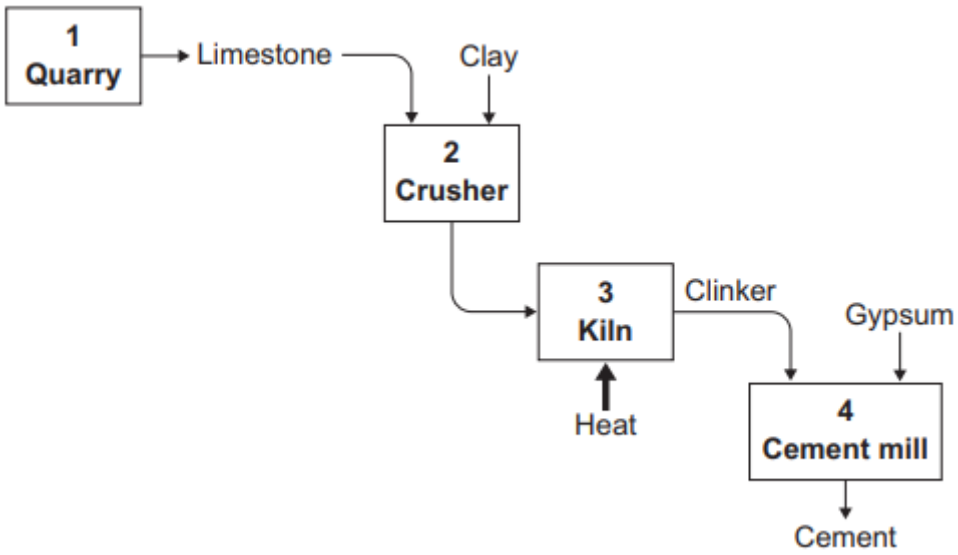
CERAMICS, COMPOSITES & CORROSION 1

Q1. Limestone, clay and gypsum are natural substances that can be quarried. The flow chart shows how they are used to make cement.



Match statements, A, B, C and D, with the numbers 1– 4 on the flow chart.

A It is where thermal decomposition takes place.

B It is where only natural substances are mixed.

C It is where a natural substance is mixed with a man-made substance.

D It is where limestone is obtained.

(4 marks)

Q2. Concrete is made when cement, sand, gravel and water are mixed together. The strength of concrete depends on how much cement is used in the mixture. Large buildings should be made of strong concrete. It is important that the concrete used for buildings has the correct strength. In an experiment, different concrete mixtures were made up and allowed to set in a mould. The amount of cement added was varied, but the mix of sand, gravel and water was kept constant. The size of the mould was also kept the same. The results of a series of tests are shown in the table.

		Strength in Newtons				
Concrete sample	**Percentage (%) of cement**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Average**
1	5	100	110	105	105	105
2	10	120	130	125	125	125
3	15	160	160	120	160	160
4	20	180	180	180	165	
5	25	170	165	175	170	170
6	30	150	145	145	140	145

(a) Which row in the table below is correct?

	The percentage (%) of cement is . . .	**The pattern in the results is best shown using a . . .**
1	an independent categoric variable	line graph
2	a dependent continuous variable	bar chart
3	an independent continuous variable	line graph
4	a dependent categoric variable	bar chart

(1 mark)

(b) The average result for Concrete sample 4 is . . .

1 165 N.

2 176 N.

3 177 N.

4 180 N.

(1 mark)

(c) What is the best conclusion that can be made from the results in the table?

1 The strength of the concrete is directly proportioned to the percentage of cement.

2 The percentage of cement affects the strength of the concrete.

3 The concrete could be made stronger if steel rods were used for reinforcement.

4 Earthquakes cause weak buildings to fall down.

(1 mark)

(d) What is the best way to improve the reliability of the results of this experiment?

1 Use a range of sizes of moulds and take an average of all the results.

2 Repeat the series of tests with different mixes of sand and gravel.

3 Repeat the same tests and compare the results.

4 Use equipment that can measure strength more accurately.

(1 mark)

Q3. Glass is made by heating limestone with silicon dioxide at 1700 °C. Sodium carbonate and potassium carbonate are also added.

(a) Limestone contains calcium carbonate. The reaction between calcium carbonate and silicon dioxide produces calcium silicate. The equation for this reaction is:

$$CaCO_3 + SiO_2 \rightarrow X + CO_2$$

X represents the formula for calcium silicate.

The equation will be balanced if the formula for calcium silicate is . . .

1 $CaSiO_2$

2 $CaSi_2O$

3 $CaSiO_3$

4 Ca_2SiO_2

(1 mark)

(b) Glass sheets are produced by pouring hot liquid glass onto molten tin. The glass floats on top of the molten tin and is allowed to cool. The viscosity of the hot liquid glass needs to be just right when poured onto the molten tin.

The viscosity of hot liquid glass depends partly on its temperature. The viscosity also depends on the composition of the glass.

The table shows how the lowest pouring temperature depends on the amounts of sodium and potassium in the glass.

Sodium percentage (%)	Potassium percentage (%)	Lowest pouring temperature in °C
0	20	450
4	16	400
10	10	390
16	4	395
18	2	410
20	0	440

The manufacturer wants to use the lowest pouring temperature for the glass. In what range of sodium content should further work be done to determine the lowest pouring temperature?

1 0% to 10%

2 4% to 16%

3 10% to 18%

4 16% to 20%

(1 mark)

(c) Listed below are four possible reasons why the manufacturer wants to use the lowest pouring temperature.

Reason K – It uses less energy

Reason L – It reduces the loss of glass by evaporation

Reason M – It makes the process cheaper

Reason N – It increases carbon emissions

Which of these are the most likely reasons for using the lowest pouring temperature?

1 Reasons K and L

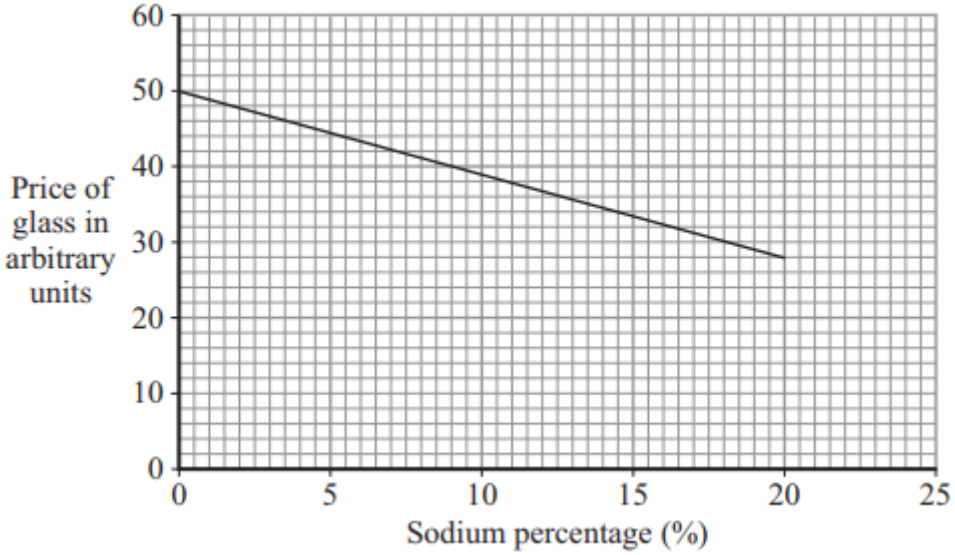
2 Reasons K and M

3 Reasons L and N

4 Reasons M and N

(1 mark)

(d) The graph shows how the price of glass depends on the sodium percentage (%).



Use the information from the table on page 24 and the graph above. What will be the effects of increasing the sodium percentage in the glass from 10 % to 20 %?

1 to decrease the price of the glass and decrease the pouring temperature

2 to decrease the price of the glass and increase the pouring temperature

3 to increase the price of the glass and decrease the pouring temperature

4 to increase the price of the glass and increase the pouring temperature

(1 mark)

Q4. A man is going to make a concrete base for his garage. He does an investigation to find out the ratio of sand to cement that will produce the strongest concrete:

- He makes several mixtures, changing the ratio of sand to cement.
- He measures the sand and cement quantities using a trowel.
- He makes a block of concrete with the same amount of each of the different mixtures.
- He makes the blocks exactly the same size.
- He drops a metal ball, from a measured height, onto each of the concrete blocks.
- He observes the concrete to see if it breaks.

The man starts by dropping the metal ball from a height of 10 cm onto one of the blocks. He gradually increases the height until the block breaks. He records this height. He repeats this process with each of the concrete blocks.

The results are shown in the table below.

Trowels of sand	Trowels of cement	Height in cm
8	1	18
7	1	24
6	1	30
5	1	36
4	1	37
3	1	41
2	1	45

(a) The independent variable in this test is the . . .

1 size of the concrete blocks.

2 ratio of sand to cement.

3 type of metal ball dropped.

4 height from which the metal ball is dropped.

(1 mark)

(b) The man is not confident that the height readings of 36 cm and 37 cm are correct. What should he do?

1 repeat all the measurements using a heavier metal ball

2 repeat the measurement for the 5:1 ratio of sand to cement

3 repeat the measurement for the 4:1 ratio of sand to cement

4 repeat the measurements for the 5:1 and 4:1 ratios of sand to cement

(1 mark)

(c) The results in the table show a pattern.

The pattern is that . . .

1 as the ratio of sand to cement decreases, the strength of the concrete increases.

2 as the quantity of sand increases, the strength of the concrete increases.

3 as the quantity of sand decreases, the concrete breaks at a lower height.

4 the strength of the concrete is directly proportional to the quantity of sand added.

(1 mark)

(d) How could the man obtain results that are more reliable?

1 use different types of cement

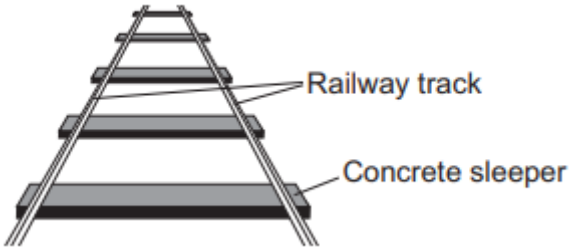
2 weigh out the sand with a balance

3 repeat the test for all mixtures and calculate the mean

4 add stones to some of the concrete mixtures

(1 mark)

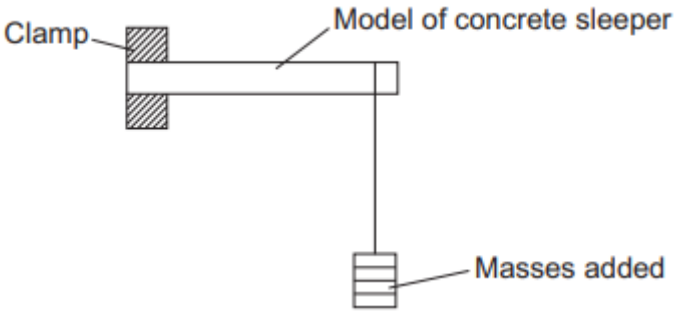
Q5. In the UK, railway sleepers are often made from concrete.



A scientist was asked to find the best concrete mixture to use so that railway sleepers would not break easily.

The scientist made:

- a mould to make small models of concrete sleepers
- concrete mixtures using crushed rock, sand, cement and water
- the equipment shown to add 0.1 kg masses until the model sleeper broke.



The scientist's results are shown in the table.

Concrete mixture in % by volume			Total mass added to break the model sleeper in kg			
Cement	Sand	Crushed rock	Test 1	Test 2	Test 3	Mean
10	70	20	1.1	1.3	1.2	1.2
20	60	20	2.6	2.5	2.4	
30	50	20	3.3	3.3	3.3	3.3
40	40	20	3.8	4.0	3.3	3.9
50	30	20	4.5	4.2	4.3	4.3

(a)(i) Calculate the mean total mass added to break the model sleeper that has 20 cement by volume.

_____

Mean = ... kg

(1 mark)

(ii) Choose one result in the table that the scientist should check and test again.

Result: % cement by volume ..... Test number .....

Explain why you chose this result.

_____

_____

(2 marks)

(iii) What is the relationship between the total mass to break the model sleeper and the percentage (%) of cement by volume in the concrete mixture?

_____

(1 mark)

(iv) Suggest one other variable that the scientist should have recorded in the table of results.

_____

(1 mark)

(b) The scientist thought that full-size railway sleepers should be made from 30 % cement, 50 % sand and 20 % crushed rock. What other information about these three materials is needed before the scientist recommends using this mixture to make a full-size railway sleeper?

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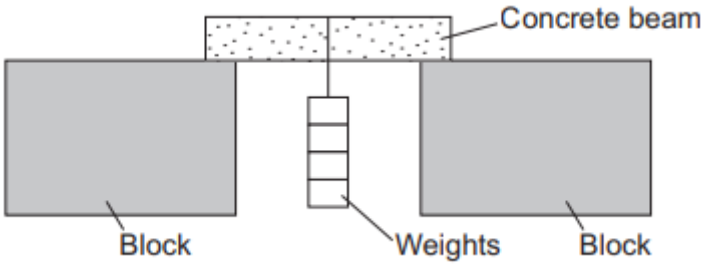
_____

(2 marks)

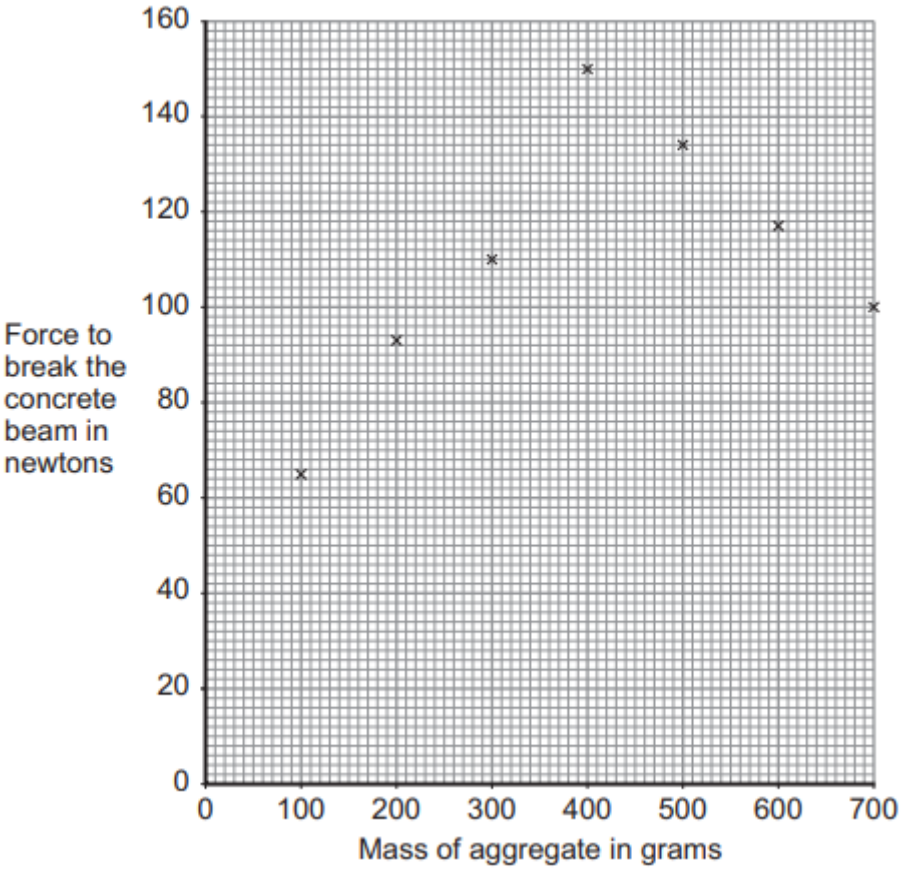
Q6. Cement is made from limestone and clay. Concrete is made by mixing cement with water, sand and aggregate (small pieces of rock). A group of students did an investigation on the amount of aggregate needed to make the strongest concrete beam.

The students used this method:

- use the same mass of cement and the same mass of sand but change the mass of aggregate to make seven different concrete mixtures
- use the different concrete mixtures to make beams of the same size
- add weights, as shown in the figure, until the concrete beam breaks.



The students' results are plotted on the graph in the figure.



(i) One of the points is anomalous. Complete the graph in Figure 3 by drawing two straight lines of best fit.

(2 marks)

(ii) Describe one way the students could improve the method so that their results are more accurate for each graph point.

_____

_____

_____

_____

(2 marks)

(iii) What force is needed to break a concrete beam containing no aggregate? Show your working on the graph.

Force = ... newtons

(2 marks)

(iv) One of the students concluded that:

'The force needed to break a concrete beam increases as the mass of aggregate increases.'

The student's conclusion is not completely correct. Use values from the graph to explain why.

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_____

_____

_____

_____

(3 marks)

Total marks (32)