Candidate Style Answer

Chemistry A

Unit F321 Atoms, Bonds and Groups – High banded response

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

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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

High 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 of the same element 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]**

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^5$

Comments

This is all correct. The definition of isotopes is a text book definition, the particles are all correct and the electronic structure, although a more difficult example, is also correct.

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. **[3]**

✎ In your answer, you should use appropriate technical terms, spelled correctly.

In the first experiment iodide ions were reduced to iodine because bromine is more reactive than iodine. A displacement reaction has taken place. In the second experiment bromine could not displace chlorine because chlorine is more reactive than bromine, so no reaction takes place.

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

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

Comments

The response in part (i) covers all three marking points. The technical terms, "iodide" and "iodine" have also been used and spelled correctly. In (ii), the species have all been identified correctly, but the candidate has apparently forgotten the comparatively easy step of balancing the equation.

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 use 10g of each food and shake it with 100 cm3 of water to dissolve all the chloride ions. Then I would filter and add the same volume of silver nitrate solution to each sample. A white precipitate of silver chloride would form if there were chloride ions in the food.

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

The amount of chloride is not the same as the amount of salt because salt is sodium chloride, so there will be more sodium chloride. Also, it is the sodium that is bad for you.

Comments

The answer clearly covers the test for chloride ions and its result. However there is no attempt to compare the results for different foods. The comment about salt not being simply chloride ions is not the same as the answer in the mark scheme but is nevertheless correct.

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]**

S

(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]**

K

Comments

Good answers and all correct except (v), where the candidate has made the common error that the heaviest atom must be the largest. Surprisingly, they have gone on to a correct answer to (vi), realising that Group 1 elements lose an electron most easily.

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 the electrons go into the same shell, so the distance from the nucleus gets less and the shielding stays the same. However, the nuclear charge increases as a proton is added each time, causing a stronger electrostatic attraction on the outer electrons, pulling them in.

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

$$Na^{2+}(g) \rightarrow Na^{3+}(g) + e^{-}(g)$$

(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]**

X is in Group 4 because there is a sudden jump in ionisation energies between 4 and 5 which means that we have moved into a new shell, nearer the nucleus and with less shielding. This means that it is much more difficult to remove the fifth electron.

It must be silicon because it is in Period 3.

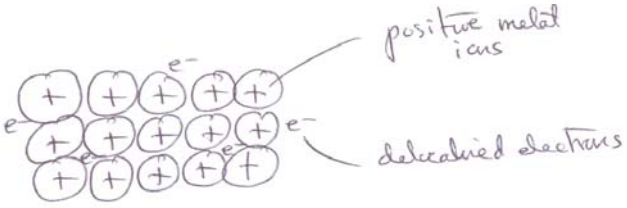
Comments

This candidate has obviously revised ionisation energies! All three points are covered in (i): indeed, all three alternatives are given for the first marking point … but this is a standard recall question. The equation in (ii) is correct and we do not worry about the unnecessary (g) after the electron. The identification and explanation for element X is outstanding.

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 delocalised electrons are free to move and carry the current.

Comments

The drawing of a giant metallic structure is good and clearly labelled. Without the labels, the + in a circle would have been too ambiguous - possibly a proton or nucleus. Part (ii) is correct.

Question 3 (b)

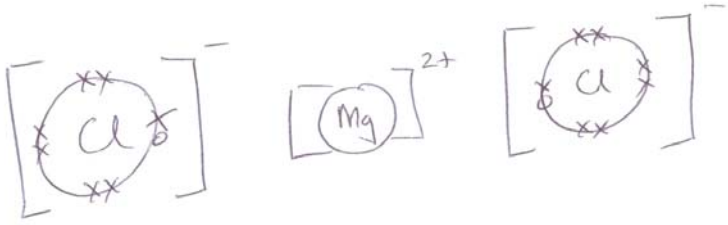
(b) The metal magnesium reacts with the non-metal chlorine to form a compound magnesium chloride, $MgCl_2$, which has ionic bonding.

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

Strong forces of electrostatic attraction between oppositely charged ions

(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 there are no free electrons to carry the charge.

In pure water there are no charge carriers because it is covalent.

In magnesium chloride solution the electrons are now free to move.

Comments

The first two parts are correct. In (iii), however, the candidate does not mention ions, appearing to believe that the charge carriers in ionic compounds are electrons. The second statement is correct. The first statement is correct, if not complete. The candidate's only error is the omission of ions.

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 simple molecular structure with only very weak van der Waals' forces between the molecules. Carbon is a giant covalent structure with strong covalent bonds throughout the structure.

Comments

A good answer covering the weak intermolecular bonds and the strong covalent bonds. The technical terms are both spelt correctly in the correct context. However, there is no reference to the fact that the bonds/forces have to be broken. The candidate is not picking up all the marks on the three mark questions.

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 $CaCO_3$ = 2.68/100.1 = 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 CaCO3**.** **[2]**

Volume = 2.5 x 643/2 = 803.75 cm^3

Comments

The candidate started well, showing all their working and giving the correct answers for the first two parts. The volume of solution needed is more difficult and here there is just a jumble of numbers and a very large answer. There are too many errors to allow any marks.

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 $Ca(NO_3)_2$ = 69.50/164.1 = 0.4235

Mol H_2O = 30.50/18 = 1.694

Ratio = 0.4235 : 1.694 = 1:4

Formula is $Ca(NO_3)_2.4H_2O$

Comments

Perfect!

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, which is oxidation. Hydrogen's has gone down from +1 to 0, which is reduction.

(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. **[2]**

Explain this observation. Include an equation in your answer.

Calcium is reacting with the water.

$2Ca + 2H_2O \rightarrow 2CaOH + H_2$

Comments

The oxidation numbers are used to give a detailed answer in the first part. In the second part, the candidate has realised that the calcium has reacted with water but has not given a product, as required in the mark scheme. The equation is incorrect as the formula for calcium hydroxide is wrong. However, the H_2 means that some credit will be given.

Question 5 (a)

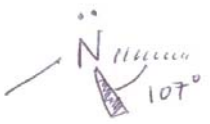
5 Water, ammonia and sulfur dioxide are simple molecular compounds.

(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. **[4]**

molecule	NH_3	SO_2
shape of molecule with bond angles		

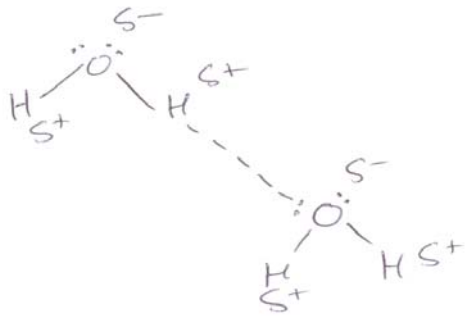
Comments

The numbers of bonding and lone pairs are correct in (i). The ammonia molecule is straight from the specification and is correct, as is the bond angle. However, sulfur dioxide is one of the analogous molecules referred to in the specification and this candidate appears to have ignored the lone pair, assuming that the molecule is analogous to 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]**



In water, oxygen is much more electronegative than hydrogen, polarising the bonds to a unique extent allowing hydrogen to form a second, longer, weaker bond.

This gives ice an open structure, making it less dense than water, so it floats on top of water.

The hydrogen bond is strong so it takes a lot of energy to break it, giving water a high melting point.

Paper Total [60]

Comments

The diagram is perfect, showing the dipoles and lone pairs as well as a longer hydrogen bond. The density is well described. However water does not have a "high" melting point, it is just higher than expected when compared to molecules with a similar molar mass. Nor are hydrogen bonds "strong", just stronger than the other intermolecular forces.

Overall Comments

This candidate has scored a high mark for this paper.