BTEC Level 3 National in Applied Science: Chemistry

First teaching September 2016

Sample Marked Learner Work

External Assessment

Unit 1: Principles and Applications of Science I

In preparation for the first teaching from September 2016 and as a part of the on-going support that we offer to our centres, we have been developing support materials to help you better understand the application of Nationals BTEC Level 3 qualification.

What is Sample Marked Learner Work (SMLW)?

The following learner work has been prepared as guidance for centres and learners. It can be used as a helpful tool when teaching and preparing for external units.

Each question explores two responses; one good response, followed by a poor response. These responses demonstrate how marks can be both attained and lost.

The SMLW includes examples of real learners' work, accompanied with examiner tips and comments based on the responses of how learners performed.

Below are two boxes and a tips section displaying the format. Each question will show a learner response, followed by comments on the command verbs and the content of the question. Tips may be offered where possible.

The appendix has attached a mark scheme showing all the possible responses that perhaps were not explored in the SMLW, but can still be attained.

The red box comments on the command verbs used in the question. Command typically means; to instruct or order for something to be done. Likewise, in assessments, learners are required to answer questions, with the help of a command verb which gives them a sense of direction when answering a question.

This box highlights the command verb used and comments if the learner has successfully done this, or not.

The green box comments on the content words and phrases. Content makes reference to subject knowledge that originates from the specification. Learners are required to use subject specific knowledge to answer the questions in order to gain maximum marks.

The comments include:

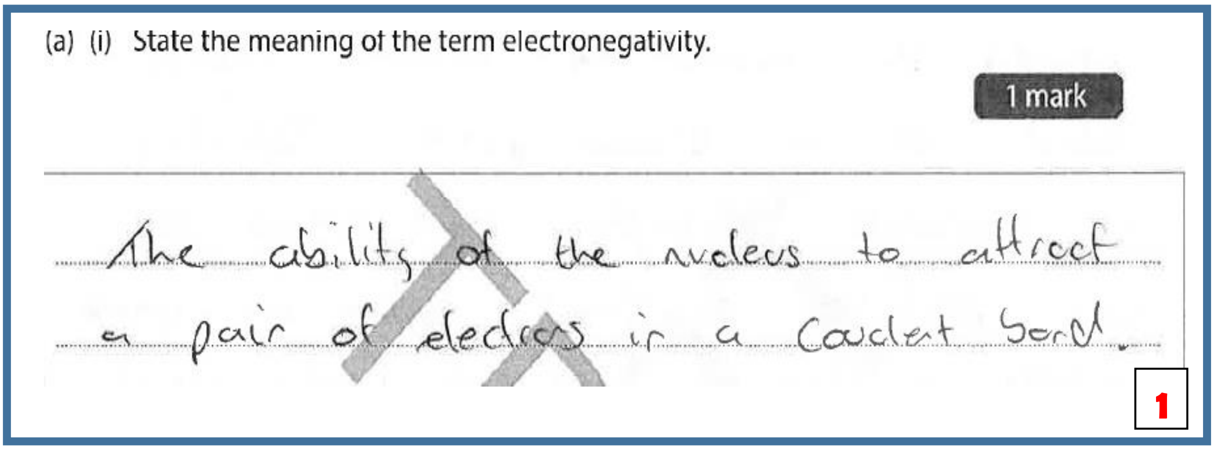
- *Any key words/phrases used in the learner's answer.*
- *Why has the learner gained x amount of marks? And why/how have they not gained any further marks?*
- *Any suggestions/ ideas regarding the structure of the answer.*
- *If the answer meets full marks- why it is a strong answer? What part of the content has been mentioned to gain these marks?*

Tips offer helpful hints that the learner may find useful. For example:

- *Recommended length of the answer*
- *Reference to the amount of marks awarded*
- *General advice for the learner when answering questions*

Question 6a i: State the meaning of the term electronegativity

[Total marks for Q6ai= 1 mark]



(a) (i) State the meaning of the term electronegativity.

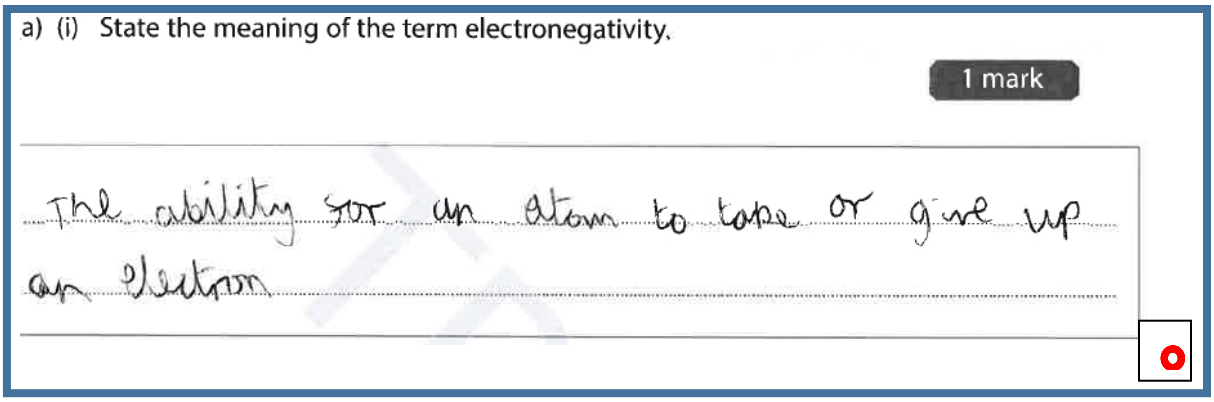
1 mark

The ability of the nucleus to attract a pair of electrons in a covalent bond.

1

Good response: The command phrase is state the meaning of. A simple definition of the term electronegativity is required. Specific words used in the mark scheme are not required as long as the meaning is clear, which it is in this example.

Good response: This question targets A2 Understand the physical properties of elements – electronegativity. Stating that the electronegativity is the ability of the nucleus to attract a pair of electrons in a covalent bond is another way of stating that electronegativity is the ability of an atom in a molecule to attract a bonding pair of electrons and is enough for the mark.



a) (i) State the meaning of the term electronegativity.

1 mark

The ability for an atom to take or give up an electron

0

Poor response: The learner has attempted to describe the trend but has unfortunately confused groups and periods.

Poor response: This learner has confused electronegativity with ionic bonding, discussing transfer of electrons. The mark scheme requires the learner to make reference to a bonding pair of electrons, with some idea of what it is attracted to, so no marks can be awarded here.

TIPS!

- The command verb or phrase should help the learner to understand what is required.
- If the question is worth 1 mark only a brief one sentence definition is needed.

Question 6a ii Describe the trends in electronegativity in the periods and groups of the periodic table *[Total marks for Q6aii= 2 marks]*

ii) Describe the trends in electronegativity in the periods and groups of the periodic table.

2 marks

It increases along the periods and decreases slightly down the groups

2

Good response: The command verb here is 'describe'. The learner is required to look at a graph and describe the trends in the electronegativity. The question does not ask for an explanation, so all that is needed is a simple answer which states that electronegativity increases across a period and decreases down a group.
This learner has used the command verb correctly.

Good response: This question targets A2 Understand the physical properties of elements – electronegativity. The learner has given both marking points in a concise answer so can be awarded both marks. It is obvious that the 'It' referred to in the question means the electronegativity so the marks can be awarded. As a general rule though the use of 'it' should be avoided as in some cases it is ambiguous and learners may lose marks. It is better to always state what they are referring to rather than using the word 'it' in their answers.

(ii) Describe the trends in electronegativity in the periods and groups of the periodic table.

2 marks

Electronegativity decreases as you go down the peroids and increases when you go along the graups

0

Poor response: The learner has understood what she needed to do here but has not gained any marks as she has confused groups and periods.

Poor response: This learner has confused periods and groups thinking that the periods go down the table and the groups across. Consequently no marks can be scored. It is unfortunate that the learner has made this fundamental mistake because they have seen from the graph that electronegativity decreases down the table and increases across, but the incorrect use of the terms periods and groups has lost her the marks.

TIPS!

When a question asks for a description of a trend in a graph or table learners should not waste time trying to explain the trend if this is not asked for in the question.

Question 6a iii: State the three factors that affect the electronegativity of an element. *[Total marks for Q6aiii= 2 marks]*

(iii) State the **three** factors that affect the electronegativity of an element.

3 marks

1 Molecular size

2 Atomic radius ✓

3 Electron shielding ✓

2

DO NOT WRITE IN THIS AREA

Good response: The command verb here is 'state'. This command verb requires just a statement of fact. No explanation or description is required. The learner has understood the command verb and given three simple statements.

Good response: This question targets A2 Understand the physical properties of elements – electronegativity. The learner has stated two of the mark scheme answers in points 2 and 3 and has therefore scored two marks. The first factor is not correct as it would be atomic size and not molecular size that would affect the electronegativity. However in this case atomic size would not score a third mark as it is the same marking point as atomic radius, which has already been awarded a mark. The correct answer that would have scored the 3rd mark is nuclear charge.

iii) State the **three** factors that affect the electronegativity of an element.

3 marks

Whether it is metal / non-metal

How many electrons are in the outer Shell

The Size of the element.

0

Poor response: The learner has stated three facts but unfortunately they are not correct answers to this question.

Poor response: Non-metals are generally more electronegative than metals but the answer is too vague. Electronegativity depends on the number of inner electron shells and not the number of electrons in the outer shell. If the learner had said the size of the atom rather than the size of the element for the 3rd factor they would have scored the first marking point, but again this is too vague an answer so no marks can be awarded here.

TIPS!

- When asked to state 3 factors, answers should be brief and time not wasted giving explanations.
- State normally requires the learner to recall knowledge and if they have revised thoroughly this type of question should be easy.

Question 6b: Explain the two types of intermolecular force that exists in nitrogen (IV) oxide. *[Total marks for Q6b= 4 marks]*

Nitrogen(IV) oxide is a gas which dissolves in water in the atmosphere to form acid rain.

Electronegativity of nitrogen 3.006

Electronegativity of oxygen 3.610

Explain the **two** types of intermolecular force that exist in nitrogen(IV) oxide.

4 marks

1 Nitrogen (IV) oxide is polar as oxygen is more electronegative than nitrogen so it has Permanent dipole - dipole forces.

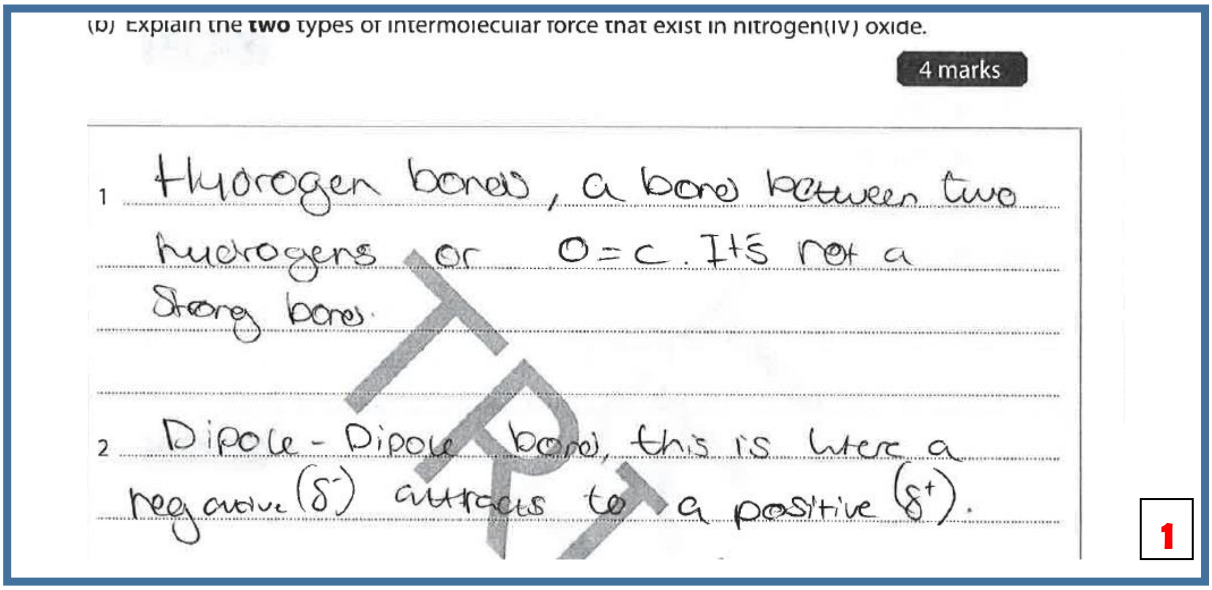
2 It also has induced dipole - dipole forces.

3

Good response: The command verb here is '<u>explain</u>'. This means there must be some justification as to why the nitrogen (IV) oxide has the types of intermolecular forces mentioned. This learner has correctly identified the two types of intermolecular forces present and given a correct explanation for one of them.

Good response: This question targets A1 Structure and bonding – understand intermolecular forces. The learner has stated that nitrogen (IV) oxide is polar as oxygen is more electronegative than nitrogen so it has permanent dipole-dipole forces. They have used the information given in the stem to come to this conclusion and have given a good explanation so have gained 2 marks for this part of the question.

The learner has stated that it also has induced dipole-dipole forces but has given no explanation as to how these occur so only 1 mark can be awarded here. In order to gain all 4 marks they should have explained how one molecule induces a dipole in an adjacent molecule to produce the force.



(b) Explain the **two** types of intermolecular force that exist in nitrogen(IV) oxide.

4 marks

1 Hyorogen bonds, a bond between two hudrogens or O=C. It's not a strong bond.

2 Dipole - Dipole bond, this is where a negative (δ^-) attracts to a positive (δ^+).

1

Poor response: The learner has given two types of intermolecular force, one of which is correct, but there is no explanation as to why there are dipole-dipole forces present.

Poor response: This learner has been awarded 1 mark for the mention of a dipole-dipole bond, which is another way of saying that the bond is polar, which is an acceptable answer on the mark scheme. The learner cannot be awarded an explanation mark here as they have has described what a dipole-dipole bond is but not explained why it is present in nitrogen (IV) oxide or why it leads to permanent dipole-dipole forces.

Hydrogen bonds are not present here, as there is no hydrogen in the molecule of nitrogen (IV) oxide and the description of the hydrogen bond is also incorrect.

TIPS!

- In a question where the learner is asked for two explanations, they need to give 2 examples with a justification for each.
- The information in the stem of the question is usually there to help the learners answer the question. Encourage learners to read this information carefully and underline key facts and data.

Question 7b i: Explain the arrangement of the electrons in the third energy level of silicon. *[Total marks for Q7bi= 3 mark]*

Silicon has four electrons in the third energy level.

(b) (i) Explain the arrangement of the electrons in the third energy level of silicon.

3 marks

Si is $1s^2 2s^2 2p^6 3s^2 3p^2$. The 3rd energy level has 2 electrons in an s orbital and 2 electrons in a p orbital. The s level fills first as it is a lower energy level.

2

Good response: The command word is '<u>explain</u>' which requires justification as to why the electrons are arranged as they are in the 3rd energy level of silicon. The learner has addressed this by giving the electron configuration and explaining the difference in the energy levels of the electrons.

Good response: This question targets A1 Structure and bonding – understand electronic structure of atoms and A2 understand the electronic arrangement of elements using s, p, d notation. The learner has given the full electron configuration of silicon although only the 3rd energy level electrons needed to be present for the first mark. They have given a partial explanation in terms of the difference in energy, which gains the second mark, but in order to gain all 3 marking points they should have explained that the electrons in the p orbital do not pair up and fill the orbitals singly as $3p_x^1$ and $3p_y^1$, so 2 marks awarded.

(b) (i) Explain the arrangement of the electrons in the third energy level of silicon.

3 marks

2 of Silicons outer electrons will be in the s Sub level and 2 of the electrons will be in the p Sub Shell. This is due to Also These electrons will be as far away as they can be from eachother in the shells due to electron pair repulsion

0

Poor response: The learner has attempted an explanation but unfortunately it is incorrect.

Poor response: The learner has used the periodic table at the back of the paper to look up the atomic number of silicon and therefore knows that there are 14 electrons in a silicon atom. The learner has referred to two s and two p electrons which is correct but has not related them to the third energy level. The answer is too vague as the third energy level has not been referred to. In this question it is easier to give the relevant part of the electron configuration rather than trying to explain it in words. The idea of electrons being as far away as they can be from each other implies that the learner is confusing this question with electrons in covalent bonds repelling each other, which is not relevant to this question. No marks can be awarded here.

TIPS!

- In a question about electron configurations the learner should give the relevant configuration or part of the configuration using the s and p notation.
- The learner needs to look at the mark allocation for the question. If it is worth 3 marks, one piece of information and two explanation points are needed to gain full marks.
- The learner should use the periodic table at the back of the paper to look up atomic numbers. These do not have to be remembered.

Question 7b ii: Explain why the first ionisation energy of silicon (789 KJ mol-[1]) is greater than that of germanium (762 KJ mol-[1]).

[Total marks for Q7b ii= 2 marks]

(ii) Explain why the first ionisation energy of silicon (789 kJ mol^{-1}) is greater than that of germanium (762 kJ mol^{-1}).

2 marks

~~Gera~~ Germanium has an extra shell of electrons on it, so the force between the nucleus and outer electrons is less than that of silicon.

2

Good response: The command verb here is '<u>explain</u>'. The data is given in the question and the learner needs to give a linked explanation as to why the ionisation energies are different, which this learner has done.

Good response: This question targets A2 Understand the physical properties of elements – reasons for trends in ionisation energy down Groups. The learner has stated that germanium has an extra shell of electrons on it, which gains the 1st marking point. The learner has also explained this by saying, so the force between the nucleus and the outer electrons is less than that of silicon, which gains the 2nd marking point. Attraction would have been a better word to use than force, but it is clear what the learner means so the word force has been accepted here.
This is a good explanation and both marks can be scored here. It is the reverse argument to what is stated in the mark scheme and this is acceptable as it clearly explains the difference in ionisation energies.

(ii) Explain why the first ionisation energy of silicon (789 kJ mol^{-1}) is greater than that of germanium (762 kJ mol^{-1}).

2 marks

Silicon has less electrons in it's outershell as it has 4 in it's third energy level whereas germanium has 14 electrons in it's outer shell

0

Poor response: The learner has given one piece of information which unfortunately is incorrect and there is no explanation as to why this would make a difference to the ionisation energies, so the command verb has not been addressed.

Poor response: The learner has used the periodic table at the back of the paper to look up the positions of silicon and germanium in order to determine what periods they are in and hence how many shells of electrons each element has.
It is not true that silicon has fewer electrons in the outermost shell as silicon and germanium are in the same group so they both have four electrons in the outer shell. For elements in the same group the ionisation energy differs because of the number of shells not because of the number of electrons in the outer shell. Even if the learner had given a correct statement about the number of shells they would not have gained the second mark as they have not explained why this affects the ionisation energy.

No marks can be scored here.

- Learners must be encouraged to use the Periodic Table provided to help them with questions where data on specific elements is given.
- In a 2 mark explain question such as this a linked explanation needs to be given.

Question 8a: State the name of the force between the calcium and chloride ions. *[Total marks for Q8a= 1 mark]*

8 The production of the ionic compound calcium chloride is an important industrial process.

Calcium chloride has a large range of uses, for example in the pharmaceutical industry and in the food industry.

(a) State the name of the force between the calcium and chloride ions.

1 mark

Electrostatic force

1

Good response: The command phrase is '<u>state the name' of</u> which requires a simple one or two word answer. This learner has stated the correct force.

Good response: This question targets A1 Structure and bonding – Understand ionic bonding: strong electrostatic attraction between oppositely charged ions.
The learner has named the force correctly and has gained the mark. In fact the word electrostatic would have been enough as the word force is given in the question.

(a) State the name of the force between the calcium and chloride ions.

$CaCl_2$

1 mark

intermolecular force

ionic bond

0

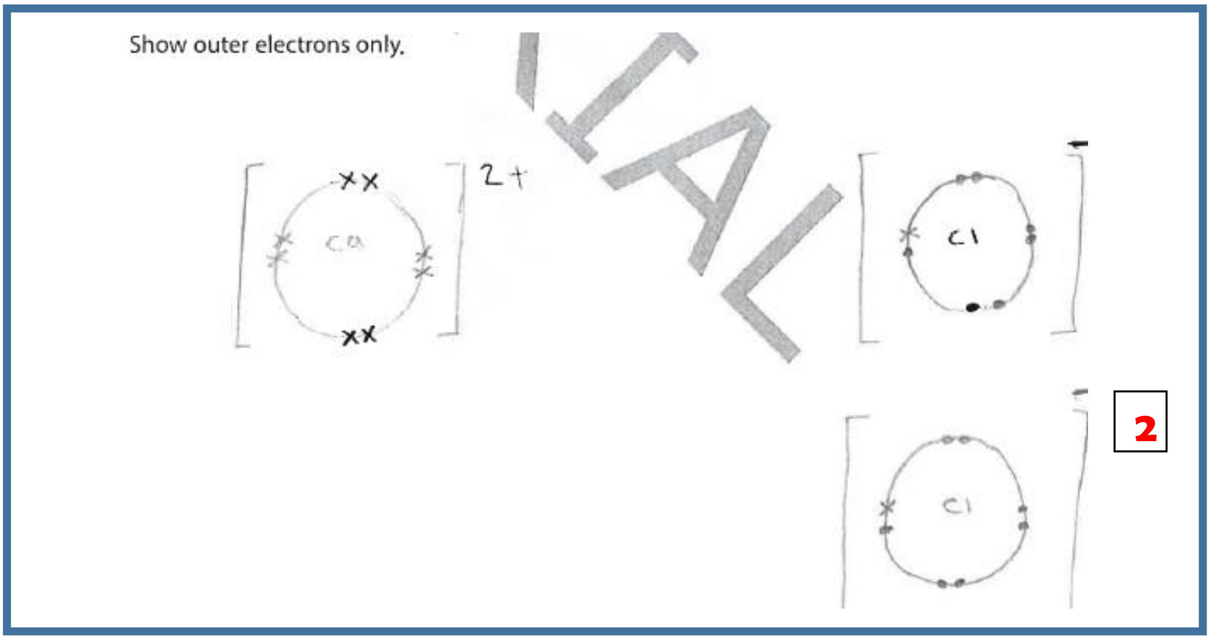
Poor response: The learner has stated the name of two forces when only one is required. Neither answer is correct here so no marks are gained.

Poor response: It is true that there is an ionic bond in calcium chloride, but this is not an acceptable answer here as the question asks for the type of force and the learner must say that it is an electrostatic force to gain the mark. In this case even if the learner had named the force correctly they would still have not gained a mark. This is because they have also written intermolecular force, which is incorrect and therefore would negate any correct answer given.
No marks can be awarded here.

TIPS!

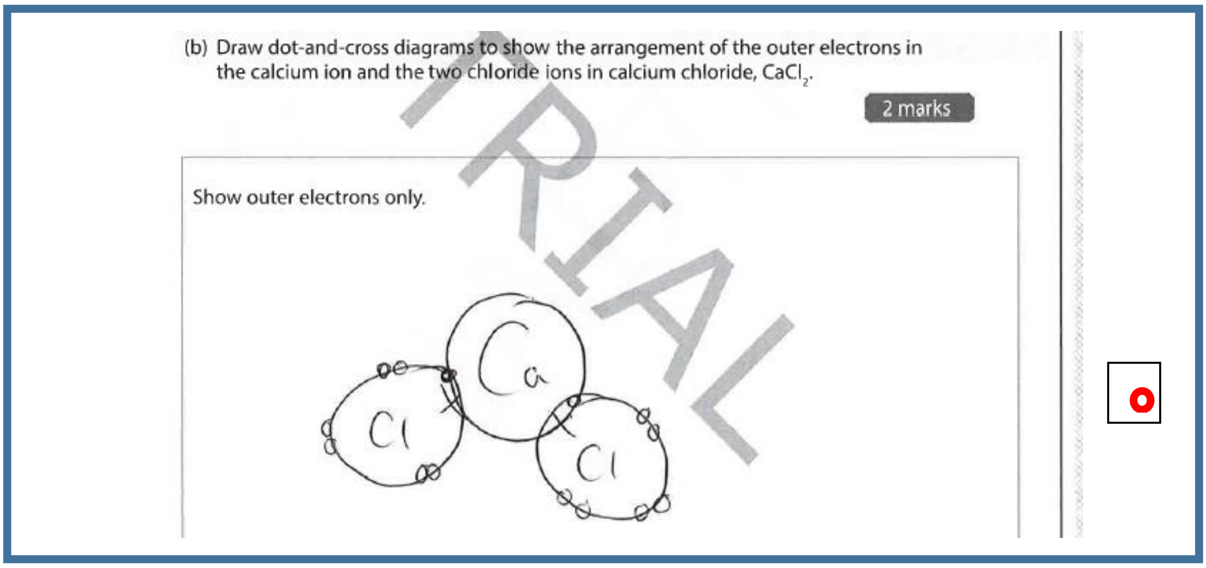
- When a question asks the learner to state the name of something only a simple one or two word answer is required.
- Learners should never give more than one answer in a question like this as a wrong answer could lose them the mark which could have been gained for the correct answer.

Question 8b: Draw-dot-and cross diagrams to show the arrangement of the outer electrons in the calcium ion and the two chloride ions in calcium chloride, $CaCl_2$ *[Total marks for Q8b= 2 marks]*



Good response: The command verb here is 'draw'. The learner has correctly drawn the calcium ion and the two chloride ions that she has been asked to draw.

Good response: This question targets A1 Structure and bonding – Understand ionic bonding: electronic configuration diagrams of cations and anions. The learner has gained both marks here as they have drawn the ions asked for with the correct number of outer shell electrons in each case, which gains the first marking point. The learner has also given the correct charges on the ions for the second marking point.
It is important that learners read the full question. This question asks for outer shell electrons only and this learner has not wasted time drawing the inner shells.



Poor response: The learner has drawn a diagram of what she thinks is the correct structure, but unfortunately she has not read the question carefully enough and has shown a covalently bonded molecule.

Poor response: The learner has used the periodic table at the back of the paper to look up the positions of calcium and chlorine in order to determine the number of electrons on the outer shell of each element and hence the charges on the ions. The learner has not answered the question correctly as it is clear from the wording of the question that calcium chloride is an ionic compound as calcium and chloride ions are referred to. The learner has drawn a structure showing covalent bonding so cannot be awarded any marks.

TIPS!

- When asked to draw a dot-and-cross diagram the learner should read the question carefully as the instructions will help the learner to decide what is needed to gain the marks.
- When the question asks for outer electrons only, the learner should not waste time drawing inner electron shells.
- The learner should use the periodic table at the back of the paper to see which groups the elements are in so that they can work out the charges on the ions.

Question 8c: Calculate the maximum mass of calcium chloride, CaCl2, that can be produced when 500kg of calcium carbonate, CaCO3, reacts with excess dilute hydrochloric acid

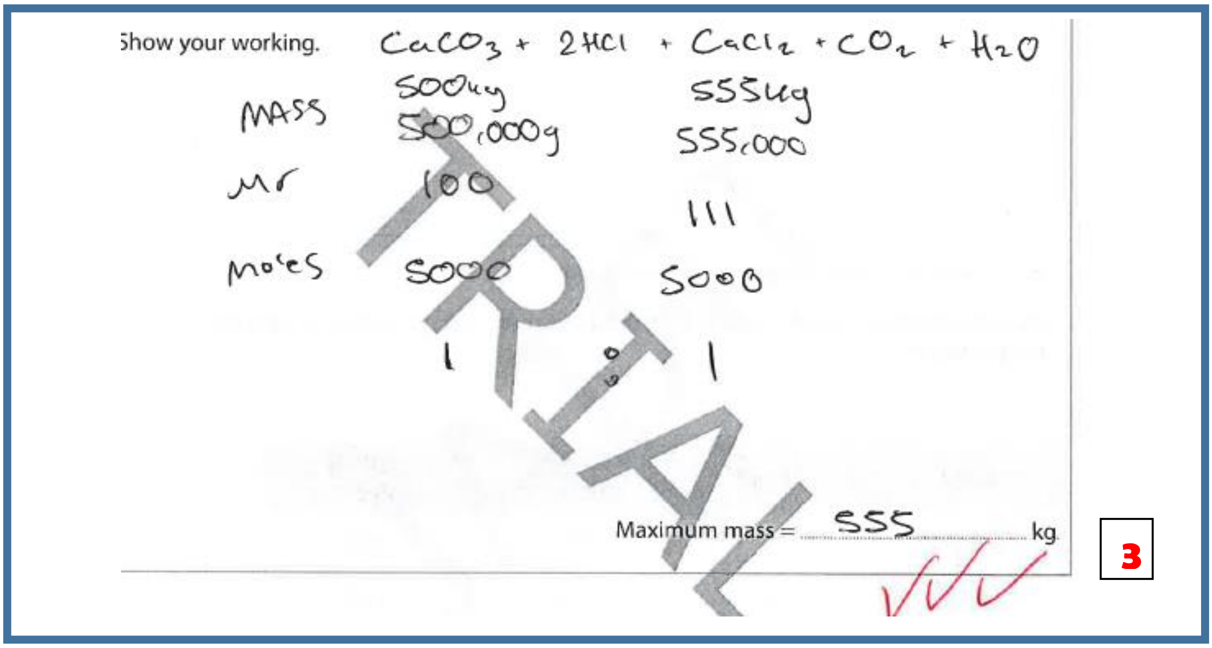
[Total marks for Q8c = 3 marks]

The reaction between calcium carbonate and hydrochloric acid can produce extremely pure calcium chloride, which is suitable for use in the food industry.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

(c) Calculate the maximum mass of calcium chloride, $CaCl_2$, that can be produced when 500 kg of calcium carbonate, $CaCO_3$, reacts with excess dilute hydrochloric acid.

3 marks

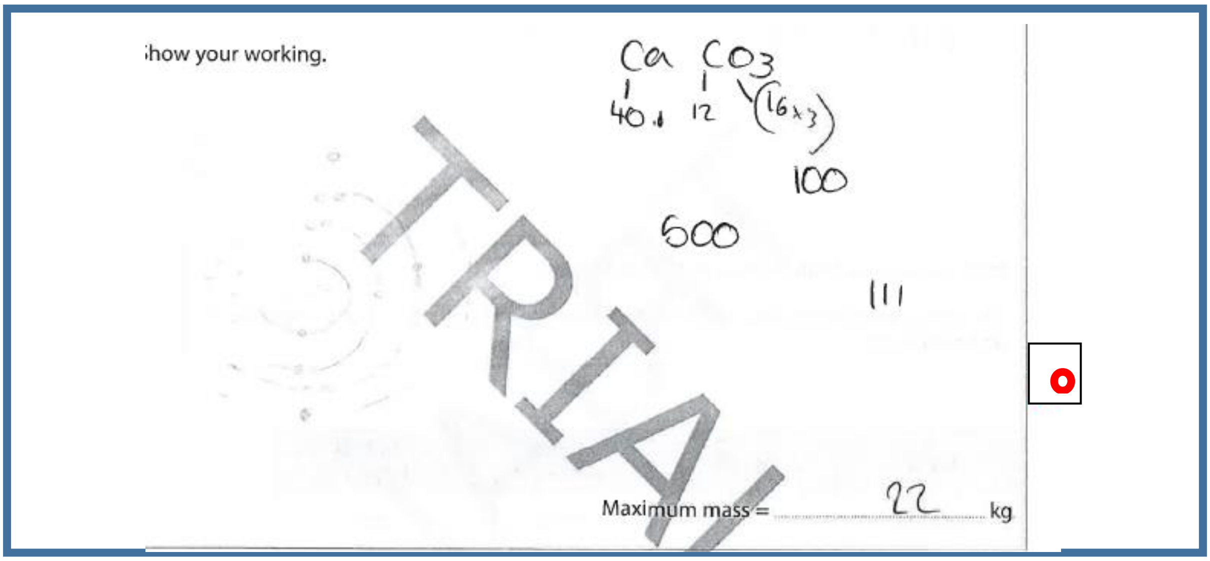

Show your working.

	$CaCO_3$ + 2HCl	→ $CaCl_2$ + CO_2 + H_2O
MASS	500kg 500,000g	555kg 555,000
Mr	100	111
Moles	5000	5000
	1 :	1

Maximum mass = 555 kg

Good response: The command verb here is '<u>calculate</u>'. This requires the learner to use mathematical processes to produce a numerical answer. This learner has calculated the maximum mass correctly.

Good response: This question targets A1 Structure and bonding- Understand the quantities used in chemical reactions: reacting quantities. The learner has used the equation to find the correct 1:1 mole ratio which is the first marking point. They have then looked up the relative atomic masses using the periodic table and hence calculated the Mr values correctly. They have used these values to calculate the correct answer and so both the second and third marking points can be awarded, therefore all 3 marks have been scored. The layout of the answer is a little unusual as it appears to be back to front, but this has not detrimentally affected the answer as the working is clearly shown.
In all calculations it is important that learners show their working as they may gain marks for an early step even if they get the final answer wrong.



Poor response: The learner has made a start at the calculation by finding the Mr of calcium carbonate, but unfortunately this alone is not creditworthy.

Poor response: The learner has found the Mr for calcium carbonate and 111 is also written in the box, which is the Mr of calcium chloride, but there is no indication as to where this number has come from.

The learner has not used the equation to find the mole ratio so cannot score the first marking point. The second marking point is for using the 100, 111 and 500 correctly in a mathematical expression, which they have not done and the third marking point is for the correct answer of 555kg. As the answer is incorrect and how they obtained it is not shown, they cannot have the third marking point, so no marks can be awarded.

- When doing calculations the learners should always show their working, setting the steps out clearly. If an error is made in their working, the error can be carried forward and some marks can still be awarded.
- If an equation for a reaction is given before a calculation question it is likely that the learners will need to use this equation to do the calculation.

Question 9a: Suggest an explanation why young hearts are the best ones to use in transplants. *[Total marks for Q9a = 2 marks]*

(a) Write the balanced equation for the reaction of aluminium in air to form aluminium oxide.

2 marks

$4Al + 3O_2 \rightarrow 2Al_2O_3$

2

Good response: The command verb here is '<u>write'.</u> This is the command verb used when the question is asking the learner to write an equation. The learner has written the balanced equation correctly.

Good response: This question targets A1 Structure and bonding – Understand balanced equations.
The learner has written all the chemical formulae correctly and so has gained the first marking point. They have also balanced the equation correctly giving them the second marking point, so 2 marks have been awarded here.

(a) Write the balanced equation for the reaction of aluminium in air to form aluminium oxide.

2 marks

$2Al + O_2 \rightarrow 2AlO$

0

Poor response: The learner has written a balanced equation, but unfortunately it is incorrect.

Poor response: The learner has used the periodic table at the back of the paper to look up the positions of aluminium and oxygen in order to determine the charges on the ions and hence work out the formula of aluminium oxide.
The learner has given the correct symbol for aluminium and the correct formula for oxygen. The formula of aluminium oxide however is incorrect, so the first marking point cannot be awarded. Even though they have balanced their equation correctly they cannot have the balancing mark because this mark can only be awarded if all the formulae are correct. No marks can be awarded here.

TIPS!

- When writing balanced equations the learner should use the information in the Periodic Table to help work out any formulae needed.
- Learners should make sure when writing formulae that the correct case letters are used and that sub and superscript numbers are used correctly.

Question 9b: State the time period when depolarisation is taking place.

[Total marks for Q9 b-6 marks]

Most metals have high melting and boiling points.

The table shows the melting and boiling points of three metals: sodium, magnesium and potassium.

Metal	Group	Melting points/°C	Boiling points/°C
Sodium	1	97.72	883
Magnesium	2	650	1090
Potassium	1	63.38	759

(b) Discuss the different melting and boiling points of the three metals and the trends they show.

6 marks

Sodium and magnesium are both in Period 3, but the melting and boiling points of magnesium are greater than those of sodium because magnesium has 2 electrons in its outer shell and sodium only has 1. This means there is stronger attraction between the positive nuclei and delocalised electrons in magnesium so more energy is needed to break the metallic bonds. Potassium has lower melting and boiling points than sodium because it is lower down in group 1 so it has more electron shells. This means there is more shielding so less attraction between the nuclei and the delocalised electrons making the metallic bond weaker so less energy is needed to break it.

6

Good response: The command verb here is '<u>discuss</u>'. This requires the learner to study the data given and to provide a reasoned argument as to why the melting and boiling points of the three metals differ.

The learner has given reasoned arguments as to why the melting and boiling points are higher for magnesium and lower for potassium compared to sodium, so she has addressed the command verb correctly.

Good response: This question targets A2 Understand the physical properties of elements – trends in melting point and boiling point.
The learner has clearly explained why magnesium has a higher melting and boiling point than sodium and also why potassium has a lower melting and boiling point than sodium. This answer has addressed both parts of the question and can therefore be awarded all six marks.

(b) Discuss the different melting and boiling points of the three metals and the trends they show.

6 marks

The further down you go in group 1 the melting and boiling point decreases, it is because it is easier to break the bonds. going across the period the melting point increases and so does the boiling point as it is harder to break their bonds.

1

Poor response: The learner has not addressed the command verb here as there is no reasoned argument as to why the melting and boiling points differ and although the idea of bonds being easier or harder to break has been given there is no discussion as to why this affects the melting and boiling points.

Poor response: The learner has analysed and interpreted all pieces of information comprehensively. They have supported their ideas throughout by sustained application of the relevant evidence and they have produced a well-developed discussion that is clear and logical. Most of the indicative content has been addressed.

The learner has addressed the first point of the indicative content by saying the further down you go in group 1 the melting and boiling point decreases and going across the period the melting point increases and so does the boiling point. The idea of this being related to bond breaking is also present, but the answer is too general as the specific metals in the table have not been referred to. There is just enough here for a Level 1 answer and 1 mark has been awarded.

When answering six mark questions learners are advised to use a blank page on the exam paper to write a brief plan as to how they are going to answer the question, making a note of any scientific terms they will need to use. They do not need to include everything in the indicative content to achieve distinction level, but they need to address all parts of the question. If data is provided they should refer to this data in their answer and use it when putting forward any arguments.

The learner has given an adequate interpretation and analysis of the data by making general comments but the statements made are generic, rather than specific to the metals in the table. The discussion shows some structure and coherence.

TIPS!

In a levelled based answer learners need to use any data provided and make sure they address all aspects of the question and do what the command verb is asking for.

Unit 1: Principles and Applications of Science I – sample mark scheme

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first learner in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Learners must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks, if the learner's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a learner's response, the team leader must be consulted.
- Crossed-out work should be marked, UNLESS the learner has replaced it with an alternative response.
- You will not see 'or words to that effect' (OWTTE). Alternative correct wording should be credited in every answer, unless the mark scheme has specified specific wording that must be present.
- Round brackets () indicate words that are not essential, e.g. '(hence) distance is increased'.
- Error carried forward (ECF), means that a wrong answer given in an earlier part of a question is used correctly in a later part of a question.
- / indicates that the responses are alternatives and either answer should receive full credit.

Specific marking guidance for levels-based mark schemes*

Levels-based mark schemes (LBMS) have been designed to assess learners' work holistically. They consist of two parts: indicative content and levels-based descriptors. Indicative content reflects specific content-related points that a learner might make. Levels-based descriptors articulate the skills that a learner is likely to demonstrate, in relation to the assessment outcomes being targeted by the question. Different rows in the levels, represent the progression of these skills.

When using a levels-based mark scheme, the 'best fit' approach should be used.

- Examiners should first make a holistic judgement on which band most closely matches the learner's response, and place it within that band. Learners will be placed in the band that best describes their answer.
- The mark awarded within the band will be decided based on the quality of the answer, in response to the assessment focus/objective and will be modified according to how securely all bullet points are displayed at that band.
- Marks will be awarded towards the top or bottom of that band, depending on how they have evidenced each of the descriptor bullet points.

Section B – Periodicity and properties of elements

Question number	Answer	Additional guidance	Mark
6(a)(i)	• The ability of an element/atom in a molecule, to attract a bonding pair of electrons		**(1)**

Question number	Answer	Additional guidance	Mark
6(a)(ii)	A description that makes reference to the following points: • decrease in electronegativity down a group **(1)** • increase in electronegativity across a period left to right **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
6(a)(iii)	• atomic radius **(1)** • nuclear charge **(1)** • screening (by electron shells/orbitals) **(1)**	Accept number of protons in nucleus Accept shielding as an alternative to screening	**(3)**

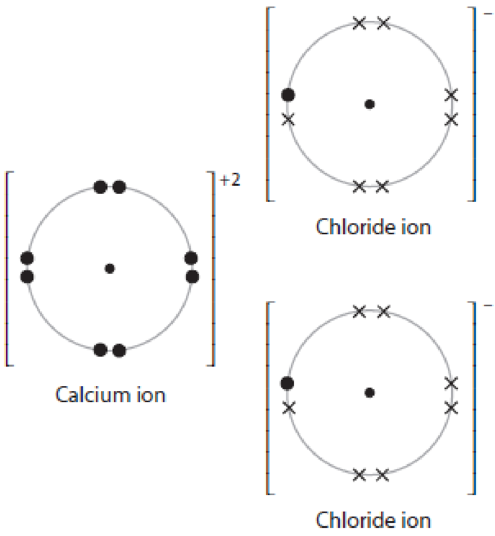
Question number	Answer	Additional guidance	Mark
6(b)	An explanation that makes reference to the following points: • induced dipole-dipole/London force/ dispersion force **(1)** • fluctuation in electron density, creates an instantaneous dipole in one molecule and this induces a dipole in a neighbouring molecule **(1)** • permanent dipole-dipole force **(1)** • due to a difference in electro-negativities **(1)**	Accept the nitrogen-oxygen bond is polar.	**(4)**

Question number	Answer	Additional guidance	Mark
7(a)	• B (carbon)		**(1)**

Question number	Answer	Additional guidance	Mark
7(b)(i)	Any explanation that makes reference to the following points: • (arrangement should be) ($1s^2$ $2s^2$ $2p_x^2$ $2p_y^2$ $2p_z^2$) $3s^2$ $3p_x^1$ $3p_y^1$ **(1)** • $3s^2$ fills first because it is lower energy **(1)** • then the p orbitals fill singularly before doubly **(1)**	Accept $1s^2$ $2s^2$ $2p_x^2$ $2p_y^2$ $2p_z^2$ $3s^2$ $3p^2$	**(3)**

Question number	Answer	Additional guidance	Mark
7(b)(ii)	Any explanation that makes reference to the following points: • stronger attraction between (positive charge of) protons in the nucleus and the (negative charge of) outer electrons (in silicon) **(1)** and • because the outer electrons are closer to the nucleus/smaller atomic radius/ fewer electron shells (in silicon) **(1)** or • because of less shielding (in silicon) **(1)**	Reject ionic radius/ molecules ignore just 'fewer electrons'. Accept reverse argument for germanium.	**(2)**

Question number	Answer	Additional guidance	Mark
8(a)	• electrostatic force		**(1)**

Question number	Answer	Additional guidance	Mark
8(b)	 • correct charges on each ion Ca^{2+} Cl^{-} **(1)** • correct number of electrons from each ion on the outer shell **(1)**	Ignore inner shells. Reject covalent bonding. Ignore whether dots or crosses.	**(2)**

Question Number	Answer	Additional guidance	Mark
8(c)	• calcium carbonate to calcium chloride 1:1 ratio **(1)** • (111 × 500) ÷ 100 **(1)** • answer = 555 (kg) **(1)**		**(3)**

Question number	Answer	Additional guidance	Mark
9(a)	$4Al + 3O_2 \rightarrow 2Al_2O_3$ • correct formula **(1)** • correct balancing **(1)**	Allow multiples.	**(2)**

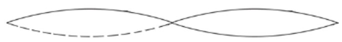
Question number	Indicative content
9(b)	Answers will be credited according to the learner's demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content, but learners should be rewarded for other relevant answers. • melting and boiling point increases across the period/decreases down a group • sodium and potassium have different physical properties from magnesium because they are in a different group • potassium has more electron shells than sodium, therefore potassium has more shielding between electron shells and the nucleus than sodium, thus has lower melting and boiling points • sodium and potassium atoms has one free electron/one electron on outer shell • magnesium atom has two free electrons/two electrons on outer shell • higher electron density in magnesium metallic bond means strong bond, therefore higher melting and boiling point than group 1 metals • stronger attraction between magnesium nucleus and delocalised electrons than in group 1 metals ORA • one more proton in nucleus of magnesium than sodium ORA, means a stronger attraction in the metallic bond, therefore magnesium has a higher melting and boiling point than sodium • bond harder to break in group 2 metal ORA • more energy needed to boil/melt magnesium ORA

Mark scheme (award up to 6 marks) refer to the guidance on the cover of this document for how to apply levels-based mark schemes*.		
Level	**Mark**	**Descriptor**
	0	no rewardable content
Level 1	1–2	• adequate interpretation, analysis and/or evaluation of the scientific information, with generalised comments being made • generic statements may be presented rather than linkages being made, so that lines of reasoning are unsupported or partially supported • the discussion shows some structure and coherence
Level 2	3–4	• good analysis, interpretation and/or evaluation of the scientific information, leading to lines of argument that are occasionally supported through the application of relevant evidence • lines of argument mostly supported through the application of relevant evidence • the discussion shows a structure that is mostly clear, coherent and logical
Level 3	5–6	• comprehensive analysis, interpretation and/or evaluation of all pieces of scientific information • line(s) of argument consistently supported throughout by sustained application of relevant evidence • the discussion shows a well-developed structure that is clear, coherent and logical

Section C – Waves in communication

Question number	Answer	Additional guidance	Mark
10(a)	• node/N labelled at either P or Q **(1)** • antinode/A labelled at mid-point of PQ **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
10(b)	• PQ = $\frac{1}{2}$ × wavelength **(1)**	Accept wavelength = 2 × PQ	**(1)**

Question number	Answer	Additional guidance	Mark
10(c)	P  Q		**(1)**

Question number	Answer	Additional guidance	Mark
10(d)	An explanation that makes reference to the following points: • a string has a series of natural frequencies **(1)** • corresponding to a number of half wavelengths **(1)** • a stationary wave is produced only when the frequency of the vibration generator produces waves of those wavelengths **(1)**	Forced frequency = natural frequency. Without reference to this situation award 2 marks.	**(3)**