|  |  |
| --- | --- |
| **Element** | **Reaction with water** |
| Potassium | Violently |
| Sodium | Very quickly |
| Lithium | Quickly |
| Calcium | More slowly |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

This revision covers: 1) Reactivity series, 2) Oxidation/reduction reactions, 3) Electrolysis, 4) Acid-Base reactions

**Reactivity series**

The reactivity series allows us to predict how metals will react. A more reactive metal will displace a less reactive metal from a compound. Rusting is an oxidation reaction.

**The reactivity series**

In a reactivity series, the most reactive [**element**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-zxqcq6f) is placed at the top and the least reactive element at the bottom. More reactive metals have a greater tendency to lose [**electrons**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-zd4f4wx) and form positive [**ions**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-zcy6vcw).

|  |  |
| --- | --- |
| **Element** | **Reaction with dilute acids** |
| Calcium | Very quickly |
| Magnesium | Quickly |
| Zinc | More slowly |
| Iron | More slowly than zinc |
| Copper | Very slowly |
| Silver | Barely reacts |
| Gold | Does not react |

A **reactivity series of metals** could include any elements. See the example at right. Observations of the way that these elements react with water, [**acids**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-zvjgwmn) and steam enable us to put them into this series.

The tables at right show how the elements react with water and dilute acids



**Non-metals in the reactivity series**

It is useful to place **carbon** and **hydrogen** into the reactivity series because these elements can be used to extract metals. At left is the reactivity series including carbon and hydrogen.

Note that zinc and iron can be [**displaced**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-z2h4mp3) from their [**oxides**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision#glossary-zqb7fg8) using carbon but not using hydrogen. However, copper can be extracted using carbon or hydrogen.

**Displacement reactions of metal oxides**

A more reactive metal will [**displace**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/2#glossary-z2h4mp3) a less reactive metal from a [**compound**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/2#glossary-zgdbd2p). The [**thermite reaction**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/2#glossary-zyh4mp3) is a good example of this. It is used to produce white hot molten (liquid) iron in remote locations for welding. A lot of heat is needed to start the reaction, but then it releases an incredible amount of heat, enough to melt the iron.

Aluminum + iron(III) oxide → iron + aluminum oxide

2Al + Fe2O3 → 2Fe + Al2O3

Because aluminum is more reactive than iron, it displaces iron from iron(III) oxide. The aluminum removes oxygen from the iron(III) oxide:

* iron is [**reduced**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/2#glossary-zgkgwmn)
* aluminum is [**oxidized**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/2#glossary-zwvjn39)

In general, the greater the difference in reactivity between two metals in a displacement reaction, the greater the amount of energy released.

Aluminum is much higher than iron in the reactivity series, so the thermite reaction releases a lot of energy. Magnesium is very high in the reactivity series, and copper is very low - so the reaction between magnesium and copper oxide is more violent.

*EXAMPLE 1:* Reactions between metals and metal oxides allow us to put a selection of metals into a reactivity series. Using metals A, B and C:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Metal A** | **Metal B** | **Metal C** |
| **A oxide** | X | Displaces A | Displaces A |
| **B oxide** | No reaction | X | No reaction |
| **C oxide** | No reaction | Displaces C | X |

**Metal A** cannot displace either B or C - so it must be the **least reactive** and be at the bottom of this reactivity series.

**Metal B** displaces both A and C - so it must be the **most reactive** and be at the top of this reactivity series.

**Metal C** displaces A but cannot displace B - so it must be more reactive than A but less reactive than B, and be in between them in this reactivity series. Therefore, the order is as shown at right.

**Displacement reactions of solutions**

A more reactive metal will [**displace**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/3#glossary-z2h4mp3) a less reactive metal from a solution of one of its salts. For example:

magnesium + copper(II) sulfate → copper + magnesium sulfate

Mg(s) + CuSO4(aq) → Cu(s) + MgSO4(aq)

In this reaction, the blue color of the copper(II) sulfate fades as it is used up (magnesium sulfate solution is colorless). We would also see copper metal forming.

*EXAMPLE 2:* Reactions between metals and solutions of metal salts allow us to put a selection of metals into a reactivity series. Using metals J, K and L, view the table below (left).

**Metal J** displaces both K and L - so it must be the **most reactive** and be at the top of this reactivity series.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Metal J** | **Metal K** | **Metal L** |
| **J sulfate** | X | No reaction | No reaction |
| **K sulfate** | Displaces K | X | Displaces K |
| **L sulfate** | Displaces L | No reaction | X |

**Metal K** cannot displace either J or L - so it must be the **least reactive** and be at the bottom of this reactivity series.

**Metal L**displaces K but cannot displace J - so it must be more reactive than K but less reactive than J, and be in between them in this reactivity series. Therefore, the order is:



**Oxidation and reduction**

**Oxidation** is the loss of [**electrons**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/4#glossary-zd4f4wx) from a substance. It is also the gain of oxygen by a substance. For example, magnesium is oxidized when it reacts with oxygen to form magnesium oxide:

magnesium + oxygen → magnesium oxide

2Mg + O2 → 2MgO

**Reduction** is the gain of electrons by a substance. It is also the loss of oxygen from a substance. For example, copper(II) oxide can be reduced to form copper when it reacts with hydrogen:

copper(II) oxide + hydrogen → copper + water

CuO + H2 → Cu + H2O

Usually, oxidation and reduction take place at the same time in a reaction. We call this type of reaction a **redox reaction**.

Note that:

* the **oxidizing agent** is the chemical that causes oxidation
* the **reducing agent** causes the other chemical to be reduced

Take a look at the following [**thermite reaction**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/4#glossary-zyh4mp3): Aluminum + iron(III) oxide → iron + aluminum oxide

It is easy to see that the aluminum has been oxidized. This means that the iron oxide is the **oxidizing agent**. We can also see that the iron oxide has been reduced. This means that the aluminum is the **reducing agent**.

**Rusting**

Rusting is an [**oxidation**](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/5#glossary-zwvjn39) reaction. The iron reacts with water and oxygen to form hydrated iron(III) oxide, which we see as rust. Here is the word equation for the reaction:

iron + water + oxygen → hydrated iron(III) oxide

Iron and steel rust when they come into contact with water and oxygen. Both water and oxygen are needed for rusting to occur. In the experiment below, the nail does not rust when air (containing oxygen) or water is not present:



*Calcium chloride absorbs water in the right-hand test tube*

*Salt dissolved in water does not cause rusting - but it does speed it up, as does*[***acid rain***](http://www.bbc.co.uk/education/guides/zqjsgk7/revision/5#glossary-zf8vkqt)*.*

Aluminum does not rust (corrode) because its surface is protected by a natural layer of aluminum oxide. This prevents the metal below from coming into contact with air (containing oxygen).

Unlike rust, which can flake off the surface of iron and steel objects, the layer of aluminum oxide does not flake off.

**Metal and non-metal oxides**

Many metals and non-metals react with oxygen in the air when they are heated to produce **metal oxides** and **non-metal oxides**.

The table shows three of these reactions in detail.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **Type** | **Reaction type** | **Oxide** | **Nature** |
| Magnesium | Metal | Highly exothermic - magnesium burns with bright white flame | Magnesium oxide, MgO - solid white powder | Basic |
| Carbon | Non-metal | Exothermic - carbon glows orange when heated strongly | Carbon dioxide, CO2 - colorless gas with no odor | Acidic |
| Sulfur | Non-metal | Burns slowly with a blue flame | Sulfur dioxide, SO2 - colorless gas with choking smell | Acidic |

**Electrolysis**

**Passing an electric current through ionic compounds when they are molten or in aqueous solution causes them to break down into simpler substances. During this process – which is called electrolysis - negative ions are discharged at the positive electrode (anode) and positive ions are discharged at the negative electrode (cathode). The amount of product is directly proportional to the current flowing and the time taken.**

## Electrolysis

**Electrolysis** is the decomposition (breaking down) of a liquid by passing an electric current through it.

Electrolysis needs:

* an **electrolyte** – the liquid that the electric current flows through
* a negative [*electrode*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/)  (the **cathode**)
* a positive electrode (the **anode**)
* a **dc** (direct current) power supply

During electrolysis, [*ions*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) in the electrolyte move to the electrodes and are discharged there.

| **Name** | **Formula** |
| --- | --- |
| Hydrogen | H+ |
| Ammonium | NH4+ |
| Sodium | Na+ |
| Copper(II) | Cu2+ |

###  Cations Anions

**Anions** are negatively charged ions. They are attracted to the **anode** (positive electrode). You should be able to recognize anions from their chemical formulae, which all have a – sign.

The table shows some examples.

**Cations** are positively charged ions. They are attracted to the **cathode** (negative electrode). You should be able to recognize cations from their chemical formulae, which all have a + sign.

The table shows some examples.

| **Name** | **Formula** |
| --- | --- |
| Chloride | Cl- |
| Oxide | O2- |
| Hydroxide | OH- |
| Sulfate | SO42- |

##  Electrolysis of sodium hydroxide and sulfuric acid

Electrolysis of **aqueous solutions** (where an ionic substance is dissolved in water) can easily be carried out in a school laboratory. You will need:

* a beaker or similar container for the [*electrolyte*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) [**electrolyte**: A substance which in solution will conduct an electric current.]
* two graphite rods or copper strips for the [*electrodes*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) [**electrode**: A conductor used to establish electrical contact with a circuit. The electrode attached to the negative terminal of a battery is called a negative electrode, or cathode. The electrode attached to the positive terminal of a battery is the positive electrode, or anode.]
* a power pack or battery, with leads to connect the terminals to the electrodes



Apparatus needed for electrolysis of aqueous solutions

### Sodium hydroxide and sulfuric acid

When sodium hydroxide solution or sulfuric acid is electrolyzed, two gases are produced:

* hydrogen at the cathode
* oxygen at the [*anode*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/)
* These gases can be collected in test tubes placed over the electrodes. Simple chemical tests show which is which:
* hydrogen burns with a ‘pop’ when lit using a splint
* oxygen makes a glowing splint relight

### Half-equations [E]

Sodium hydroxide solution and sulfuric acid both contain hydrogen ions, H+, and hydroxide ions, OH–. The following **half equations** describe what happens at the two electrodes.

At the cathode: 2H+ + 2e-→ H2

At the anode: 4OH- - 4e- → O2 + 2H2O

You might have expected sodium to be produced at the cathode during the electrolysis of sodium hydroxide solution. However, sodium is more reactive than hydrogen, so hydrogen is given off instead.

## Electrolysis of copper(II) sulfate

Copper(II) sulfate solution can be [*electrolyzed*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) [ using carbon [*electrodes*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/). During electrolysis:

* the [*cathode*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) gets coated with copper
* bubbles of oxygen are given off at the [*anode*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/)

Copper(II) sulfate solution is blue because of the copper(II) [*ions*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/)  it contains. As these ions are discharged as copper [*atoms*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) at the cathode, the blue color of the solution gradually fades.

### Half equations [E]

The following half equations describe what happens at the two electrodes.

At the cathode: Cu2+ + 2e- → Cu

At the anode: 4OH- - 4e- → O2 + 2H2O

## Electrolysis of molten compounds

The [*ions*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/)  in the [*electrolyte*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) must be free to move to the[*electrodes*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) for [*electrolysis*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) to work. They are free to move in [*aqueous solutions*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) and in [*molten*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) liquids. However, the ions are in fixed positions in solid ionic [*compounds*](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/chemistry_out_there/electrolysis/revision/print/) - they cannot move around, so electrolysis does not work in solids.



Ions in ionic solids are arranged in a giant lattice and cannot move around

When a **molten** (melted) ionic compound is electrolyzed:

* the **positive ions** are discharged at the **cathode**
* the **negative ions** are discharged at the **anode**
* For example, during the electrolysis of molten lead bromide:
* lead ions, Pb2+, move to the cathode and are discharged as lead
* bromide ions, Br–, move to the anode and are discharged as bromine

### Half equations [E]

Molten mead bromide contains Pb2+ ions and Br– ions. The half equations for the electrode processes:

At the cathode: Pb2+ + 2e- → Pb

At the anode: 2Br- - 2e- → Br2

**Acids and bases**

**Bases are substances that can react with acids and neutralize them. Alkalis are bases that are soluble in water. The pH scale measures how acidic or alkaline a substance is. Substances with a pH lower than 7 are acidic, those with a pH of 7 are neutral and those with a pH greater than 7 are alkaline.**

**The pH scale**

The chemical properties of many solutions enable them to be divided into three categories - **acids, alkalis and neutral solutions**. The strength of the acidity or alkalinity is expressed by the **pH scale**.

* solutions with a pH less than 7 are **acidic**
* solutions with a pH of 7 are **neutral**
* solutions with a pH greater than 7 are **alkaline**.

If **universal indicator** is added to a solution it changes to a color that shows the pH of the solution.

**Bases and acids**

Bases are substances that can react with acids and neutralize them. Bases such as metal oxides and metal hydroxides react with acids to form neutral products.

Examples of bases include: copper(II) oxide, and zinc hydroxide.

An alkali is a soluble base, a base that can dissolve in water. For example, copper(II) oxide is a base because it can neutralize acids but, because it does not dissolve in water, it is not an alkali.

Examples of alkalis include: sodium hydroxide, and potassium hydroxide.

*All alkalis are bases.*

**Neutralization**

When an alkali is added to an acid the pH of the mixture rises. This is because the alkali reacts with the acid to form neutral products. The reverse situation also happens too: when an acid is added to an alkali the pH of the mixture falls. This is because the acid reacts with the alkali to form neutral products.

A reaction in which acidity or alkalinity is removed is called neutralization. A neutralization involving an acid and a base (or alkali) always produces salt and water.

acid + base → salt + water

**Hydrogen ions and pH**

In all solution, all acids contain hydrogen ions, H+. The greater the concentration of these hydrogen ions, the lower the pH.

**Naming salts**

The name of the salt produced in a neutralization reaction can be predicted. The first part of the name is ‘ammonium’ if the base used is ammonia. Otherwise, it is the name of the metal in the base. The second part of the name comes from the acid used:

* chloride, if hydrochloric acid is used
* nitrate, if nitric acid is used
* sulfate, if sulfuric acid is used
* phosphate, if phosphoric acid is used.

The table shows some examples.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **acid** | **+** | **base** | **→** | **salt + water** |
| hydrochloric acid | + | copper oxide | → | copper chloride + water |
| sulfuric acid | + | sodium hydroxide | → | sodium sulfate + water |
| nitric acid | + | calcium hydroxide | → | calcium nitrate + water |
| phosphoric acid | + | iron(III) oxide | → | iron(III) phosphate + water |

**Carbonates and acids**

Carbonates also neutralize acids. As well as a salt and water, **carbon dioxide** is also produced. The name of the salt can be predicted in just the same way.

For example: hydrochloric acid + potassium carbonate → potassium chloride + water + carbon dioxide

References:

<http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/limestone/calciumcarbonaterev1.shtml>

<http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/fundamentals/chemicalreactionsrev1.shtml>

<http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/chemical_resources/acids_basesrev_print.shtml>

<http://www.bbc.co.uk/education/guides/zjwnb9q/revision/6>

<http://www.bbc.co.uk/education/guides/z8ktyrd/revision/3>

<http://www.bbc.co.uk/education/guides/zqjsgk7/revision/6>

**Review Questions: Multiple-Choice**

Use the reactivity series, shown at right, to answer questions 1-3

1. Which is the most reactive of these three metals?
2. Lithium
3. Copper
4. Zinc
5. Which metal can be displaced from its ores by heating with carbon? [E]
6. Calcium
7. Iron
8. Platinum
9. Which of these displacement reactions will produce the most energy? [E]
10. Iron oxide and aluminum
11. Magnesium and copper oxide
12. Magnesium and silver nitrate
13. What has been reduced in this reaction: iron oxide + carbon → iron + carbon monoxide?
14. Iron oxide
15. Carbon
16. Carbon monoxide
17. What is oxidized in this reaction: lead oxide + carbon → lead + carbon monoxide?
18. Lead oxide
19. Carbon
20. Lead
21. Which three substances are essential for rusting to take place?
22. Iron, salt and water
23. Iron, oxygen, water
24. Steel, oxygen, acid
25. Why does aluminum not corrode as quickly as steel and iron?
26. It is not very reactive
27. It is always painted
28. It has a protective layer of aluminum oxide
29. What is produced from the electrolysis of sea water? [E]
30. Hydrogen and oxygen
31. Chlorine and hydrogen
32. Chlorine, hydrogen and sodium hydroxide
33. What type of substances undergo electrolysis?
34. Ionic
35. Covalent
36. Metallic
37. Which electrode do the negative ions move to?
38. Positive
39. Negative
40. They stay in solution
41. What name is given to a positive charged particle?
42. Anion
43. Cation
44. Atom
45. Why does solid lead bromide not conduct electricity? [E]
46. It has no ions in it
47. There are no covalent electrons that are able to move
48. The ions are fixed in place and cannot move
49. If electricity is passed through molten lead bromide, what happens?
50. It splits into lead and bromine
51. It catches on fire
52. Nothing
53. Which of the following describes the products formed at the negative electrode (cathode)?
54. Metals or hydrogen
55. Metals or oxygen
56. Halogens or oxygen
57. Which of the following describes the products formed at the negative electrode (cathode)?
58. Metals or hydrogen
59. Metals or oxygen
60. Halogens or oxygen
61. If electricity is passed through molten zinc chloride, what happens? [E]
62. Zinc is formed at the cathode and chlorine at the anode
63. Zinc is formed at the anode and chlorine at the cathode
64. Hydrogen is formed at the cathode and oxygen is formed at the anode
65. In the electrolysis of zinc chloride, which is the correct half equation for the negative electrode (cathode)? [E]
66. 2Br- → Br2 + 2e-
67. Zn2+ + 2e- → Zn
68. Zn → Zn2+ + 2e-
69. What is produced when aqueous copper chloride is electrolyzed?
70. Copper at the cathode and chlorine at the anode
71. Hydrogen at the cathode and chlorine at the anode
72. Copper at the cathode and oxygen at the anode
73. Which of the options could be used as an electrolyte when purifying copper?
74. Copper sulfate
75. Lead nitrate
76. Distilled water
77. Which half equation shows what happens at the negative electrode when purifying copper by electrolysis? [E]
78. Cu2+ + 2e- →Cu
79. Cu2+ → Cu + 2e-
80. Cu → Cu2+ + 2e-
81. Which pH would show a strong acid?
82. 1
83. 14
84. 5
85. What are the products from a metal carbonate + acid reaction?
86. Salt and water
87. Salt, water and carbon dioxide
88. Salt and carbon dioxide
89. Zinc oxide + sulfuric acid 🡪 ?
90. zinc sulfate + water
91. zinc sulfide + water
92. zinc sulfuric acid
93. What color does litmus solution turn in an alkali?
94. Red
95. Green
96. Blue
97. Which of these might have a pH of 9?
98. Ethanoic acid
99. Sulfuric acid
100. Calcium hydroxide
101. Universal indicator is added to a colorless solution and turns dark blue. What does this tell you?
102. It is an acid
103. It is neutral
104. It is an alkali
105. Which ion is present in all acid solutions?
106. Hydrogen ion, H+
107. Hydroxide ion, OH-
108. Hydride ion, H-
109. What name is given to a base that dissolves in water?
110. Amphoteric
111. An alkali
112. A salt
113. Which ionic equation takes place in an acid-alkali neutralization reaction? [E]
114. H+ + OH- → H2O
115. HCl → H+ + Cl-
116. NH3 + H2O → NH4+ + OH-
117. When an alkali neutralizes an acid, what is made?
118. water
119. salt and water
120. salt only
121. Top of Form
122. Which of these is the most likely pH of a weak alkali?
123. 8
124. 14
125. 6
126. All of the following produce water and a salt when reacted with acid. Which of the following also produces another substance?
127. A base
128. A carbonate
129. An alkali
130. What is the name of the salt produced when nitric acid is neutralized by copper carbonate? [E]
131. Nitrogen carbonate
132. Copper chloride
133. Copper nitrate
134. A sample of acid rain in a beaker has a pH of 4. Alkali is dripped in. What happens to the pH of the liquid in the beaker?
135. It goes down
136. It stays the same
137. It goes up
138. The balanced symbol equation for the reaction between sulfuric acid and potassium hydroxide solution is: [E]
139. H2SO4 + KOH → KSO4 + H2O
140. H2SO4 + 2KOH → K2SO4 + H2O
141. H2SO4 + 2KOH → K2SO4 + 2H2O
142. Which of these combinations of reactants would produce potassium nitrate? [E]
143. Sodium hydroxide and sulfuric acid
144. Potassium carbonate and hydrochloric acid
145. Potassium hydroxide + nitric acid
146. Bottom of Form
147. Which of the following is a correctly balanced equation for the oxidation of copper? [E]
148. Cu + O2 → CuO
149. Cu + O2 → 2CuO
150. 2Cu + O2 → 2CuO

**Review Questions: Short-Response**

1. A student had access to the following substances. Which of these substances would be a good choice for the student as an electrolyte? Why?

|  |  |  |
| --- | --- | --- |
| **Substance** | **Type of Bonding** | **Solubility in Water** |
| Silver chloride (AgCl) | Ionic | Insoluble |
| Dextrose (C6H12O6) | Covalent | Soluble |
| Potassium carbonate (K2CO3) | Ionic | Soluble |
| Lauric acid [CH3(CH2)10COOH] | Covalent | Insoluble |

1. The figure below shows a process in which a copper chloride is split into elements.



* 1. Name the process shown in the figure.
	2. Label the cathode and the anode.
	3. Describe and explain, in terms of ions, electrons and atoms, what happens to cause an orange-brown layer to build up on the surface of electrode on the left.
	4. Name a gas that is contained in the bubbles rising from the surface of electrode on the right.
	5. Write the half-equations for the reaction at each electrode. [E]

|  |  |  |
| --- | --- | --- |
| **Substance** | **Product at negativeelectrode** | **Product at positiveelectrode** |
| Molten leadbromide | lead | **A**  |
| Molten **B** | magnesium | chlorine |
| Aqueous sodiumsulfate solution | **C** | oxygen |
| Aqueous coppersulfate solution | **D** | **E** |

1. The table shows the results of passing electricity through some substances. Carbon electrodes were used.
2. Name **A**, **B**, **C**, **D** and **E**.
3. What is the name used for substances that conduct electricity and are decomposed by it?
4. Why must the substances be molten or in solution?

 (d) Explain why reduction takes place at the negative electrode. [E]

1. The diagram shows a cell used for the electrolysis of brine. Brine is a solution of sodium chloride in water. [E]

(a) Name and give the formulae of the positive ions in brine.

 (b) Name and give the formulae of the negative ions in brine.

 (c) Name gases **A** and **B**. [E]

 (d) Explain as fully as you can how gas **B** is produced. [E]

 (e) Name the product in solution **C**. [E]

1. Review the following, choosing the correct word from each pair in brackets by circling it.

*Acids are compounds that dissolve in water giving hydrogen ions. Sulfuric acid is an example. It can be neutralized by (acids/bases) to form salts called (nitrates / sulfates).  Many (metals/non-metals) react with acids to give (hydrogen/carbon dioxide). Acids react with (chlorides/carbonates) to give (hydrogen/carbon dioxide).  Since they contain ions, solutions of acids are (good/poor) conductors of electricity. They also affect indicators. Litmus turns (red/blue) in acids while universal indicator turns (red/green/blue). The level of acidity of an acid is shown by its (concentration/pH number). The (higher/lower) the number, the more acidic the solution.*

1. **A** and **B** are white powders. **A** is insoluble in water, but **B** dissolves. Its solution has a pH of 3. A mixture of **A** and **B** bubbles or effervesces in water, giving off a gas. A clear solution forms.

**a**Which of the two powders is an acid?

**b**The other powder is a carbonate. Which gas  bubbles off in the reaction?

**c**Although **A** is insoluble in water, a clear solution  forms when the mixture of **A** and **B** is added to water. Suggest why. [E]

1. Oxygen reacts with other elements to form oxides. Three examples are: calcium oxide, phosphorus pentoxide, and copper(II) oxide.

**a** Which of these is:

* **i**an insoluble base?
* **ii**a soluble base?
* **iii** an acidic oxide?

**b**When the soluble base is dissolved in water, the solution changes the color of litmus paper. What color change will you see?

**c i** Write a word equation for the reaction between the insoluble base and sulfuric acid.

**ii** What is this type of reaction called?

**d** Name another acidic oxide.

1. Complete the following equations to show what happens when metals are heated with oxides of other metals.

a) magnesium + copper oxide 🡪

b) lead + tin oxide 🡪

c) [Extended] Fe2O3(s) + 3Zn(s) 🡪

1. State which element is oxidized and which is reduced in the reactions that were shown above.

a) magnesium + copper oxide Oxidized: Reduced: .

b) lead + tin oxide Oxidized: Reduced: .

c) [Extended] Fe2O3(s) + 3Zn(s) Oxidized: Reduced: .

1. When iron oxide is heated with aluminum powder, the following reaction takes place:

Aluminum + iron oxide → iron + aluminum oxide

When aluminum oxide is heated with iron no reaction takes place.

1. Which of the two metals is more reactive? [E]
2. The formula for iron oxide is Fe2O3. The formula for aluminum oxide is Al2O3. Write a balanced symbol equation to show the reaction between aluminum and iron oxide. [E]

c) Window frames made from aluminum do not corrode as quickly as windows made form iron. Explain this statement using the information above.

1. The table below is about the preparation of salts. [E]

|  |  |  |  |
| --- | --- | --- | --- |
| **Method of preparation** | **Reactants** | **Salt formed** | **Other products** |
| **a** acid + alkali | calcium hydroxide and nitric acid | calcium nitrate | water |
| **b** acid + metal | zinc and hydrochloric acid | .................................. | ................................. |
| **c** acid + alkali | ................. and potassium hydroxide | potassium sulfate | water only |
| **d** acid + carbonate | .............................. and ......................... | sodium chloride | water and .............. |
| **e** acid + metal | .............................. and ......................... | iron(II) sulfate | ................................. |
| **f** acid + ................... | nitric acid and sodium hydroxide | ................................... | ................................. |
| **g** acid + insoluble base | .............................. and copper(II) oxide | copper(II) sulfate | ................................. |
| **h** acid + .................. | .............................. and ............................. | copper(II) sulfate | carbon dioxide and ............... |

1. Fill in the missing details for rows a-d. Here is a word bank:

Zinc chloride, hydrogen, sulfuric acid, hydrochloric acid, sodium carbonate, carbon dioxide

1. Fill in the missing details for rows e-h. [E]
2. Write a word equation for the reaction between calcium hydroxide and nitric acid (row a)
3. Write balanced equations for THREE of the eight reactions. [E]