Candidate Style Answer

Chemistry A

Unit F321 Atoms, Bonds and Groups – Medium banded response

This Support Material booklet is designed to accompany the OCR GCE Chemistry A Specimen Paper F321 for teaching from September 2008.

Contents

Introduction

OCR has produced these candidate style answers to support teachers in interpreting the assessment criteria for the new GCE specifications and to bridge the gap between new specification release and availability of exemplar candidate work.

This content has been produced by senior OCR examiners, with the input of Chairs of Examiners, to illustrate how the sample assessment questions might be answered and provide some commentary on what factors contribute to an overall grading. The candidate style answers are not written in a way that is intended to replicate student work but to demonstrate what a “good” or “excellent” response might include, supported by examiner commentary and conclusions.

As these responses have not been through full moderation and do not replicate student work, they have not been graded and are instead, banded “medium” or “high” to give an indication of the level of each response.

Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

Unit F321 Atoms, Bonds and Groups

Medium banded response

Question 1 (a)

1 The Group 7 element bromine was discovered by Balard in 1826. Bromine gets its name from the Greek *bromos* meaning stench.

(a) Bromine consists of a mixture of two isotopes, ^{79}Br and ^{81}Br.

(i) What is meant by the term *isotopes*? **[1]**

Atoms with a different number of neutrons

(ii) Complete the table below to show the atomic structures of the bromine isotopes. **[2]**

	protons	**neutrons**	**electrons**
^{79}Br	*35*	*44*	*35*
^{81}Br	*35*	*46*	*35*

(iii) Write the full electronic configuration of a bromine atom. **[1]**

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $4p^6$ $5s^2$ $5p^6$ $6s^1$

Comments

The definition of isotopes is insufficient; atoms of different elements have different numbers of neutrons. The particles are all correct in (ii). The electronic structure, a more difficult example, is missing any d-electrons.

Question 1 (b)

(b) A student added an aqueous solution of sodium iodide to a solution of bromine.

The colour turned from orange to a deep brown.

The student then added an aqueous solution of sodium chloride to a solution of bromine.

The orange colour was unchanged.

(i) Explain these observations.

In your answer, you should use appropriate technical terms, spelled correctly. **[3]**

In the first experiment bromine displaced iodine. In the second experiment nothing happens. This proves that chlorine is most reactive, then bromine, then iodine.

(ii) Write an ionic equation for the reaction that has taken place. **[1]**

$$I_2^+ + Br^- \rightarrow Br_2^+ + I^-$$

Comments

The response in part (i) makes no reference to iodide (ions). No conclusions are made from the individual experiments, but the overall order of reactivity is given. The equation is incorrect.

Question 1 (c)

(c) A student read about possible health problems arising from the use of common salt added to different foods. The student decided to compare the salt content of different foods using simple test-tube tests to test the chloride content.

Plan a simple qualitative experiment to compare the quantity of chloride ions in different foods. Comment on the validity of claiming that the chloride content is the same as the salt content. **[4]**

I would add silver nitrate solution to each food sample. A white precipitate of silver chloride would form if there were chloride ions in the food.

$$Ag^+ + Cl^- \rightarrow AgCl$$

This would tell you how much chloride there was in the food, not how much salt there was.

Comments

The answer clearly covers the test for chloride ions and its result, despite the fact that the food has not been made into a solution. However there is no attempt to compare the results for different foods and the comment about chloride and salt is irrelevant.

Question 2 (a)

2 This question refers to the elements in the first four periods of the Periodic Table.

							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

(a) Identify an element from the first four periods that fits each of the following descriptions.

(i) The element that forms a 2– ion with the same electronic configuration as Ar. **[1]**

0

(ii) The element that forms a 3+ ion with ten electrons. **[1]**

Al

(iii) An element that forms a compound with fluorine with trigonal planar molecules. **[1]**

B

(iv) The element that forms a chloride XCl_2 with a molar mass of 111.1 g mol^{-1}. **[1]**

Ca

(v) The element with the largest atomic radius. **[1]**

Kr

(vi) The element with the smallest first ionisation energy. **[1]**

Kr

Comments

In (i) O has been incorrectly selected: although it does form an O^{2-} ion, it is not in Period 3. The candidate has made the common error that the heaviest atom must be the largest in (v) and gone on to assume that it will therefore have the lowest ionisation energy in (vi). The other three answers are correct.

Question 2 (b)

(b) Ionisation energies provide information about the model for the electron structure of elements.

(i) Explain why first ionisation energies show a general increase across Period 3, Na–Ar. **[3]**

As you go across a period, protons are added to the nucleus, pulling the electrons in.

(ii) Write an equation, including state symbols, to represent the third ionisation energy of sodium. **[1]**

$$Na(g) \rightarrow Na^{3+}(g) + 3e^{-}(g)$$

(iii) Element **X** is in Period 3 of the Periodic Table, Na–Ar.

The first six ionisation energies of an element **X** are shown below.

ionisation number	1st	2nd	3rd	4th	5th	6th
ionisation energy /kJ mol^{-1}	789	1577	3232	4 556	16091	19 785

Predict, with reasons, the identity of element **X**. **[2]**

The big jump in numbers between 4th and 5th means it is in Group 4 with 4 electrons in its outer shell, so it must be silicon.

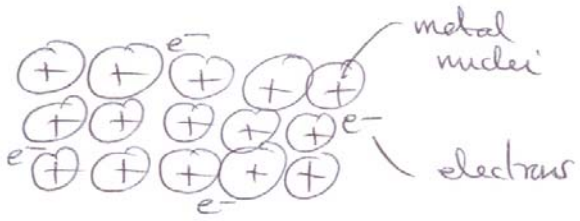
Comments

In (i), the increasing number of protons in the nucleus and for the 'pulling in', which is equivalent to a 'decrease in atomic radius', are both given. In (ii) there is the common error of combining the first three ionisation energies. The very basic answer to (iii) covers the marking points.

Question 3 (a)

3 Chemists have developed models for bonding and structure. These models are used to explain different properties of metals and non-metals.

(a) **(i)** Draw a labelled diagram to show the currently accepted model for *metallic bonding*. **[2]**



(ii) What feature of this model allows metals to conduct electricity? **[1]**

The electrons can move.

Comments

The drawing of a giant metallic structure is good but the 'nuclei' label is incorrect. Part (ii) is correct.

Question 3 (b)

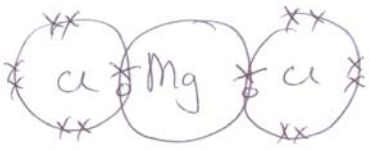
(b) The metal magnesium reacts with the non-metal chlorine to form a compound magnesium chloride, $MgCl_2$, which has ionic bonding.

(i) State what is meant by an *ionic bond*. **[1]**

Electrons are transferred from one atom to another.

(ii) '*Dot-and-cross*' diagrams are used to model which electrons are present in the ion.

Draw a '*dot-and-cross*' diagram, including outer electron shells only, to show the ions present in magnesium chloride, $MgCl_2$. **[2]**



(iii) A student finds that solid magnesium chloride and pure water do not conduct electricity. The student dissolved the magnesium chloride in the water and the resulting solution **does** conduct electricity.

Explain these observations. **[3]**

In solid magnesium chloride and pure water there are no ions.

In magnesium chloride solution there are ions.

Comments

The definition of ionic bonding shows a common misconception, this is not the definition. The dot and cross diagram shows another common error, with magnesium chloride being drawn as a covalent molecule. In part (iii), although the candidate gives an explanation of why water does not conduct electricity, the candidate clearly believes that the ions are only formed when the solid dissolves in water.

Question 3 (c)

(c) The non-metals chlorine and carbon have very different boiling points. Chlorine is a gas at room temperature but carbon does not boil until well over 4500 ^{o}C.

Explain this difference, in terms of bonding and structure.

In your answer, you should use appropriate technical terms, spelled correctly. **[3]**

Chlorine is a gas because it's made of little molecules with weak forces between the molecules. Carbon is a giant structure with strong bonds. It's easier to break weak bonds.

Comments

The answer is just too vague. There is no mention of van des Waals' or intermolecular forces. Neither are covalent bonds mentioned. However, there is some idea of comparison of the bond strengths.

Question 4 (a)

4 Calcium and its compounds, have properties typical of Group 2 in the Periodic Table.

(a) Calcium carbonate, $CaCO_3$, reacts with acids such as nitric acid.

A student neutralised 2.68 g of $CaCO_3$ with 2.50 mol dm^{-3} nitric acid, HNO_3.

The equation for this reaction is shown below.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

(i) Determine the amount, in mol, of $CaCO_3$ reacted. **[2]**

Mol $CaCO_3$ = 2.68/100 = 0.0268

(ii) Calculate the volume, in cm^3, of CO_2 produced at room temperature and pressure. **[1]**

Volume CO_2 = 0.0268 x 24 000 = 643 cm^3

(iii) Calculate the volume of 2.50 mol dm^{-3} HNO_3 needed to neutralise 2.68 g of $CaCO_3$**.** **[2]**

Mol HNO_3 = 2 x 0.0268 = 0.0536

Volume of HNO_3 = 0.0536 x 2.5 = 0.134 cm^3

Comments

The candidate did not use their data sheet and therefore got the relative formula mass as 100 rather than 100.1. They lost the first mark but carried their error forward to pick up the second mark. Part (ii) is correct. In (iii) they calculate the number of moles correctly but cannot then continue to a correct volume of nitric acid.

Question 4 (b)

(b) The student left the solution of calcium nitrate formed in **(a)** to crystallise. Crystals of hydrated calcium nitrate formed containing 30.50% of H_2O, by mass.

Calculate the formula of the hydrated calcium nitrate. **[3]**

Mol $Ca(NO_3)_2$ = 69.50/82 = 0.8476

Mol H_2O = 30.50/18 = 1.694

Ratio = 0.4235 : 0.8476 = 1:2

Formula is $Ca(NO_3)_2.2H_2O$

Comments

Despite the incorrect answer, the only error is the incorrect rfm for calcium nitrate, where the candidate appears to have used atomic numbers. Both other marks can be awarded consequentially, as the candidate has shown all their working.

Question 4 (c)

(c) A student prepared an aqueous solution of calcium chloride by reacting calcium with hydrochloric acid.

$$Ca(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2(g)$$

(i) Using oxidation numbers, show that this is a redox reaction. **[2]**

Calcium's oxidation number has gone up from 0 to 2. Hydrogen's has gone down.

(ii) The student had added the exact amount of calcium required to react with the hydrochloric acid used. After carrying out the experiment, the student accidentally added some more calcium. The student was surprised that the extra calcium still reacted.

Explain this observation. Include an equation in your answer. **[2]**

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

Comments

In the first part hydrogen's oxidation numbers are not given. In the second part there is no written answer, but the mark scheme accepts the correct equation.

Question 5 (a)

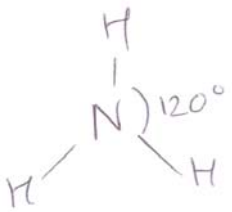
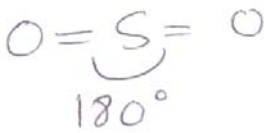
5 Water, ammonia and sulfur dioxide are simple molecular compounds.

(a) Pairs of electrons in molecules may be present as *bonding pairs* or as *lone pairs*.

(i) Complete the table below for water, ammonia and sulfur dioxide. **[2]**

molecule	H_2O	NH_3	SO_2
number of bonding pairs of electrons	*2*	*3*	4 (two double bonds)
number of lone pairs of electrons around central atom	*2*	*1*	1

(ii) Use your answers to **a(i)** to help you draw the shape of, and bond angle in, a molecule of NH_3 and of SO_2.

molecule	NH_3	SO_2
shape of molecule with bond angles		

[4]

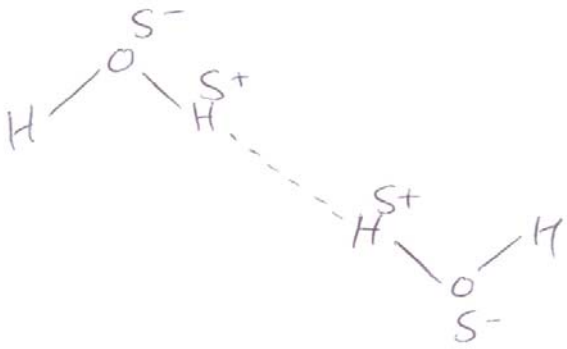
Comments

The numbers of bonding and lone pairs are correct in (i). The ammonia molecule is drawn as trigonal planar, ignoring the lone pair. Sulfur dioxide is one of the analogous molecules referred to in the specification and this candidate has assumed that it is like carbon dioxide, losing these marks.

Question 5 (b)

(b) Water forms hydrogen bonds which influences its properties.

Explain, with a diagram, what is meant by *hydrogen bonding* and explain **two** anomalous properties of water resulting from hydrogen bonding. **[6]**



Oxygen is very electronegative polarising the bonds.

Ice floats on top of water.

Water a higher melting point than expected.

Paper Total [60]

Comments

The diagram is wrong, as the hydrogen bond is between two hydrogens. However the dipoles are correct. The density is described, without explanation. Similarly, the statement that water's melting point is higher than expected is correct, but again there is no explanation.

Overall Comments

This candidate has scored about half of the available marks.