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90944



909440



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Level 1 Science, 2015

90944 Demonstrate understanding of aspects of acids and bases

9.30 a.m. Tuesday 10 November 2015
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of acids and bases.	Demonstrate in-depth understanding of aspects of acids and bases.	Demonstrate comprehensive understanding of aspects of acids and bases.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Pull out Resource Booklet 90944R from the centre of this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

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Merit

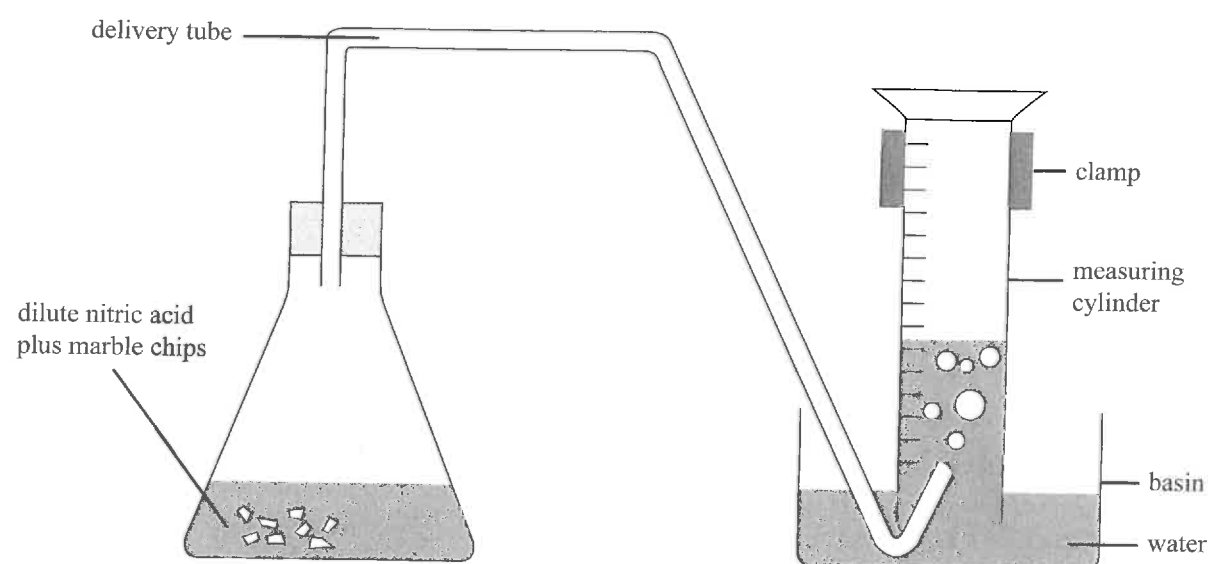
TOTAL

15

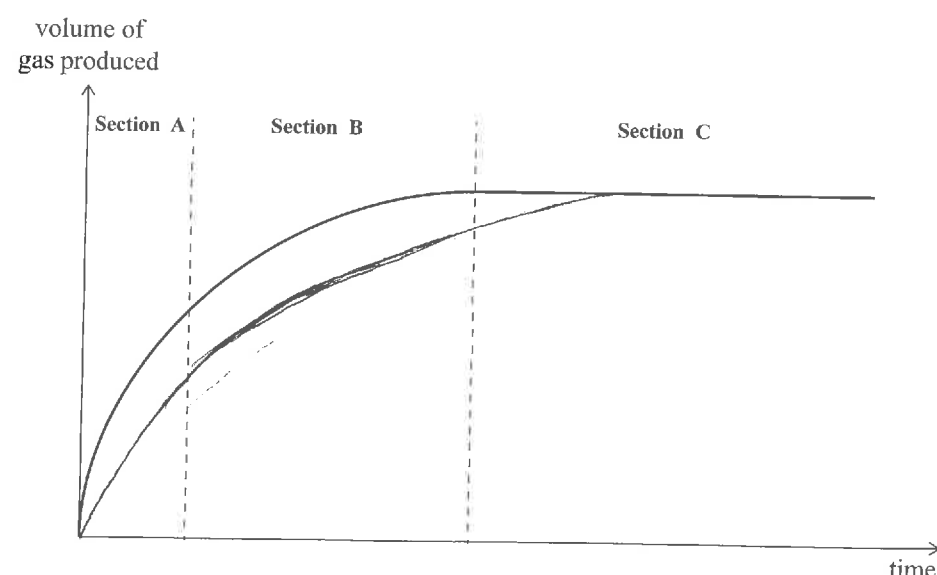
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QUESTION ONE

Marble chips (calcium carbonate) were added to nitric acid in a conical flask. The temperature of the acid was 50°C . The flask was connected to an inverted measuring cylinder in a basin of water to measure the volume of gas produced, as shown in the diagram below.



The graph below shows the volume of gas produced against time.



- (a) Explain what is happening in terms of particle collisions and rate of reaction in **each section** of the graph.

Section A: Collision theory states that particles must collide with sufficient energy at the correct orientation to ~~produce~~ make a product. The gradient of this section is steep, showing that products are being made rapidly because there ~~are~~ is lots of both reactants, so they collide more and produce lots of successful collisions.

Section B:

In this part of the graph, the gradient of the line is less steep - this means the rate of the reaction has lowered. This is because as the gas is produced, the reactants are being used up, so there are less reactant particles to collide and create the gas.

Section C:

We can see here the gradient is flat - the reaction has fully stopped and no more gas is being produced. This is because one of the reactants has been completely used up and turned into gas, so there are no longer sufficient reactants to collide.

- (b) The reaction was carried out again but this time at 20°C . The mass and size of the marble chips, and the concentration and volume of nitric acid used were kept the same.

(i) Draw a line on the graph that represents the reaction at 20°C .

- (ii) Explain why you drew this line where you did, and explain if this means that the rate of reaction is slower, the same, or faster.

In your answer you should

- discuss why you drew your line with the slope that you did, and why you stopped the line at the point that you did
- explain the effect of temperature on reaction rate, in terms of particle collisions.

I drew my line below the original with a less dramatic gradient, meeting with the original to become flat during section C.

I drew my line like this because this reaction will be slower and longer - so the initial reaction rate is slowed on the overall reaction takes longer, so it finishes

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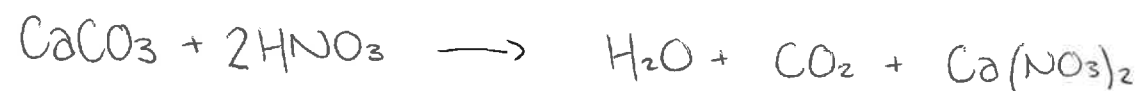
later than the original.
Cooler temperatures result in slower reaction rates. This is because when particles are hot, they vibrate vigorously and collide lots; therefore when the particles are cool they move less and subsequently collide less, resulting in a lower reaction rate.

- (c) Write a word equation AND a balanced symbol equation for the reaction between nitric acid and calcium carbonate.

Word equation:

Calcium carbonate + Nitric acid \rightarrow Water + Carbon dioxide + Calcium nitrate

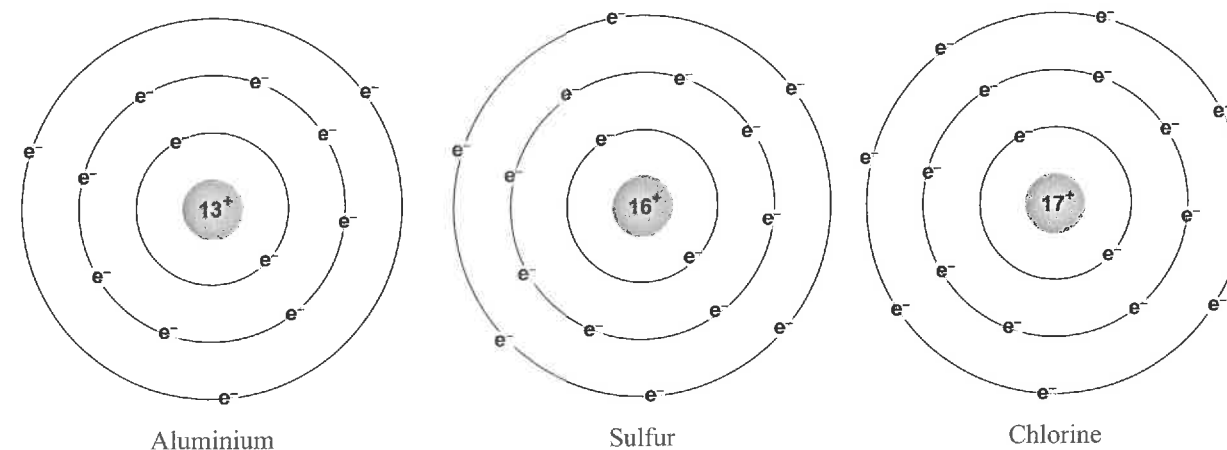
Balanced symbol equation:



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QUESTION TWO

The diagrams below show models of three different atoms.



- (a) Each of these atoms can form ions, as listed below.

- Explain why each of the **ions** has the charge it does, in terms of electron arrangement and number of protons.
- Ions are charged atoms. Explain how each of the ions below reached the charge shown. You should discuss particles gained or lost by the atoms involved, and the reasons for this.

Aluminium ion, Al^{3+} : This ion has the 13 protons of its original atom, but only 10 negative electrons to give a charge of 3^+ . This is because it ~~loses~~ ^{gives away} its two valence electrons when it can, so it can achieve a stable outer shell - in the second shell, ~~stable~~ ^{stable} a full shell has 8 electrons.

Sulfide ion, S^{2-} : Sulfur gains 2 negative electrons to become an ion charged -2 : Stability in the third electron shell is at 8, and sulfur atoms have 6. The shortest path to a stable outer shell is by gaining 2 more electrons.

Chloride ion, Cl^- : Chlorine atoms have 17 protons and 17 electrons - chloride is formed by gaining one more electron, so the charge is -1 . Again, chlorine's shortest route to a stable valence shell is not to lose its 7 valence electrons but instead to gain one more.

(b) Explain why an ionic bond would **not** form between a sulfide ion and a chloride ion.

In your answer you should:

- describe an ionic bond
- refer to charges and electron arrangements of the ions involved.

An ionic bond is between 1 or more of each a positive ion (cation) and negative ion (anion). This is because the ~~the~~ cation gives ~~the~~ ^{one} electrons to the anion, and a bond is formed. This bond is between metals and non-metals.

Sulfide (S^{2-}) and Chloride (Cl^{-}) are both negative ~~ele~~ ions. They both want to gain electrons: S^{2-} has an electron arrangement of 2, 8, ~~7~~ and gains ~~one~~ ^{two} electrons; for Cl it's 2, 8, 7 and it gains one electron.

(c) Determine the ionic formulae of the compound that forms when aluminium combines with chlorine, AND when aluminium combines with sulfur.

In your answer you should:

- consider the ratio of ions in each formula, and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in each formula to the number of electrons lost or gained by each atom when forming ions.

Aluminium and chlorine: These two elements combine to produce Aluminium chloride - $AlCl_3$. There are 3 chloride ~~a~~ ions to every aluminium, because Cl^{-} has a charge of -1 and Al^{3+} has a charge of +3. When ~~a~~ an Aluminium atom becomes an ion, it discards three ~~of its~~ valence electrons. However chlorine only accepts one electron to become Chloride, so three chlorine atoms must be used to complete the bond.

Aluminium and sulfur: These two create the compound of Aluminium sulfide - Al_2S_3 . There is 2 Aluminium cations and 3 sulfide anions in every Aluminium sulfide molecule. This is because the charges have to balance. Aluminium gives 3 electrons so has a +3 charge but sulfide only takes 2 (-2 charge). The lowest ^{ratio} combination that evens out the charges is 2 Al^{3+} to 3 S^{2-} , because you then have 6 positive charges and 6 negative charges, resulting in a neutrally charged molecule.

QUESTION THREE

The chemical equation below represents the reaction between hydrochloric acid and sodium hydroxide:



- (a) Complete the table below to show the approximate pH for each of the three solutions.

	Colour when UI is added	pH
HCl	red	1
NaOH	purple	13
H ₂ O	green	7

- (b) Water is formed in the reaction above.

Explain what ions form water in this reaction, and where they come from.

You may use an equation but this is not required.

The ions that create water are H^+ and OH^- ions. The acidic HCl donates the hydrogen cation, and the basic NaOH gives both the hydrogen ions as well as Oxygen anions.

- (c) NaOH is gradually added to a solution of HCl with universal indicator present, until no further colour change occurs.

Discuss what is occurring in the beaker at each of the pH's shown, as the NaOH is added.

In your answer you should refer to:

- the colours that would occur at each pH
- the relative amounts of hydrogen and hydroxide present at each of the pH's shown.

pH = 1 (before any NaOH is added): The solution would be red as only hydrochloric acid is present. There would only be hydrogen ions present in the solution.

pH = 4: The colour would have turned into a golden orangy-yellow. Adding OH^- ions from the base that react with hydroxide would leave less H^+ ions than before.

pH = 7: The solution would be a rich green colour as it is completely neutralized. There would be no spare hydroxide or hydrogen ions in the solution.

pH = 10: The colour would now resemble a blue tone. More base has been added, so with no spare H^+ ions, hydroxide ions are present in the solution.

pH = 13: The solution would now be purple in colour and highly basic. There would be lots of OH^- ions in the solution.

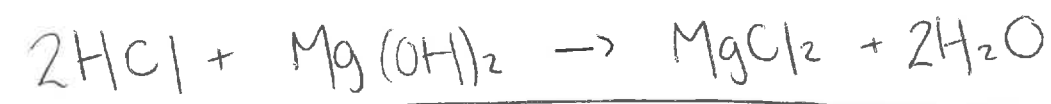
- (d) In a different chemical reaction, hydrochloric acid reacts with magnesium hydroxide.

Write a word equation and a balanced chemical equation for this reaction in the boxes below.

Word equation:

Hydrochloric acid + Magnesium hydroxide \rightarrow Magnesium chloride + water

Balanced symbol equation:



Achieved with Merit exemplar for 90944 2015		Total score	15
Q	Grade score	Annotation	
1	M6	<p>This candidate appreciated that the reaction occurred slower and finished at the same point as the reaction at a higher temperature. These two points were indicated on the graph.</p> <p>They could explain that as one or both of the reactant particles are becoming used up (in Section B) or completely used up (in Section C) the reaction slows and eventually stops.</p> <p>To take this candidate to the next level they needed to explain that as the temperature is lowered the speed of particles decreases and hence the frequency of effective collisions. To say that they collide less is not enough.</p>	
2	M5	<p>This candidate discussed the ratio of negative electrons to positive protons to give an ion that is both charged and stable however they only had aluminium losing two electrons not three.</p> <p>There was a good discussion on ionic bonds being between ions of opposite charges and a good discussion of how aluminium and sulfur form a neutral ionic compound.</p> <p>To earn excellence for this question this candidate needed to extend this same argument to the bonding of aluminium and chlorine.</p>	
3	A4	<p>This candidate mentioned the correct pH of the correct colours in the table as well as the correct colours at pH= 4 and pH = 10.</p> <p>Added to the above the candidate mentioned pH= 7 being neutral as well as giving a correct word and symbol equation.</p> <p>To get to a higher grade this candidate needed to appreciate that it is H^+ ions and OH^- ions that form water. This idea was a little confused with the addition of the statement that NaOH gives both hydrogen ions as well as oxygen anions (this last statement being incorrect).</p> <p>A statement that both H^+ ions and OH^- are in differing concentrations and are present in solutions of pH = 1 through to pH = 13 is missing. The statement in pH = 10 that there are no spare H^+ ions does not help this candidate's case.</p>	

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Merit

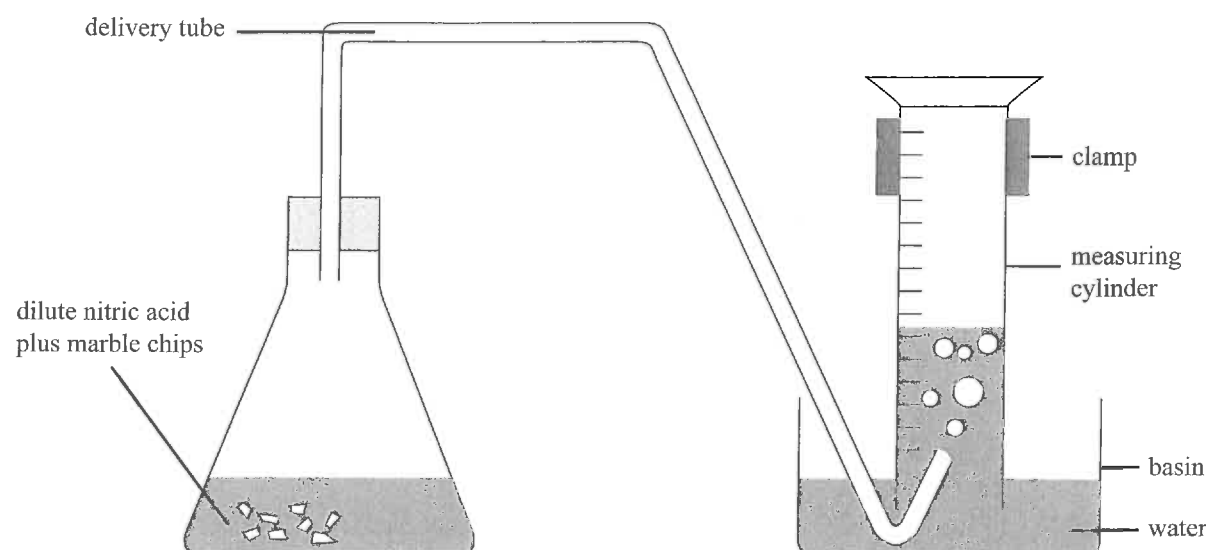
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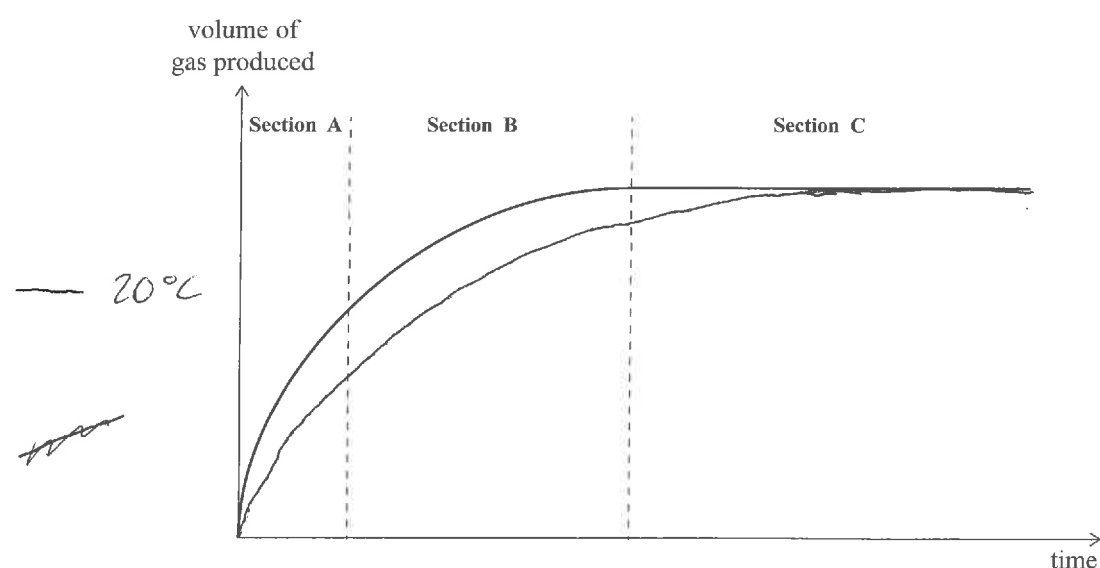
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QUESTION ONE

Marble chips (calcium carbonate) were added to nitric acid in a conical flask. The temperature of the acid was 50°C. The flask was connected to an inverted measuring cylinder in a basin of water to measure the volume of gas produced, as shown in the diagram below.



The graph below shows the volume of gas produced against time.



- (a) Explain what is happening in terms of particle collisions and rate of reaction in **each** section of the graph.

Section A: The particles are ~~colliding~~ ^{moving} rapidly causing more collisions and making the rate of reaction faster.

Section B: The particles are moving slower, causing less collisions and making the rate of reaction slower.

Section C: There are ~~no more~~ ^{few} collisions, making the rate of reaction ~~or~~ ^{very} low. The particles are ~~barely~~ ^{not} moving with enough energy to make the collisions matter.

- (b) The reaction was carried out again but this time at 20°C. The mass and size of the marble chips, and the concentration and volume of nitric acid used were kept the same.

- (i) Draw a line on the graph that represents the reaction at 20°C.
- (ii) Explain why you drew this line where you did, and explain if this means that the rate of reaction is slower, the same, or faster.

In your answer you should

- discuss why you drew your line with the slope that you did, and why you stopped the line at the point that you did
- explain the effect of temperature on reaction rate, in terms of particle collisions.

I drew my line where I did because with a lower temperature, the reaction rate is slower meaning the gas is collected slower. I stopped where I did because at some point ~~at~~ this experiment ^{must} come to an end and the marble chips will have stopped reacting with the acid.

When the temperature

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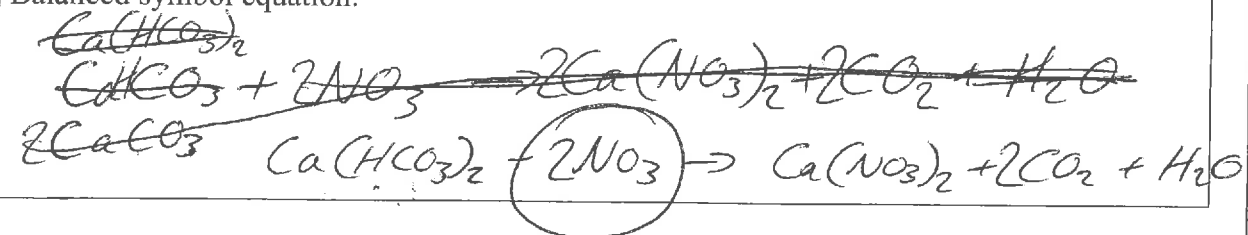
is low, the particles don't have ^{the} a lot of energy that they need to collide quickly. This slows down the rate of reaction.

- (c) Write a word equation AND a balanced symbol equation for the reaction between nitric acid and calcium carbonate.

Word equation:

Calcium Carbonate + Nitric acid \rightarrow Calcium nitrate + Carbon Dioxide + water

Balanced symbol equation:

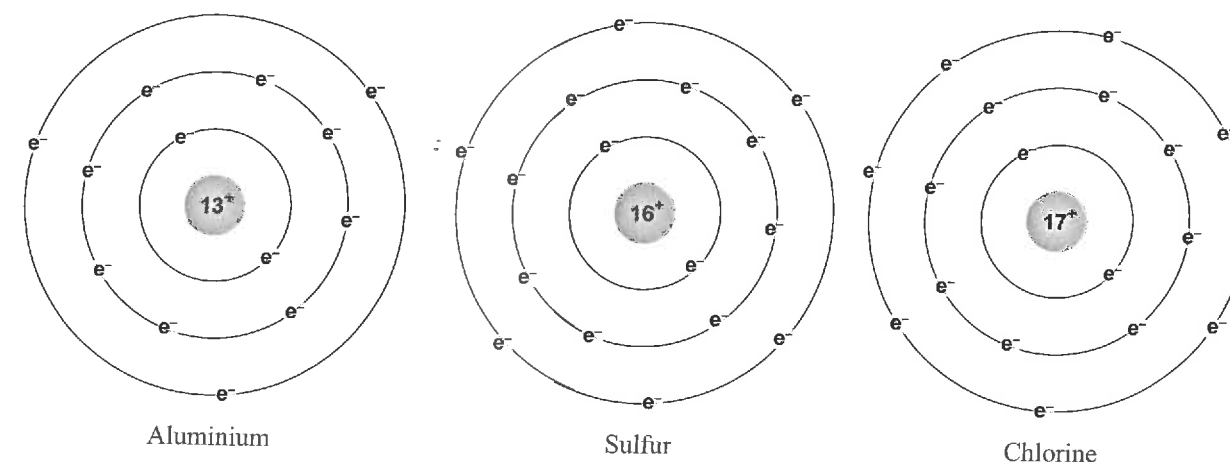


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QUESTION TWO

The diagrams below show models of three different atoms.



- (a) Each of these atoms can form ions, as listed below.

- Explain why each of the **ions** has the charge it does, in terms of electron arrangement and number of protons.
- Ions are charged atoms. Explain how each of the ions below reached the charge shown. You should discuss particles gained or lost by the atoms involved, and the reasons for this.

Aluminium ion, Al^{3+} : Aluminium ^{ion} has a charge of +3 because, when becoming an ion, it lost 3 electrons, making the ion have 3 more protons than electrons. It did this to get a full valence shell and to become stable.

Sulfide ion, S^{2-} : Sulfide ions have a charge of -2 because, when becoming an ion, it gained 2 electrons, making the ion have 2 more electrons than protons. It did this to gain a full valence shell and to become stable.

Chloride ion, Cl^- : Chloride ions have a charge of -1 because, when becoming an ion, it gained an electron, making the ion have 1 more electron than the number of protons. It did this to gain a full valence shell and to become stable.

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- (b) Explain why an ionic bond would **not** form between a sulfide ion and a chloride ion.

In your answer you should:

- describe an ionic bond
- refer to charges and electron arrangements of the ions involved.

An ionic bond occurs when a positively ^{charged} ion bonds with a negatively charged ion. Sulfide and chloride are both negatively charged ions so will repel rather than attract each other. If an ion with a charge of -2 attracts an ion with a charge of $+1$ then the negative ion will need 2 of the positive ion to cancel out the negative charge so they can become neutral.

- (c) Determine the ionic formulae of the compound that forms when aluminium combines with chlorine, AND when aluminium combines with sulfur.

In your answer you should:

- consider the ratio of ions in each formula, and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in each formula to the number of electrons lost or gained by each atom when forming ions.

Aluminium and chlorine: The formula for the combination of aluminium ^{ions} and chloride ^{ions} is $AlCl_3$. This is because Aluminium loses 3 electrons when becoming an ion ^{gaining a charge of $3+$} and since chlorine ^{gains} only 1 electron giving it a charge of $1-$, 3 of them are needed to neutralise/cancel out the positive charge of the aluminium ion.

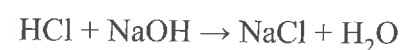
Aluminium and sulfur: The formula for the combination of aluminium ions and sulfide ions is Al_2S_3 . This is because aluminium loses 3 electrons when becoming an ion ^{giving it a charge of $3+$} and Sulfur gains 2 electrons when becoming an ion ^{giving it a charge of $2-$} . This means that to make the compound neutral for the ions to cancel each other out, they need to be of equal opposite charge, which is why 2 aluminium ions are needed to neutralise this compound and 3 sulfide ions.

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QUESTION THREE

The chemical equation below represents the reaction between hydrochloric acid and sodium hydroxide:



- (a) Complete the table below to show the approximate pH for each of the three solutions.

	Colour when UI is added	pH
HCl	red	1-3
NaOH	purple	12-14
H ₂ O	green	6-8

- (b) Water is formed in the reaction above.

Explain what ions form water in this reaction, and where they come from.

You may use an equation but this is not required.

The ions that form the water in this equation are the hydrogen^{ions} in the Hydrochloric acid and the Hydroxide ions in the Sodium hydroxide. They bond together to make the neutral substance of water

- (c) NaOH is gradually added to a solution of HCl with universal indicator present, until no further colour change occurs.

Discuss what is occurring in the beaker at each of the pH's shown, as the NaOH is added.

In your answer you should refer to:

- the colours that would occur at each pH
- the relative amounts of hydrogen and hydroxide present at each of the pH's shown.

pH = 1 (before any NaOH is added): The colour here would be red and there will be no hydroxide ions present, only Hydrogen ions

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pH = 4: The colour here will be yellow with more Hydrogen ions than Hydroxide ions present in the solution.

pH = 7: The colour here will be green with around equal amounts of Hydrogen and Hydroxide ions in it. ~~this is~~

pH = 10: The colour here will be blue with more Hydroxide ions than Hydrogen ions present

pH = 13: The colour here will be purple and there will be hardly any Hydrogen ions present, it will be mostly Hydroxide ions.

- (d) In a different chemical reaction, hydrochloric acid reacts with magnesium hydroxide.

Write a word equation and a balanced chemical equation for this reaction in the boxes below.

Word equation:

Hydrochloric acid + Magnesium hydroxide → Magnesium chloride + water

Balanced symbol equation:



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Q	Grade score	Annotation	
1	A4	<p>This candidate appreciated that the reaction occurred slower and finished at the same point as the reaction at a higher temperature. These two points were indicated on the graph.</p> <p>The candidate confused few reactant particle collisions with just particle collisions. These are two different ideas. They have also mentioned that the rate of reaction is very slow when in fact it has stopped.</p> <p>To take this candidate to the next level they needed to explain that as the temperature is lowered the speed of particles decreases and hence the frequency of effective collisions. To say that they need to collide quickly is not enough.</p>	
2	M6	<p>This candidate discussed the ratio of negative electrons to positive protons to give an ion that is both charged with a full valence shell, and stable.</p> <p>There is a good discussion of ionic bonding.</p> <p>What is missing is an idea of the 3+ charges in the aluminium ion cancelling out the 3- charges of the three chloride ions. The statement '3 of them' does not help as the word 'them' is ambiguous. The discussion of cancelling out of the 6+ and 6- charges of the aluminium and sulfur is also missing.</p>	
3	M5	<p>There are only two out of three pH's correct in the table.</p> <p>The discussion of the formation of water from hydrogen ions and hydroxide ions is good.</p> <p>This candidate also got the formula for magnesium hydroxide wrong with the brackets being added by the marker.</p> <p>A statement that both H^+ ions and OH^- are in differing concentrations and are present in solutions of pH = 1 through to pH = 13 is missing. Mentioning that there are no hydroxide ions present at pH= 1 and an incorrectly balanced symbol equation were also limiting factors.</p>	