

## Questions

Q1.

The isotopes of magnesium,  ${}^{24}_{12}\text{Mg}$  and  ${}^{25}_{12}\text{Mg}$ , both form ions with charge 2+. Which of the following statements about these ions is true?

- A Both ions have electronic configuration  $1s^2 2s^2 2p^6 3s^2$ .
- B  ${}^{25}_{12}\text{Mg}^{2+}$  has more protons than  ${}^{24}_{12}\text{Mg}^{2+}$ .
- C The ions have the same number of electrons but different numbers of neutrons.
- D The ions have the same number of neutrons but different numbers of protons.

(Total for question = 1 mark)

Q2.

An isotope of an element, atomic number  $z$ , has mass number  $2z + 4$ . How many neutrons are in the nucleus of the element?

- A  $z + 4$
- B  $z + 2$
- C  $z$
- D 4

(Total for question = 1 mark)

Q3.

(a) Define the term **relative isotopic mass**.

(2)

.....

.....

.....

.....

(b) Naturally occurring chlorine contains 75.53% of  ${}^{35}\text{Cl}$  and 24.47% of  ${}^{37}\text{Cl}$ .

(i) Calculate the relative atomic mass of chlorine to **four** significant figures.

(2)

(ii) Two of the peaks in the mass spectrum of chlorine,  $\text{Cl}_2$ , are at  $m/e$  70 and 74. Identify the species giving rise to these peaks.

(2)

70

.....

74

.....

(iii) What is the  $m/e$  value of the other peak that you would expect to see in this region of the mass spectrum and the identity of the species giving rise to it?

(2)

Value

.....

Species

.....

**(Total for question = 8 marks)**

Q4.

Chlorine has two isotopes with relative isotopic mass 35 and 37. Four  $m/z$  values are given below. Which will occur in a mass spectrum of chlorine gas,  $\text{Cl}_2$ , from an ion with a single positive charge?

**A** 35.5

**B** 36

**C** 71

**D** 72

**(Total for question = 1 mark)**

Q5.

Which of the following ions would undergo the greatest deflection in a mass spectrometer?

- A**  $^{35}\text{Cl}^{2+}$
- B**  $^{35}\text{Cl}^+$
- C**  $^{37}\text{Cl}^+$
- D**  $^{35}\text{Cl}^{37}\text{Cl}^+$

**(Total for question = 1 mark)**

Q6.

The relative atomic mass of an element is determined using a mass spectrometer.

(a) Define the term **relative atomic mass**.

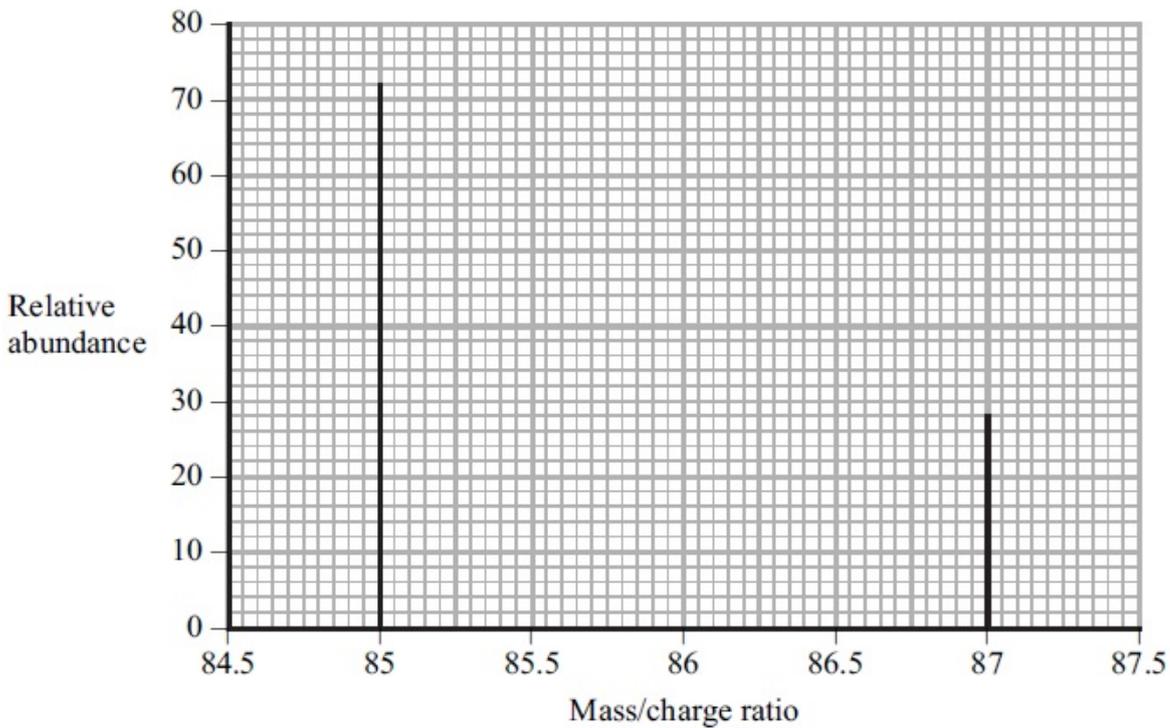
(2)

.....

.....

.....

(b) The mass spectrum of rubidium is shown below.



(i) The mass spectrum of rubidium is shown below.

(1)

.....

.....

(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

(2)

**(Total for question = 5 marks)**

Q7. The relative atomic mass is defined as

- A** the mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.
- B** the mass of an atom of an element relative to the mass of a hydrogen atom.
- C** the average mass of an element relative to 1/12 the mass of a carbon atom.
- D** the average mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.

**(Total for question = 1 mark)**

Q8. The radioactive isotope iodine-131,  $^{131}_{53}\text{I}$ , is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope,  $^{127}_{53}\text{I}$ .

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}\text{I}$	$^{127}_{53}\text{I}$
Number of protons		
Number of neutrons		

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

.....

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

.....  
(d) Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

.....  
.....  
.....  
.....

**(Total for Question = 5 marks)**

Q1. No Examiner's Report available for this question

Q2. No Examiner's Report available for this question

Q3.

**(a)**

A significant number of candidates gave the definition of relative atomic mass instead of relative isotopic mass. Both of these concepts are included in Section 1.5 a of the specification.

**SECTION B**

**Answer ALL the questions. Write your answers in the spaces provided.**

**21 (a) Define the term relative isotopic mass.**

(2)

The weighted average of all the masses of the isotopes of an element relative to  $1/12$  of carbon-12 atom.

**Results Plus: Examiner Comments**

The first mark was not awarded as the plural (i.e. isotopes) has been used and confusion is



### Results Plus: Examiner Comments

This response scores the first mark only. The second mark has not been given as the final answer has been incorrectly rounded.

### Results Plus: Examiner Tip

Make sure you understand how to round up answers to the required number of significant figures!

#### (b)(ii)

Few candidates scored both marks for this question. Many knew the formulae of the species involved, but omitted the + charge on each ion.

(ii) Two of the peaks in the mass spectrum of chlorine,  $\text{Cl}_2$ , are at  $m/e$  70 and 74.  
Identify the species giving rise to these peaks.

(2)

70  $(^{35}\text{Cl } ^{35}\text{Cl})$

74  $(^{37}\text{Cl } ^{37}\text{Cl})$

### Results Plus: Examiner Comments

This response scored one mark as the '+' charge has been omitted from both of the ions.

### Results Plus: Examiner Tip

Remember that positive ions are formed in the mass spectrometer.

#### (b)(iii)

The majority of candidates scored both marks for this question.

(iii) What is the  $m/e$  value of the other peak that you would expect to see in this region of the mass spectrum and the identity of the species giving rise to it?

(2)

Value  $72$

Species  $^{37}\text{Cl} - ^{35}\text{Cl}$  *Charge 37 with chlorine 35 or vice versa*

### Results Plus: Examiner Comments

Both marks were awarded. The missing + charge on the ion was ignored here as any such omission was penalised in (b)(ii) earlier.

### Results Plus: Examiner Tip

Remember that both atoms and molecules can form ions in a mass spectrometer!

Q4. No Examiner's Report available for this question

Q5. No Examiner's Report available for this question

Q6.

**(a)**

Most candidates picked up at least one out of the two available marks. Common omissions included a lack of reference to the word "average" or "mean" for the first mark or "carbon-12" for the second mark.

15 The relative atomic mass of an element is determined using a mass spectrometer.

(a) Define the term **relative atomic mass**.

(2)  
Relative atomic mass is the mass of an atom of an element relative to the mass of  $\frac{1}{12}$  of the atom of carbon 12.

### Results Plus: Examiner Comments

First mark is NOT awarded as no mention of average/mean. Second mark awarded as mention of carbon-12.

### Results Plus: Examiner Tip

Learn all your definitions - thoroughly!

**(b) (i)**

A large majority of candidates understood that two peaks in the mass spectrum related to the fact that rubidium has two isotopes. Sometimes the word "isomers" appeared instead of "isotopes".

(i) Explain why there are two peaks in the spectrum.

Because there are two isomers with different weight<sup>(1)</sup> causing 2 peaks of detection

(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

### Results Plus: Examiner Comments

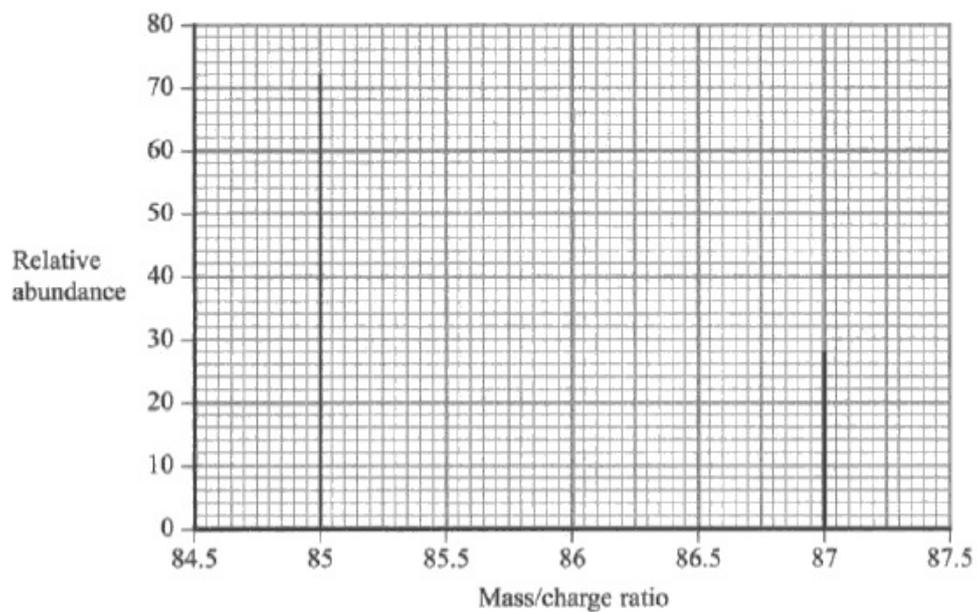
This response scores (0) as the word "isomer" has been used by mistake instead of "isotope".

### Results Plus: Examiner Tip

Don't muddle up key scientific words which are similar (e.g. "isomer" with "isotope").

### (b) (ii)

Most candidates calculated the relative atomic mass correctly as either 85.56 or 85.6. A small number of candidates mis-read the relative abundances from the graph and used relative abundances which did not add up to 100%. A small number of answers gave working which showed that candidates had taken the arithmetic mean of 85 and 87 to get an answer of 86.



(i) Explain why there are two peaks in the spectrum.

(1)

*because there are two isotopes of the element.*

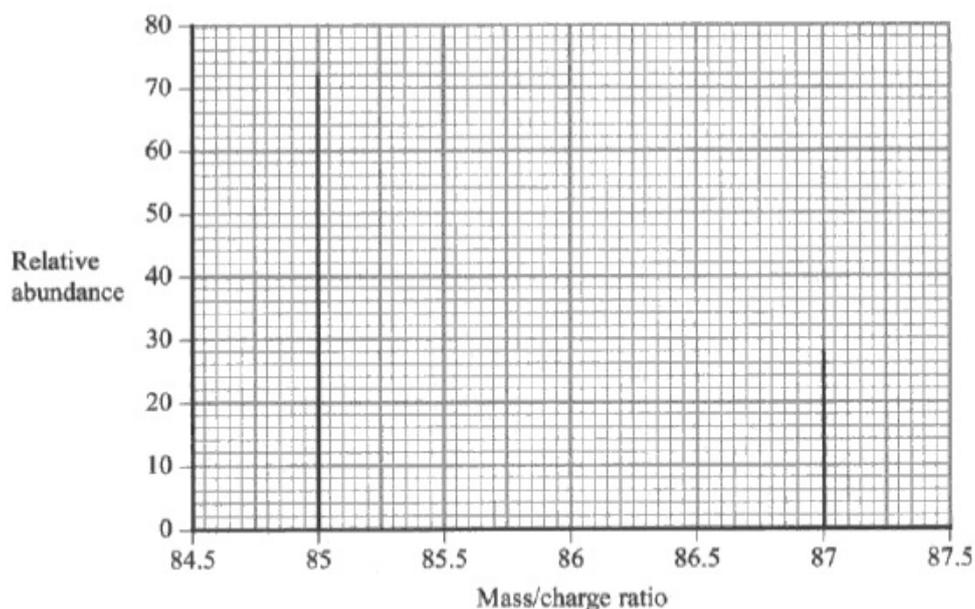
(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

(2)

$$\frac{85 + 87}{2} = \underline{86}$$

### Results Plus: Examiner Comments

The answer of 86 is incorrect. The "simple" arithmetic mean of 85 plus 87 has been calculated. So no marks were awarded.



(i) Explain why there are two peaks in the spectrum.

(1)

*Different isotopes*

(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

(2)

$$(85 \times 72) + (87 \times 28) = \frac{8556}{100} = 85.56$$

### Results Plus: Examiner Comments

Both marks were awarded for calculating the relative atomic mass correctly.

Q7. No Examiner's Report available for this question

Q8. **(a)**

Candidates found few problems here. There were one or two problems with writing of the number 4. It is important that fours and nines are easily distinguished.

18 The radioactive isotope iodine-131,  $^{131}_{53}\text{I}$ , is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope,  $^{127}_{53}\text{I}$ .

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}\text{I}$	$^{127}_{53}\text{I}$
Number of protons	53	53
Number of neutrons	25	21

### Results Plus: Examiner Comments

A rare incorrect answer in the second row.  
The numbers of protons are fine.

### Results Plus: Examiner Tip

Make sure you can calculate the numbers of protons and neutrons for different nuclear formulae.

18 The radioactive isotope iodine-131,  $^{131}_{53}\text{I}$ , is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope,  $^{127}_{53}\text{I}$ .

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}\text{I}$	$^{127}_{53}\text{I}$
Number of protons	131	127
Number of neutrons	78	74

### Results Plus: Examiner Comments

The numbers of protons has been confused with the number of nucleons.

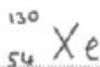
The subtraction to find the number of neutrons has been carried out correctly.

(b)

This proved more challenging but many successfully applied their knowledge of equations to work out the correct product. The most common error was to give iodine as a product not realising that with an extra proton the element changed.

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)



### Results Plus: Examiner Comments

This is an unfortunate error. The candidate has the correct element and proton number but has forgotten the mass number remains the same at 131.

### Results Plus: Examiner Tip

Remember that mass is conserved, unless measurement is made to a large number of decimal places.

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

Iodine-130

### Results Plus: Examiner Comments

The correct name and isotopic mass would have been acceptable, but this is the wrong element with the wrong mass.

### Results Plus: Examiner Tip

Applying skills in equation balancing to unfamiliar equations is vital, make sure you master the skill.

(c)

A soluble non-toxic iodide salt was needed. The vast majority gave potassium iodide, the actual chemical that was used in Japan after the tsunami damage to a nuclear power station.

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

AgI Silver iodide.

### Results Plus: Examiner Comments

Silver iodide is inappropriate as it is insoluble.

### Results Plus: Examiner Tip

Learn the solubilities of ionic salts.

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

*CaI*

### Results Plus: Examiner Comments

Calcium iodide would be acceptable but this is not the correct formula.

### Results Plus: Examiner Tip

Learn how to write formulae of simple ionic compounds.

(d)

There were many good answers here with a sensible country related to a good scientific justification, usually risk of earthquake or tsunami, though other reasonable suggestions were accepted. High population density was often given which was insufficient.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

*Japan. Since earthquakes occur and nuclear radiation may be released to the environment and cause damage when destruction of the plant that generate nuclear power occurs (nuclear power station)*

### Results Plus: Examiner Comments

This was the most popular correct choice of country but the justification is insufficient.

### Results Plus: Examiner Tip

It is worth noticing news items that relate to Chemistry and Science.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

In a heavily populated urban area. Despite it being able to power the city if the radioactive waste is not dealt with properly it could lead to ~~radio~~ radiation poisoning to the surrounding people. In addition if something goes wrong, like chernobyl, the resulting meltdown could lead to massive loss of life.

### Results Plus: Examiner Comments

This answer does not answer the question as it does not identify the country. In addition the justification, while plausible, was deemed insufficient.

### Results Plus: Examiner Tip

Always check to see that the question asked has been answered.

## Mark Scheme

Q1.

Question Number	Correct Answer	Reject	Mark
	C		1

Q2.

Question Number	Correct Answer	Mark
	A	<b>1</b>

Q3.

Question Number	Acceptable Answers	Reject	Mark
<b>(a)</b>	<p><b>First mark:</b> Mass of <b>an atom</b>/mass of <b>an isotope</b> (of an element) <b>(1)</b></p> <p>IGNORE any references to average or (weighted) mean</p> <p><b>Second mark:</b> relative to 1/12<sup>th</sup> the mass of a <sup>12</sup>C atom <b>(1)</b></p> <p>NOTE: The second mark is awarded for <b>any mention of <sup>12</sup>C</b></p> <p>IGNORE throughout the candidate's answer any references to 'moles' or '1 mol' or '12 g'</p> <p>Mark the two points independently</p>	<p>Mass of (all the) isotopes<u>s</u> /atoms<u>s</u></p> <p>'Mass of an element'</p>	<b>2</b>



Question Number	Acceptable Answers	Reject	Mark
<b>(b)(iii)</b>	<p><b>72</b> <b>(1)</b></p> <p><math>^{35}\text{Cl} - ^{37}\text{Cl}^{(+)}</math> <b>(1)</b></p> <p>ALLOW  <math>(^{35}\text{Cl} + ^{37}\text{Cl})^{(+)}</math> and/or  <math>(^{37}\text{Cl} + ^{35}\text{Cl})^{(+)}</math>  OR  <math>(^{37}\text{Cl}^{35}\text{Cl})^{(+)}</math> and/or <math>(^{37}\text{Cl}^{35}\text{Cl})^{(+)}</math>  OR  <math>(^{35}\text{Cl} \text{ and } ^{37}\text{Cl})^{(+)}</math> and/or  <math>(^{37}\text{Cl} \text{ and } ^{35}\text{Cl})^{(+)}</math></p> <p>NOTE:  The + charge is not needed on <b>this ion</b></p> <p>IGNORE extra + charges, so ALLOW  <math>^{35}\text{Cl}^+ ^{37}\text{Cl}^+</math> and/or <math>^{37}\text{Cl}^+ ^{35}\text{Cl}^+</math></p>		<b>2</b>

Q4.

Question Number	Correct Answer	Reject	Mark
	D		<b>1</b>

Q5.

Question Number	Correct Answer	Reject	Mark
	A		<b>1</b>

Q6.

Question Number	Acceptable Answers	Reject	Mark
(a)	<p><u>Average/mean mass of an atom/isotopes (1)</u> (1/12 mass of an atom of) carbon-12 (1)</p> <p>First mark: mention of mean or average mass of either an atom/isotopes <i>IGNORE</i> “weighted” before average or mean <i>IGNORE</i> any mention of “moles” in definition</p> <p>Second mark: any mention of carbon-12</p> <p><i>IGNORE</i> any reference to “moles” or “1 mole” at any stage</p> <p><i>IGNORE</i> 12 g with reference to carbon-12</p> <p>Mark the two points independently</p>	<p>“weight” instead of mass</p> <p>mean or average mass of an element... without prior mention of either an atom or isotopes</p>	2

Question Number	Acceptable Answers	Reject	Mark
(b) (i)	<p>(Rubidium/it has) two isotopes</p> <p><i>ALLOW</i> (Rubidium/it has) “different isotopes”</p> <p><i>ALLOW</i> abbreviations such as formulae of rubidium atoms or cations with isotopic masses</p>		1

Question Number	Acceptable Answers	Reject	Mark
(b) (ii)	<p><math>\frac{85 \times 72 + 87 \times 28}{100}</math> (1) = 85.56 or 85.6 (1) Correct answer with no working (2)</p> <p><b>NOTE:</b> Rounding error giving answer 85.5 scores (1)</p> <p><i>IGNORE</i> any units (for example, g/g mol<sup>-1</sup>/%)</p> <p><b>NOTE:</b> If 71% abundance used for <sup>85</sup>Rb and 29% for <sup>87</sup>Rb, answer = 85.58 or 85.6 scores (1)</p> <p>Second mark awarded if answer CQ correct on wrong abundances and /or wrong isotopic masses.</p>	<p>Calculation of simple arithmetic mean of 85 + 87 = 86 scores zero</p>	2

Question Number	Correct Answer	Reject	Mark
	D		<b>1</b>

Q8.

Question Number	Acceptable Answers	Reject	Mark
<b>(a)</b>	Isotope	$^{131}_{53}\text{I}$ $^{127}_{53}\text{I}$	<b>2</b>
	Number of protons	53                  53	
	Number of neutrons	78                  74	

Question Number	Acceptable Answers	Reject	Mark
<b>(b)</b>	Xenon / Xe / $_{54}\text{Xe}$ / $\text{Xe}_{54}$ / $^{131}_{54}\text{Xe}$	Anything else including: $^{130}\text{Xe}_{54}$ $\text{Xe}^-$ Iodine / I with or without numbers Hydrogen / H with or without numbers Te	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(c)</b>	Potassium iodide / KI  Accept any soluble, non-toxic iodide or iodate  Wrong name, correct formula (0)  Correct name, wrong formula (0)	HI KI <sub>3</sub> Wrong formulae like CaI, MgI Wrong name like calcium iodate BaI <sub>2</sub> (toxic) AgI (insoluble) Potassium iodine	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(d)</b>	<p>Country /ALLOW state <b>and</b> justification Both needed for one mark</p> <p>e.g. Japan / New Zealand / California etc</p> <p>Country / state at risk from Earthquake / tsunami / flooding</p> <p>Further examples:</p> <p>Italy with volcanoes</p> <p>Afghanistan / middle eastern / African countries terrorist / (nuclear) weapon threat / war zone / political instability / abuse of nuclear power.</p> <p>USA /America / Jamaica etc risk of hurricane / tornado</p> <p>California San Andreas fault</p>	<p>...population density</p> <p>...landslide</p> <p>...too hot</p> <p>... surrounded by other countries</p> <p>Antarctica</p>	<b>1</b>