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VCE Chemistry ½
Ionic Compounds [1.5]
Homework Solutions

Homework Outline:

Compulsory	Pg 2 – Pg 8
Supplementary	Pg 9 – Pg 17

Section A: Compulsory (43 Marks)

Sub-Section: Write the Formula of Simple & Complex (Containing Polyatomic and Transition Metal Ions) Ionic Compounds and Be Able To Name Them

Question 1 (4 marks)

For the following pairs of elements, write the formula of the ionic compound they will form:

a. Ca and Cl. (1 mark)

$CaCl_2$

b. Br and K. (1 mark)

KBr

c. Mg and O. (1 mark)

MgO

d. S and Na. (1 mark)

Na_2S

Question 2 (4 marks)

Write the formula for the ionic compound that is formed between the following:

a. $Cu^{2+}$and Cl. (1 mark)

$CuCl_2$

b. $Fe^{2+}$and PO_4^{3-}. (1 mark)

$Fe_3(PO_4)_2$

c. Cl and NH_4^+. (1 mark)

NH_4Cl

d. Ca and CO_3^{2-}. (1 mark)

$CaCO_3$

Question 3 (3 marks)

Explain why we observe ionic compounds to be between metals and non-metals.

Ionic compounds exist between metals and non-metals because metals typically want to lose electrons whereas non-metals typically want to gain them. In addition, metals have low electronegativities when paired with the high electronegativities of non-metals creating a difference large enough for an ionic bond to form.

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Sub-Section: Explain the Structure of Ionic Compounds and Be Able To Draw Electron Transfer Diagrams

Question 4 (3 marks)

Explain what occurs when an atom of Na bonds to an atom of Cl to form NaCl.

As the Na has 1 valence electron and the Cl has 7 valence electrons, the Na will first lose the 1 electron and the Cl will gain that electron in order to become ions first. After that, Na^+ and Cl^- will form an electrostatic attraction to each other thus forming an ionic bond and hence, NaCl.

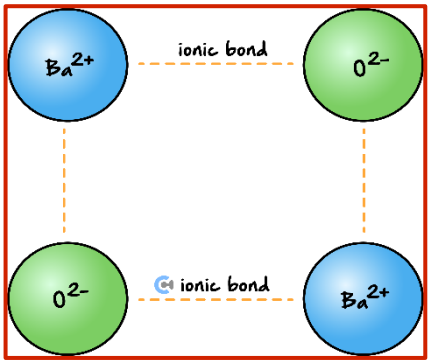
Question 5 (3 marks)

The following compound, BaO, is to be investigated.

a. Name the compound. (1 mark)

Barium Oxide

b. Draw the lattice structure of this compound, containing 2 atoms of each ion. (2 marks)



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Question 6 (7 marks)

Consider a molecule of NaCl.

a. State the bonding that holds the NaCl bonds together. (1 mark)

NaCl is held together by ionic bonds.

b. Now, consider a molecule of HCl, state what bonds hold this molecule together. (1 mark)

HCl is held together by covalent bonds.

c. Explain what happens as a result of the bonds formed to hold HCl together. (2 marks)

As a result of the covalent bond, the H is slightly positive and the Cl is slightly negative resulting in dipoles.

d. Hence, or otherwise, of the two molecules, which one do you think will exhibit stronger charge? Justify your answer. (3 marks)

NaCl has stronger charge because the charges are full charges (Na^+ and Cl^-) whereas HCl is a dipole. However, it only contains partial charges, which are weaker than full charges.

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Sub-Section: Explain the Properties of Ionic Compounds (Hardness, High MP/BP, Brittleness, Electrical Conductivity in Various States), With Reference To Their Structure and Bonding

Question 7 (2 marks)

Briefly explain why in cooking you can 'burn' sugar but you never seem to burn salt.

Salt is an ionic compound which means it has very strong intramolecular bonds as it is NaCl. As such, because of these strong intramolecular bonds it will take a lot of energy to disrupt these bonds since they are arranged in an ionic lattice and hence, we see that NaCl has a very high boiling point.

Question 8 (3 marks)

Explain why not all molecules can be covalently bonded molecules, giving an example.

In a molecule of NaCl, if the bond was a covalent bond, then both atoms would be gaining an electron. This would allow the Cl to gain 1 electron and fulfil Octet's Rule, however for Na which needs to lose 1 electron, if it gains 1 electron it will not have fulfiled Octet's Rule and will not become stable. Hence, a molecule like NaCl cannot participate in a covalent bond due to the fact that one atom needs to lose electrons and the other will need to gain electrons in order to become stable.

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Question 9 (4 marks)

When a block of Fe and a block of $CuCl_2$ are both struck with an external force, compare and explain what happens to each block, with reference to their relative lattice structures.

When a block of Fe is struck by a force, the cations in the metallic lattice will shift but due to presence of a delocalised sea of electrons, the Fe ions will still be attracted to the electrons and as such the structure will shift but will not break, which means the Fe block will just change shape as it is malleable. On the other hand, when a block of $CuCl_2$ is struck with an external force, as the ionic lattice structure comprises of Cu^{2+} and Cl^- arranged next to each other because they are opposing charges, the force would shift the structure in a way that would cause the charges to no longer align, and as they don't align, they no longer have an electrostatic attraction which will then cause the ionic lattice structure to break. Hence, $CuCl_2$ is brittle and will break when struck by an external force.

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Sub-Section: Final Boss

Question 10 (10 marks)

Consider ceramic, which is a composite material that is comprised of a mix of different ionic compounds, and iron.

a. Which material is more suitable to be used as a cooking utensil dealing with extremely high temperatures? Justify your answer. (4 marks)

Ceramic: • Ionic compounds have really strong intramolecular bonds and as such it will have a really high melting and boiling point. It also has a lower thermal conductivity than metals because it does not have delocalised electrons and so will only vibrate to transfer heat unlike metals. As utensils are meant to be insulating to be safe for human handling, it's better to use ceramic for utensils.

b. Which material is more suitable for usage as cookware instead of cooking utensils? Justify your answer. (3 marks)

Iron: • Has better thermal conductivity due to the more intense vibration of the metal structure and also carries more heat due to the delocalised sea of electrons than ceramic which can only transmit heat via vibration of the ionic lattice structure. Hence, iron will transfer heat more easily and faster making it more ideal for use as cookware like a pan.

c. Imagine you had two bowls in your house, one made of iron and the other ceramic, which one would you place on a lower shelf level and why? (3 marks)

Place the ceramic bowl on the lower shelf as ceramic is brittle, meaning while it is hard it can shatter easily when struck by a force compared to a bowl of iron. This is because if the structure of ionic compounds inside of ceramic were struck, electrostatic repulsion would occur, shattering the lattice structure. Whereas iron is malleable and would remain intact.

Section B: Supplementary (62 Marks)

Sub-Section: Write the Formula of Simple & Complex (Containing Polyatomic and Transition Metal Ions) Ionic Compounds and Be Able To Name Them

Question 11 (4 marks)

Write the formula for the ionic compound that is formed between the following:

a. Na and NO_3^-. (1 mark)

$NaNO_3$

b. K and SO_4^{2-}. (1 mark)

K_2SO_4

c. CO_3^{2-} and Mg. (1 mark)

$MgCO_3$

d. SO_3^{2-} and Ca. (1 mark)

$CaSO_3$

Question 12 (4 marks)

Find the valency of the metal ion in the following ionic compounds.

a. $Fe_2(SO_4)_3$. (1 mark)

Fe^{3+}

b. $AgCl_2$. (1 mark)

Ag^+

c. $Sn(NO_3)_4$. (1 mark)

Sn^{4+}

d. CuBr. (1 mark)

Cu^{+}

Question 13 (6 marks)

For each of the following ionic compounds, find the valency for all of the elements in the compound.

a. $K_2Cr_2O_7$. (2 marks)

$K = +1, O = -2, \quad Cr = +6$

b. $Ag(NH_3)_{2\pm}$. (2 marks)

$Ag = +3, N = -3, H = +1$

c. $[Pt(NH_3)_4]Cl_2$. (2 marks)

$Pt = +6$
$N = -3, H = +1, Cl = -1$

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Question 14 (8 marks)

A student was tasked with writing formulas for ionic compounds but made several mistakes. Identify and correct the errors below, justifying your corrections:

a. $NaSO_4$ for sodium sulphate. (2 marks)

Na_2SO_4 because $Na = +1$ and $SO_4 = -2$.

b. $Mg_3(PO_4)$ for magnesium phosphate. (2 marks)

Mg has a $+2$ charge and PO_4 has a -3 charge. Therefore, it should be $Mg_3(PO_4)_2$.

c. $Fe(NO_3)_2$ for Iron (III) nitrate. (2 marks)

Iron (III) means ion form is Fe^{3+} and NO_3 is NO_3^- so it should be $Fe(NO_3)_3$.

d. $Al(SO_4)_2$ for aluminium sulphate. (2 marks)

Al is $3+$ whereas SO_4 is -2 so it should be $Al_2(SO_4)_3$.

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Sub-Section: Explain the Structure of Ionic Compounds and Be Able To Draw Electron Transfer Diagrams

Question 15 (3 marks)

Write the formula of the compound formed from calcium and oxygen, naming the compound and explaining how this compound exists in real life

CaO, calcium oxide. This compound exists in real life as an ionic lattice comprising of Ca^{2+} ionically bonded to O^{2-} which has a dull appearance.

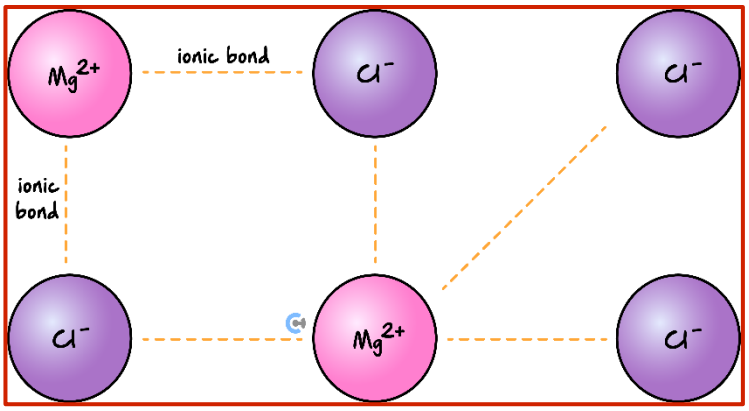
Question 16 (4 marks)

You're exploring ionic compounds in your chemistry project and encounter magnesium chloride.

a. Write the molecular formula. (1 mark)

$MgCl_2$

b. Draw the ionic lattice structure of magnesium chloride, showing at least two magnesium ions and four chloride ions. Label the forces between the ions. (3 marks)

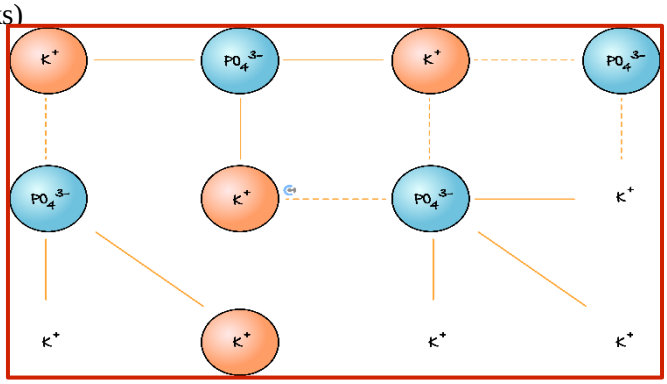


Question 17 (7 marks)

a. What is the molecular formula and name of the compound that forms between phosphate ions and potassium ions? (2 marks)

K_3PO_4 - Potassium phosphate

b. Draw the ionic lattice structure that forms above, showing at least two sets of the substance according to the molecular formula. (3 marks)



c. Compare the bonding present in (**part b.**) with the bonding that is present within a molecule of HCl. (2 marks)

Inside K_3PO_4 will have ionic bonding whereas HCl is covalently bonded. Covalent bonding involves the sharing of electrons whereas ionic bonding involves donating and accepting electrons to form an intramolecular bond.

Question 18 (7 marks)

Consider an atom of K and an atom of F.

a. Explain how they would form an ionic compound. (3 marks)

K would lose an electron to become K^+ and F would become F^- by gaining the electron the K lost. Afterwards, the K^+ and the F^- would be attracted to each other as they are ions of opposite charges and form an electrostatic attraction that is the ionic bond.

b. Now, consider the ions K^+ and F^-. Explain how they would form an ionic compound. (2 marks)

Since they are already ions, the process of forming the ionic bond will go ahead the same way. The K^+ and the F^- will form an electrostatic attraction that will be the ionic bond, there is no need for losing/gaining electrons as they already are ions.

c. Are both resulting compounds the same? Justify your answer. (2 marks)

Yes, they are the same because the ionisation of the atoms aren't included in the process of an ionic bond, it's really only the formation of the electrostatic attraction between ions that is responsible for the formation of the ionic bond.

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Sub-Section: Explain the Properties of Ionic Compounds (Hardness, High MP/BP, Brittleness, Electrical Conductivity in Various States), With Reference To Their Structure and Bonding

Question 19 (3 marks)

Explain what happens when a block of $NaNO_3$ is struck with an external force, stating the property this phenomenon can be described with.

When $NaNO_3$ is struck with a force, the molecules will shift and as they are originally aligned to their opposite charges in order to maintain the ionic lattice, when a force strikes it, the charges won't be opposite anymore. Hence, the charges repel and the ionic lattice structure will break, resulting in ionic compounds being brittle.

Question 20 (3 marks)

Between the same amount of molecules of NaCl and $CuCl_2$, explain which one would have a higher boiling point.

$CuCl_2$ would have the higher boiling point as for the same amount of molecules, the charges between Na and Cl would be $+1$ and -1 respectively, but for $CuCl_2$ it would have double the charges for the positive and negative ions. Hence, there is greater electrostatic attraction in the ionic lattice of $CuCl_2$ compared to NaCl, and hence it would require more energy to break apart. Therefore, $CuCl_2$ has a higher boiling point.

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Question 21 (5 marks)

Consider a block of copper and a block of salt.

a. Explain why a solid block of copper is able to conduct electricity, however when we use a block of salt, it doesn't work. (3 marks)

The block of copper is arranged in a metal lattice so as such there are free moving electrons that are able to conduct charge, whereas a block of NaCl all the ions are packed closely together in an ionic lattice and hence it is not able to have any free charges to be transferred, and as such will not be electrically conductive.

b. Suggest and explain how salt could conduct electricity. (2 marks)

Salt can become electrically conductive when it is dissolved in a solution. This is because the Na^+ and the Cl^- structure will no longer be packed tightly and as they are able to move freely, they can then conduct electricity as they are moving charges themselves.

Question 22 (8 marks)

Ionic compounds are used in various industries due to their unique properties. A scientist is studying the properties of ionic compounds with regard to magnesium oxide.

a. Magnesium oxide has a significantly higher melting point when compared to sodium chloride. Explain this difference. (3 marks)

Magnesium oxide has a formula of MgO, which has the ions Mg^{2+} and O^{2-} whereas NaCl has the ions Na^+ and Cl^-. Hence, MgO has greater charges which means the ionic lattice would contain more charges and a greater electrostatic attraction than the lattice of NaCl. Therefore, MgO would contain stronger intramolecular bonds and require greater energy to weaken and so it would have a higher melting point.

b. Explain what conditions should be met for magnesium oxide to conduct electricity. (3 marks)

It should either be in liquid or aqueous solution (dissolved in water). So, that means the temperature should be high enough for magnesium oxide to melt, or it should be dissolved in water or another solution. This is because this creates free moving charges due to the cations and anions being able to freely move, and hence carry charge.

c. In industry, operating costs of maintaining conditions such as temperature must be considered. Out of the methods in (**part b.**), which one is less costly and why? (2 marks)

As having liquid magnesium oxide requires greater temperatures due to its high melting point, this uses a lot of energy and hence is expensive to maintain. Whereas dissolving it in solution doesn't require as much energy, just the right solution to dissolve it in. Therefore, this method will be more cost efficient.

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