Q1. The chemical compositions of two samples of *hard water,* **A** and **B**, are shown in the table.

	Sample A	**Sample B**
pH	9	8
Ions present:	**Concentration in mg/litre**	
Ca^{2+} **Mg^{2+}** **Na^{+}**	101 2 9	135 9 6
HCO_3^- **Cl^-** **SO_4^{2-}** **NO_3^-**	299 14 5 6	6 8 136 0

(a) What does the pH value tell you about these samples?

.....

(2)

(b) Use the information in the table to explain what is meant by *hard water.*

.....

.....

(1)

(c) What would be the effect of using **temporarily** hard water in a kettle?

.....

.....

.....

.....

(2)

(d) (i) Explain which sample of water is **permanently** hard.

.....

.....

.....

.....

(3)

(ii) How could this hardness be removed?

.....

.....

(1)

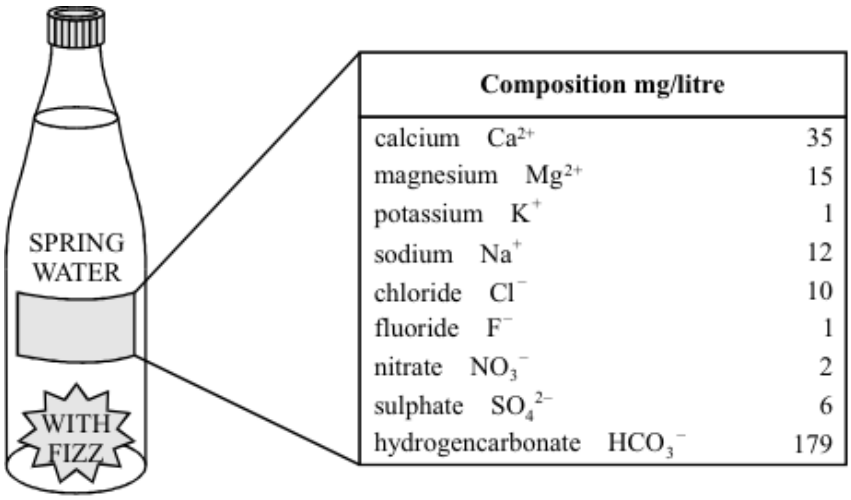
(e) State **one** advantage of drinking hard water.

.....

.....

(1)
(Total 10 marks)

Q2. The label shows the ions present in the bottle of spring water. This water is *temporarily* hard.



Composition mg/litre	
calcium Ca^{2+}	35
magnesium Mg^{2+}	15
potassium K^{+}	1
sodium Na^{+}	12
chloride Cl^{-}	10
fluoride F^{-}	1
nitrate NO_3^{-}	2
sulphate SO_4^{2-}	6
hydrogencarbonate HCO_3^{-}	179

(a) Name the compound that would be present in the greatest amount if this water were evaporated to dryness.

.....

(2)

(b) (i) What is hard water?

.....

.....

(2)

(ii) State one advantage of hard water.

.....

(1)

(c) Describe an experiment that would show that this water is *temporarily* hard.

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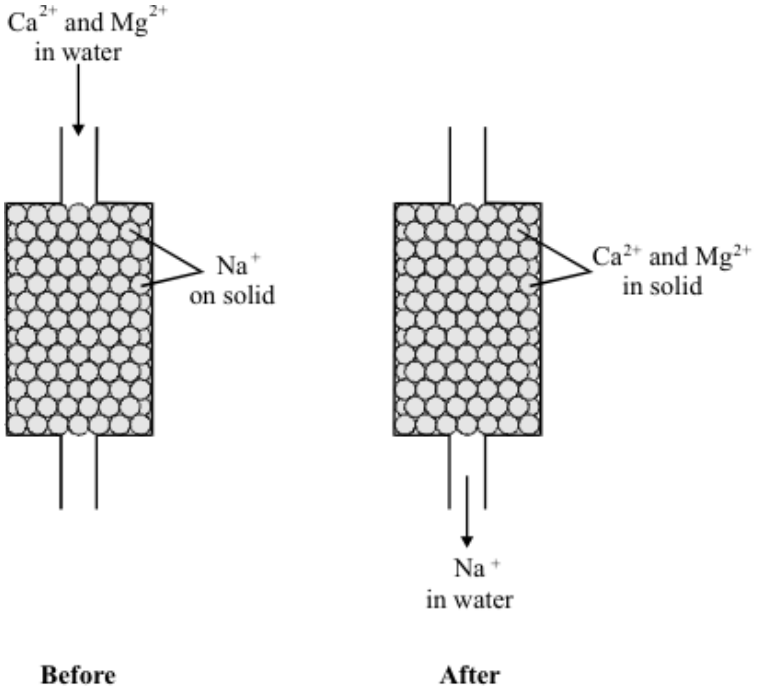
(4)

(d) This hard water may be softened as shown.



What name is given to this process?

.....

(1)

(Total 10 marks)

Q3. This information has been taken from two bottles of Australian spring water.

Ridgway Spring Water comes from a natural source deep under the Central Highlands of Victoria.

TYPICAL ANALYSIS
(mg per litre)

hydrogencarbonate	158
chloride	33
sodium	33
calcium	30
magnesium	23
potassium	9

Homeland Spring Water originates from a high mountainous source in the Central Highlands of Victoria..

TYPICAL ANALYSIS
(mg per litre)

hydrogencarbonate	158
chloride	27
sodium	24
magnesium	15
calcium	12
potassium	5

(a) The labels show the names of the ions present in Ridgway and Homeland spring waters.

Describe how these ions got into the water.

.....

.....

.....

.....

(2)

(b) Both Ridgway and Homeland spring waters are hard.

(i) There are two ions shown on the labels which make these spring waters hard.

Name **one** of these ions.

.....

(1)

(ii) Ridgway spring water is about **twice** as hard as Homeland spring water.

Use the information on the labels to explain why.

.....

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(2)

(iii) Describe how you could use soap solution to show that Ridgway spring water is about **twice** as hard as Homeland spring water. You should state how the experiment is made fair.

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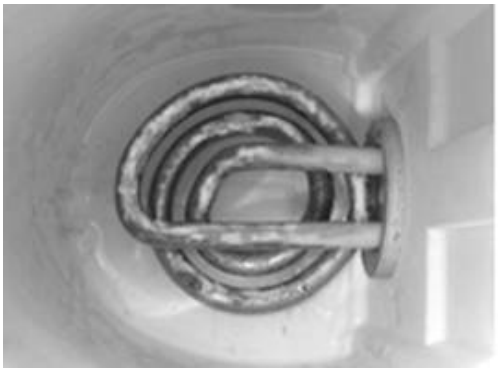
(3)
(Total 8 marks)

Q4. Two problems of hard water are *scale* and *scum*, as shown in the pictures of a heating element and a wash basin.



(a) Explain the difference between *scale* and *scum*

.....

.....

.....

.....

(2)

(b) Explain how hard water can be made soft using an ion-exchange column.

.....

.....

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.....

.....

(2)
(Total 4 marks)

Q5. In some parts of the world the water is hard, but in other parts the water is soft.

(i) Name an ion that causes water to be hard.

.....

(1)

(ii) Describe how these ions get into the water.

.....

.....

.....

.....

(2)

(iii) Sodium carbonate makes hard water soft.

Explain how.

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(2)
(Total 5 marks)

Q6. Water is a natural resource. Drinking water in some parts of the UK is soft, but in other parts drinking water is hard. Calcium ions in water cause water to be hard.

There are two types of hard water, permanent hard water and temporary hard water.

- Permanent hard water can be caused by calcium sulfate ($CaSO_4$) dissolved in the water
- Temporary hard water can be caused by calcium hydrogencarbonate ($Ca(HCO_3)_2$) dissolved in the water

(a) Temporary hard water causes the formation of scale on heating elements.

Photograph © Steve Gorton / Getty Images

(i) Explain how scale forms on heating elements.

.....

.....

.....

.....

(2)

(ii) Suggest why scale on heating elements causes problems.

.....

.....

(1)

(b) Permanent hard water can be softened.

(i) Explain how adding sodium carbonate (Na_2CO_3) softens permanent hard water.

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.....

(2)

(ii) Explain how a water filter containing carbon, silver and ion exchange resin softens permanent hard water.

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(2)
(Total 7 marks)

Q7. The table gives some information about the composition of three samples of water from wells in the Canary Islands, Crete and Cyprus.

	Mineral content of water in mg per litre		
Ions	**Canary Islands**	**Crete**	**Cyprus**
Calcium, Ca^{2+}	28	82	18
Magnesium, Mg^{2+}	14	41	13
Sodium, Na^{+}	53	7	22
Chloride, Cl^{-}	7	143	39
Hydrogencarbonate, HCO_3^{-}	281	5	93
Sulfate, SO_4^{2-}	2	14	16

(a) Describe and explain how ions get into these samples of water.

.....

.....

.....

.....

(2)

(b) The sample of water from Crete is harder than the other two.

Use the information in the table to explain why.

.....

.....

(1)

(c) People who use hard water can expect higher costs than people who use soft water.

Explain why.

.....

.....

.....

.....

(2)

(d) Hard water can be made soft by removing the ions that cause hardness.

State **one** way these ions can be removed.

.....

.....

(1)

(Total 6 marks)

Q8. Read the following information and then answer the questions.

Chlorine – for better, for worse?

Chlorine is used to make bleaches, plastics and medicines. Swimming pool water is often treated with chlorine.

Chlorine is used to make water safe to drink. It is relatively cheap and easy to use. People who drink untreated water risk dying from typhoid and cholera.

However, chlorine is a poisonous chemical. It causes breathing difficulties and can kill people. Some people are also allergic to chlorine.

(a) How does chlorine make water safe to drink?

.....

.....

(1)

(b) The amount of chlorine in swimming pool water should be carefully monitored and controlled.

Explain why.

.....

.....

.....

.....

(2)

(c) Developing countries are likely to choose chlorination as their method of making water safe to drink.

Suggest why.

.....

.....

.....

(1)

(d) A government is setting up an enquiry into the safety of using chlorine.

(i) Suggest why people from all political parties should be represented.

.....

.....

.....

(1)

(ii) Suggest why the opinion of a well-respected scientist might change the outcome of any discussion.

.....

.....

.....

(1)

(iii) The decision taken about the safety of using chlorine should be based on evidence and data rather than on hearsay and opinion.

Suggest why.

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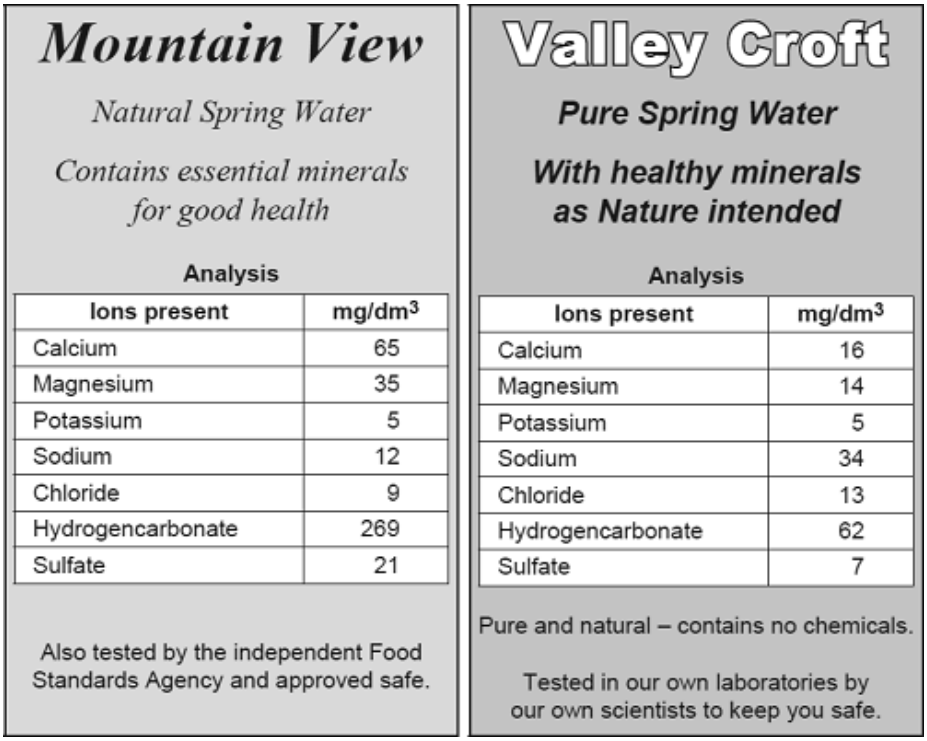
(1)

(Total 7 marks)

Q9. These labels have been taken from two bottles of spring water.



Mountain View

Natural Spring Water

Contains essential minerals for good health

Analysis

Ions present	mg/dm^3
Calcium	65
Magnesium	35
Potassium	5
Sodium	12
Chloride	9
Hydrogencarbonate	269
Sulfate	21

Also tested by the independent Food Standards Agency and approved safe.

Valley Croft

Pure Spring Water

With healthy minerals as Nature intended

Analysis

Ions present	mg/dm^3
Calcium	16
Magnesium	14
Potassium	5
Sodium	34
Chloride	13
Hydrogencarbonate	62
Sulfate	7

Pure and natural – contains no chemicals.

Tested in our own laboratories by our own scientists to keep you safe.

(a) Mountain View and Valley Croft spring waters are hard because they contain calcium and magnesium ions.

(i) Mountain View spring water is about **three** times as hard as Valley Croft spring water.

Use the information on the labels to explain why.

.....

.....

.....

.....

(2)

(ii) Describe how a student could use soap solution to show that Mountain View spring water is about **three** times as hard as Valley Croft spring water.

You should state how the experiment is made fair and give the expected result.

.....

.....

.....

.....

.....

.....

(3)

(b) Why is hard water good for health?

.....

.....

(1)

(c) Give **one** disadvantage of hard water.

.....

(1)

(d) (i) Suggest why people should be concerned about the claim that Valley Croft spring water "contains no chemicals".

.....

.....

.....

(1)

(ii) Suggest why people should be concerned that Valley Croft spring water has only been tested by their own scientists.

.....

.....

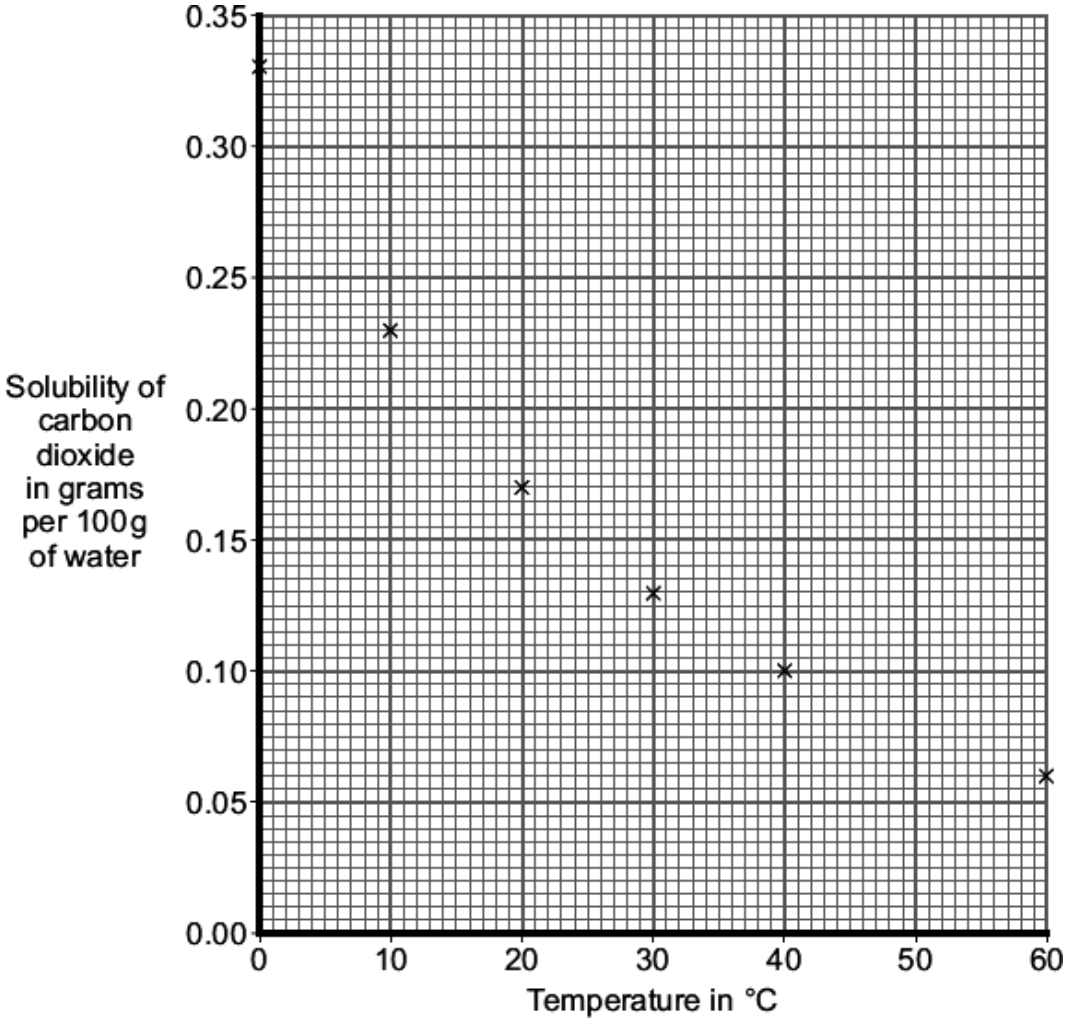
.....

(1)

(Total 9 marks)

Q10. In some parts of the UK, the water is hard.

(a) As rain falls through the air, carbon dioxide dissolves in the water. The graph shows the solubility of carbon dioxide in water at different temperatures.



(i) Complete the graph by drawing a smooth curve through the points.

(1)

(ii) Use the graph to find the mass of carbon dioxide that dissolves in water at 50 °C.

Mass = ... g

(1)

(iii) Calculate the mass of carbon dioxide that bubbles out of 100 g of water when the temperature rises from 20 °C to 60 °C.

.....

.....

Mass = ... g

(2)

(b) Hard water contains dissolved calcium compounds.
Carbon dioxide dissolved in water reacts with calcium carbonate in limestone.
The product is calcium hydrogencarbonate which dissolves in water.

$$CaCO_3(s) + H_2O(l) + CO_2(g) \rightleftharpoons Ca(HCO_3)_2(aq)$$

When this hard water is heated, an insoluble scale is produced.
Use the chemical equation to explain how this happens.

.....

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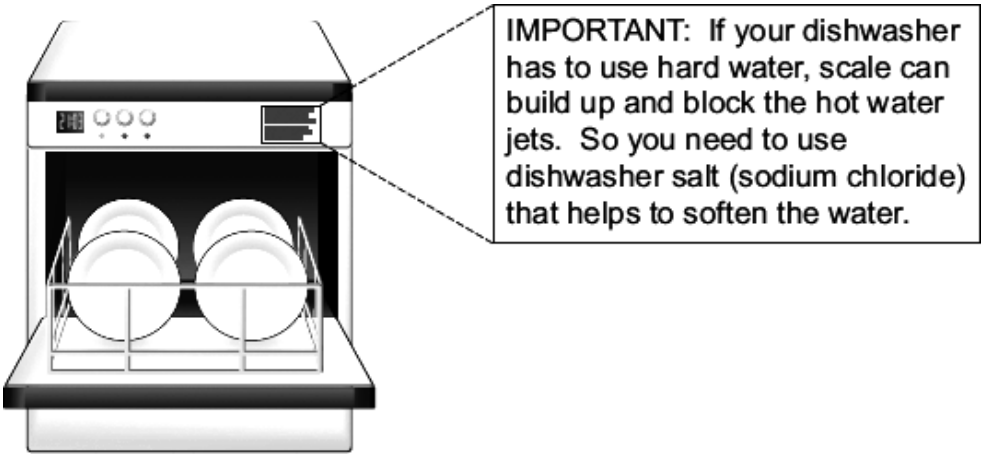
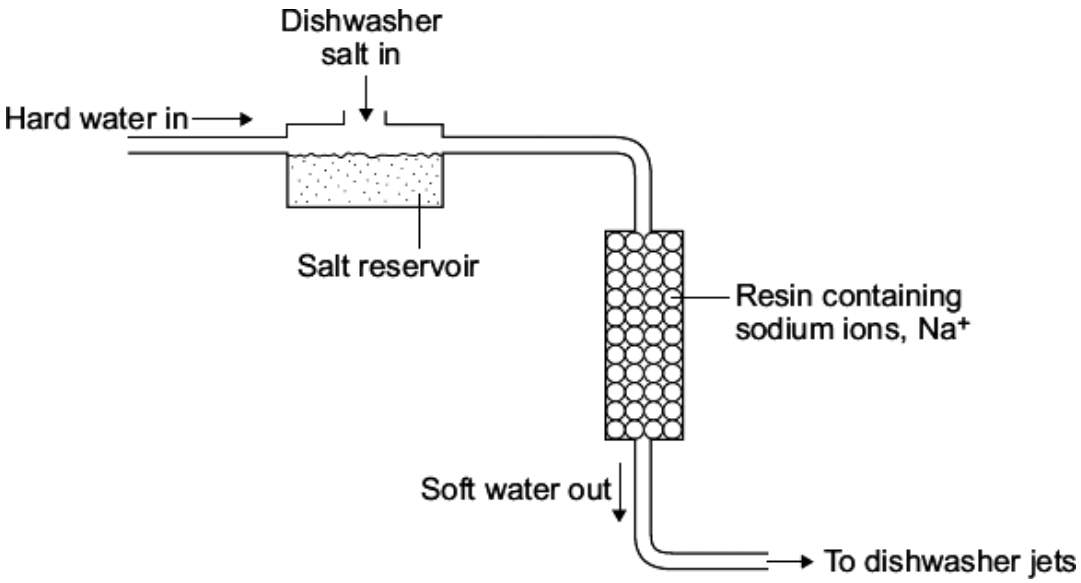
.....

(2)

(c) This label was on a dishwasher.



This dishwasher has a built-in water softener.



Use the information and your knowledge and understanding to explain how sodium chloride helps to soften the water in this dishwasher.

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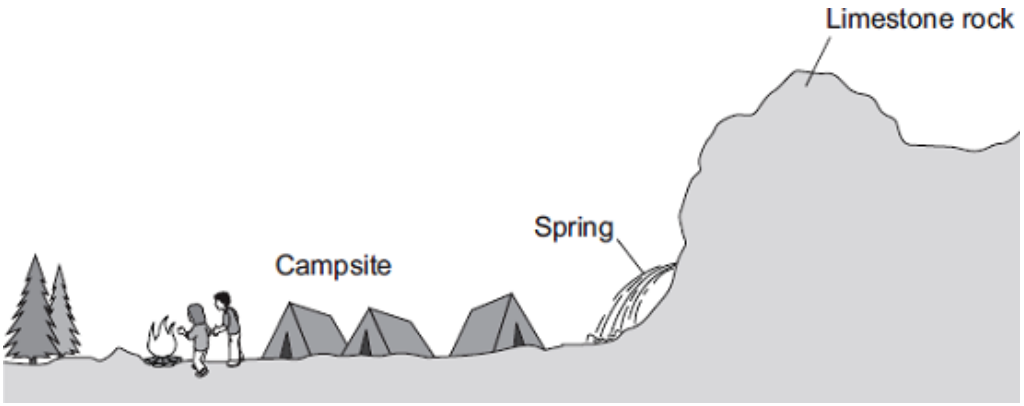
(4)
(Total 10 marks)

Q11. This question is about hard water.



(a) A campsite has a spring, where water flows out of limestone rock.

(i) The water from the spring is hard because it contains calcium ions.

How do the calcium ions get into the spring water?

.....

.....

(1)

(ii) A student at the campsite boils some of the spring water in a pan. The inside of the pan becomes coated with a white solid.

What is the white solid?

.....

(1)

(iii) When the student uses soap to wash in the spring water, scum forms.
Scum is **not** formed if the spring water has been boiled and allowed to cool.

Draw a ring around the correct answer to complete the sentence.

The hardness in the spring water is

acidic.
permanent
temporary.

(1)

(b) In a laboratory, a student compared the hardness of three different samples of water.

The student measured 20 cm^3 of water into a boiling tube.

The student then:

- added a drop of soap solution
- shook the boiling tube for 10 seconds
- looked to see if a permanent lather had formed.

The student repeated the procedure until a permanent lather formed.

The results are shown in the table.

Water sample	**Number of drops of soap solution needed to form a permanent lather**			
	Test 1	**Test 2**	**Test 3**	**Mean**
Spring water	13	11	6	
Tap water	7	5	6	6
Distilled water	1	1	1	1

(i) Calculate the correct mean for spring water.

.....

Mean = ... drops

(2)

(ii) Which of the three sources of water was hardest?

Draw a ring round the correct answer.

distilled water **spring water** **tap water**

Use the results in the table to give a reason for your answer.

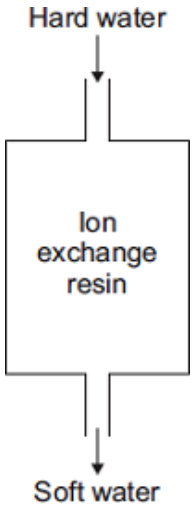
.....

.....

.....

(2)

(c) Ion exchange columns are used to soften hard water.



(i) Draw a ring around the correct answer to complete each sentence.

The ion exchange column softens water by

dissolving
evaporating
removing

calcium ions.

Calcium ions in the water exchange with

chloride
magnesium
sodium

ions in the column.

(2)

(ii) After a few weeks sodium chloride solution needs to be passed through the ion exchange column.

Suggest why.

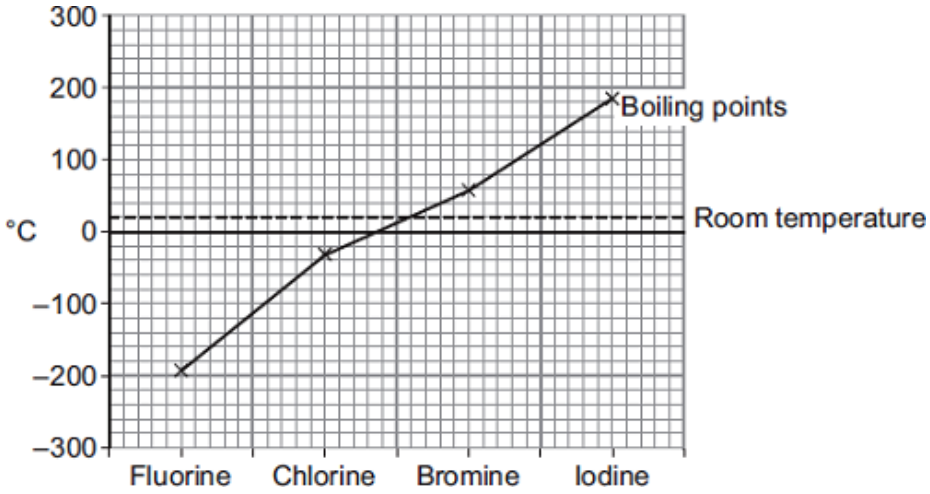
.....

.....

(1)

(Total 10 marks)

Q12. The graph shows the boiling points of the halogens.



(a) Use the graph to help you answer these questions.

(i) Use the correct answer from the box to complete the sentence.

gas	liquid	solid

At room temperature chlorine is a ..... .

(1)

(ii) Describe the trend in boiling point from fluorine to iodine.

.....

.....

(1)

(b) Chlorine reacts with metals to produce metal chlorides.

(i) When a chlorine atom forms a chloride ion it gains one electron.

What is the charge on a chloride ion?

.....

(1)

(ii) Write a word equation for the reaction between sodium and chlorine.

.....

(1)

(c) In the UK water companies add chlorine to tap water.

Why is chlorine added to tap water?

.....

(1)

(d) Water companies add fluoride to tap water in some parts of the UK.

Fluoride is added to improve dental health.

Suggest **one** reason why some people are against adding fluoride to tap water.

.....

.....

.....

(1)
(Total 6 marks)