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Level 1 Chemistry, 2016

90934 Demonstrate understanding of aspects of chemical reactions

2.00 p.m. Monday 21 November 2016
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of chemical reactions.	Demonstrate in-depth understanding of aspects of chemical reactions.	Demonstrate comprehensive understanding of aspects of chemical reactions.

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.

A periodic table and other reference material are provided in the Resource Booklet L1–CHEMR.

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 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 24

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QUESTION ONE

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(a) Name the precipitate that is formed when the following solutions are mixed together.
You may use the solubility rules provided in the resource booklet.

(i) Zinc nitrate and sodium carbonate

Zinc carbonate – $ZnCO_3$

(ii) Barium chloride and sodium sulfate

Barium sulfate – $BaSO_4$

(b) (i) Copper sulfate solution and sodium hydroxide solution react to form a precipitate.

Complete the following equation showing the formation of the precipitate.

$$Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2\,(s)}$$

(ii) Why is this reaction classified as a precipitation reaction?

The reactants - $CuSO_4$ and NaOH swap partner ions to form the insoluble solid/precipitate of $Cu(OH)_2$. The Cu^{2+} from the $CuSO_{4(aq)}$ reacts with the OH^- from the $NaOH_{(aq)}$. SO_4^{2-} and Na^+ are soluble, remain unchanged, and are spectator ions, so they do not take part in the reaction. A precipitate forms as the electrostatic attraction between Cu^{2+} and OH^- is greater than the attraction between polar H_2O molecules and the ions.

(iii) Describe any observations that would be seen during this reaction, and link these to the reactants and products.

A blue solution ($CuSO_{4(aq)}$) is mixed with a colourless solution ($NaOH_{(aq)}$) to form a blue insoluble, precipitate of $Cu(OH)_2$, in a colourless solution consisting of Na^+ and SO_4^{2-} spectator ions.

$CuSO_{4\,(aq)} + 2NaOH_{(aq)} \rightarrow Cu(OH)_{2\,(s)} + Na_2SO_{4\,(aq)}$

Symbol equation

(c) A solution is known to contain zinc ions OR lead ions.

How could a piece of iron metal, and a solution of sodium chloride, each be used to decide the identity of the metal?

In your answer, you should:

- for each test, write a method that could be carried out in a school laboratory
- describe any observations and link them to the reactants and products involved
- write balanced ionic equations for any reactions that occur.

(1) Testing for Pb

- Take a test-tube sample of the solution and add the iron metal to the solution. Leave overnight. If the solution changes from colourless to pale green (Fe^{2+}) and if the Fe becomes diminished & corroded with a thick layer of grey metal (due to Pb) then Pb^{2+} is present in the solution. This is because a displacement reaction occurs (Fe displaces Pb^{2+}.) Fe has a higher reactivity than Pb, (as it is able to lose electrons easily) and forces Pb to accept 2 $\bar{e}$ electrons so that Fe is able to have a full, stable valence shell. Fe becomes oxidised while Pb^{2+} is reduced. If no displacement reaction occurs then Zn ions are present in the solution as Zn has a higher reactivity than Fe and will not become displaced. (2) In the second test add NaCl to a test-tube a sample of the solution. If a white precipitate ($PbCl_2$) forms (NaCl and sample) after the 2 colourless solutions are mixed then Pb^{2+} ions are present. If no precipitate forms and no reaction occurs, then Zn^{2+} ions are present, because according to the solubility rules it is soluble when mixed with Cl^- ions. (Na^+ is a spectator ion.)

Balanced ionic equations:

1. $Fe_{(s)} + Zn^{2+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + Zn_{(s)}$ (displacement (redox) reaction)

2. $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2\,(s)}$ (precipitation reaction)

QUESTION TWO

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(a) Iron can be reacted with sulfur when a mixture of powdered iron and powdered sulfur is heated in a test tube.

(i) What type of reaction occurs?

Combination reaction

(ii) Describe any observations that would be seen during this reaction, and link these to the reactants and products.

The grey magnetic iron is mixed with powdered yellow Sulfur to create a yellow-grey mixture. When it is heated, it glows and the black, unmagnetic solid of FeS is formed. The product has different properties to the reactants.

(iii) Write a balanced symbol equation for the reaction occurring.

$Fe_{(s)} + S_{(s)} \longrightarrow FeS_{(s)}$

(b) When magnesium is heated with oxygen, a bright light is produced and a white-grey solid forms (**Reaction 1**).

When magnesium metal is added to a solution of copper sulfate, the blue colour of the solution fades and a pinky-brown solid forms (**Reaction 2**).

What are the similarities and differences between **Reaction 1** and **Reaction 2**?

In your answer, you should include:

- the types of reactions occurring
- reference to electron transfer, where appropriate
- word equations for the reactions occurring.

In reaction 1 a combination reaction occurs between Mg and O_2. During a combination reaction, 2 reactants (Mg & O_2) are chemically combined to form a stable, product (MgO). On the otherhand, in reaction 2, a displacement reaction occurs between $CuSO_4$ and Mg. Mg a more reactive metal displaces the Cu^{2+} in the solution. Reaction 1 is exothermic & releases heat whereas

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Reaction 2 does not release as much heat. Both MgO (solid) and $MgSO_4$ products of the 2 reactions are ionic compound ~~do not~~. In Reaction 1, Mg loses 2 valence electrons to form Mg^{2+} (2,8) and a full, stable valence shell. O accepts these 2 electrons to become O^{2-} (oxide ion) and have a full, stable, valence shell. The electrostatic attraction between Mg^{2+} and O^{2-} forms an ionic bond and creates the ionic compound of MgO with a thick, rigid, crystal, 3D, lattice. $2Mg + O_2 \rightarrow 2MgO$ On the otherhand in Reaction 2, Mg has a higher reactivity than Cu and is able to easily lose electrons. It forces Cu^{2+} to accept 2 electrons so that Mg itself is able to have a full stable valence shell in its preferred →

Word equation for **Reaction 1**:

Magnesium + Oxygen → Magnesium Oxide

Word equation for **Reaction 2**:

Copper sulfate + Magnesium → Magnesium sulfate + copper

E8

QUESTION THREE

(a) A small amount of solid manganese dioxide is added to a test tube of freshly prepared hydrogen peroxide solution.

(i) What observations would be made?

Explain your answer by linking any observations to the reactants and products involved.

Colourless liquid H_2O_2 bubbles and gives off a colourless gas that can relight a glowing splint (oxygen). Effervescence occurs as O_2 gas evolves. It produces a colourless solution of H_2O. The black solid (MnO_2) added to the test tube remains the same throughout the reaction as it is a catalyst. $2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$

(ii) What type of reaction is occurring?

Explain your answer.

This is an example of catalytic decomposition. The H_2O_2 breaks down or decomposes into the more stable and simple products of H_2O and O_2 with the aid of the catalyst MnO_2. MnO_2 does not take part in the reaction but it speeds up the rate of decomposition of H_2O_2 by providing an alternative pathway with lower activation energy for the decomposition of H_2O_2 to occur, through.

(b) Three white solids are known to be lead hydroxide, sodium hydrogen carbonate, and calcium carbonate.

How could the three solids be identified using decomposition reactions?

Support your answer with balanced symbol equations.

1. Upon heating $Pb(OH)_2$, H_2O and white PbO will be formed. Condensation will occ
→ on colder parts of the test tube.
The H_2O vapour turns dry cobalt chloride paper from blue to pink, confirming the prescence of water. The decomposition of $Pb(OH)_2$ only produces a white solid & water vapour and therefore can be identified. Limewater remains colourless, when vapour is passed through.

2. Upon heating $NaHCO_3$, white $NaCO_3$ colourless CO_2 and H_2O vapour will be formed. The colourless water vapour will turn Cobalt chloride paper from blue to pink while the colourless CO_2 gas turns clear limewater ($Ca(OH)_2$) milky by producing insoluble $CaCO_3$. (as shown in the reactions on the next page)

3. Upon heating $CaCO_3$, while CaO and colourless CO_2 will be produced. The CO_2 turns limewater from clear to milky. (positive test for CO_2) cobalt chloride paper remains blue, as no H_2O is produced. Therefore these three solids can be identified by thermal decomposition reactions and cobalt chloride paper & limewater ($Ca(OH)_2$) tests. The solid which has a decomposition reaction that is positive for cobalt chloride but negative for $Ca(OH)_2$ (not milky) is $Pb(OH)_2$. The solid which upon thermal decomposition produces positive test results for both tests is $NaHCO_3$ and the solid which upon decomposition, produces a negative test for cobalt chloride (remains blue) but a positive test for $Ca(OH)_2$ is calcium carbonate.

Balanced symbol equations:

1) $Pb(OH)_{2(s)} \xrightarrow{heat} PbO_{(s)} + H_2O_{(g)}$

2) $2NaHCO_{3(s)} \xrightarrow{heat} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$

3) $CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(g)}$

4) Limewater + CO_2

$Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(aq)}$

$CaCO_{3(s)} + H_2O_{(l)} + CO_{2(g)} \rightarrow Ca(HCO_3)_{2(aq)}$

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Extra paper if required.
Write the question number(s) if applicable.

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QUESTION NUMBER

2) (Mg becomes oxidised. Cu^{2+} is reduced.)

b) (cont.) ionic form of Mg^{2+}. ^ $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$.
Therefore displacing the copper. Electrons are, therefore, transferred in both reactions. Another difference between both reactions is that they both produce different products. ~~[illegible] [illegible] (CuSO₄ MgSO₄)~~. Both reactions involve Magnesium. Whilst both reactions produce ionic compounds. $MgSO_4$ is soluble in water according to the solubility rules and therefore remains as Mg^{2+} and SO_4^{2-} in the solution. MgO, produced by reaction 1, on the other hand is a solid.

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Annotated Exemplar Template

Excellence Exemplar 2016

Subject:	Chemistry	Standard:	90934	Total score:	24

Q	Grade score	Annotation
1	E8	The candidate correctly identified the precipitates and gives a correctly balanced equation. In part (b), the candidate correctly identifies that two solutions form a solid and identifies all four species which are linked to the observations. In part (c), the candidate gave a correct method, with complete observations, including that the solution turned pale green, which many candidates missed. All equations were correct.
2	E8	The candidate links the correct colours to the appropriate reactants and products, with a correct equation. In part (b), the candidate clearly describes both reaction types and states why they are classified as such. A good account of electron transfer for both reactions is given.
3	E8	In part (a), the candidate gave four observations linked to the appropriate reactants and products. The candidate clearly describes what decomposition means and links this to the reaction itself, with a correct description of what a catalyst does. In part (b), the candidate provides a logical sequential account of how to determine the identity of the three powders. Correct equations were given.