Calculate the **total** R value for the wall. [1]

R value = ... W

(d) Refer to the information about **loft insulation** and **Table 3** to answer the following questions.

(i) Plot a graph of U value against insulation thickness for insulator **B**. [4]



Examiner only

(ii) Use your graph to find the thickness of insulator **B** that needs to be used to achieve a U value of 0.16 W/m^2 °C. [1]

Thickness = ... mm

(e) A heating system uses 2000 W of electrical power to keep a house at constant temperature.

Calculate the cost of using the heating for 24 h. Include the **unit** in your answer. [4]
One unit of electricity costs 14p.

Cost = ...

END OF PAPER

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GCSE MARKING SCHEME

SCIENCE B

SUMMER 2014

Question	Marking detail	Mark
1 (a) (i)	C-B-A All correct 2; 1 correct 1	2
(ii)	Indicative content: • The loft saves 1200 J/s and double-glazing saves 800 J/s. • The cavity wall insulation saves 1000 J/s • The loft insulation is also the cheapest to install. • Therefore installing loft insulation would save the householder most money and the payback time would be shortest. • However, double-glazing saves least energy and costs significantly more than other methods so the payback time would be the longest. **5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3-4 marks** The candidate constructs an account correctly linking some relevant points such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.	6

Question			Marking detail	Mark
(b)	(i)	I.	The larger the air gaps the lower the (rate of) energy loss.	1
		II.	(After 20mm), not much increase in saving	1
	(ii)		Reading from graph of 50 (W/m^2) (1) 50 x 24 (1) = 1 200 W (correct answer only - 1 200 W (2))	2
(c)	(i)	I.	Foam insulation	1
		II.	Largest R value	1
	(ii)		Total R value = 6	1
(d)	(i)		Scale (at least half y axis) (1) plots (2) suitable best fit line (1)	4
	(ii)		Value from their graph (e.g. 148 +/-2) (1)	1
(e)			Convert 2000 W to 2 KW (1) units used = 2 x 24 = 48 (1) cost = 48 (allow ecf) x 14 = 672 (1) matching unit (1) (either 672p or £6.72). (NOT £6.72p)	4