Online Answers

Achievement Standard 90946 (Science 1.7)

Unit 9: Practice assessments (page 99)

Practice assessment 1: Using metals

Task 1: Chemical and physical properties of metals

1.

Metal	Symbol	Reaction with hot water	Reaction with dilute HCl	Conducts heat?	Density	Hardness
Lead	Pb	no reaction observed	no reaction observed	yes	high	medium
Copper	Cu	no reaction observed	no reaction observed	yes	high	medium
Aluminium	Al	bubbles slowly (only when oxide layer removed)	bubbles steadily; metal dissolves	yes	medium/ low	medium
Magnesium	Mg	bubbles of gas given off	bubbles rapidly; metal dissolves; heat given off	yes	low	medium
Iron	Fe	no reaction observed	bubbles slowly; metal dissolves	yes	high	hard

2. **Lead**

   a. Metal and hot water
   No reaction

   b. Metal and hydrochloric acid
   No reaction

   Copper

   a. Metal and hot water
   No reaction

   b. Metal and hydrochloric acid
   No reaction

   Aluminium

   a. Metal and hot water
   aluminium + water → aluminium oxide + hydrogen

   b. Metal and hydrochloric acid
   aluminium + hydrochloric acid → aluminium chloride + hydrogen

   Magnesium

   a. Metal and hot water
   magnesium + water → magnesium oxide + hydrogen

   b. Metal and hydrochloric acid
   magnesium + hydrochloric acid → magnesium chloride + hydrogen

   Iron

   a. Metal and hot water
   no reaction

   b. Metal and hydrochloric acid
   iron + hydrochloric acid → iron(II) chloride + hydrogen

Task 2: Suitability of metals for making pots and pans

1. a. Suitable properties – conducts heat, light weight, unreactive with acids and hot water, does not scratch easily, metallic lustre

   b. Unsuitable properties – heavy weight, reacts with acids and/or hot water; scratches easily, toxic to humans

   c. Cost (of metal), toxicity to humans, corrodes quickly/easily

2. *Some examples of answers (you may have others)*:

Metal	Advantages	Disadvantages
Lead	Conducts heat, unreactive with acids and hot water, malleable (can be bent into shape)	Heavy, scratches easily, toxic to humans
Copper	Conducts heat, unreactive with acids and hot water, attractive colour, malleable	Heavy, scratches easily, expensive
Aluminium	Conducts heat, light weight, forms corrosion-resistant oxide layer, malleable	Reacts slowly with acids and hot water (when oxide coating removed), scratches easily
Magnesium	Conducts heat, light weight, malleable	Reacts rapidly with acids and hot water, scratches easily
Iron	Conducts heat, does not scratch easily, cheap, malleable	Heavy, reacts slowly with acids, rusts easily

Task 3: The properties of metals, in relation to their use in pots and pans

Each metal has its own physical and chemical properties. Some of the properties make the metal useful for making cooking pots and pans, but other properties are not so useful for this purpose.

a. Lead is a silvery-grey metal and is shiny when polished. It is bent into shape easily.

It might be suitable for use in cooking pots and pans because it conducts heat. It is also unreactive, and does not react with hot water or dilute acids. However, lead pots and pans would be very heavy, scratch easily and would be toxic for humans. This makes lead unsuitable for cooking pots.

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b. Copper is a pink-orange metal. It conducts heat and is shiny when polished. It has a high density and can be bent into shape. Copper is suitable for use in cooking pots and pans because it conducts heat. It is also unreactive, so does not react with hot water or dilute acids. Copper pots and pans are quite heavy, scratch easily and are expensive. Copper is sometimes used for cooking pots because it is an attractive and unreactive metal.

c. Aluminium is a silvery-grey metal. It conducts heat, and is shiny when polished. It has a low density, is able to be bent into shape and scratches easily. Aluminium is a moderately reactive metal. It reacts quickly with air to form a dull coating of aluminium oxide:

aluminium + oxygen → aluminium oxide

The oxide layer usually prevents further corrosion by air or water. However, when the oxide layer is removed, aluminium reacts with hot water and with dilute acids to form hydrogen gas. The metal surface can become 'pitted' when this happens.

aluminium + water → aluminium oxide + hydrogen

aluminium + hydrochloric acid → aluminium chloride + hydrogen

Aluminium is suitable for use in cooking pots and pans because it is light in weight and it is mostly resistant to corrosion.

d. Magnesium is a silvery-grey metal. It conducts heat, and is shiny when polished. It has a low density, is able to be bent into shape and scratches easily. However, magnesium is a reactive metal. It reacts rapidly with dilute acids and hot water to form hydrogen gas.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

magnesium + water → magnesium oxide + hydrogen.

The reactivity of magnesium makes it unsuitable for use in cooking pots, which often contain hot water or acidic foods.

e. Iron is a silvery-grey metal. Iron conducts heat, and is shiny when polished. It has a high density, is able to be bent into shape and does not scratch easily. Iron is a moderately reactive metal, which reacts with air to form rust and with acids to form hydrogen.

iron + oxygen → iron(III) oxide ('rust')

iron + hydrochloric acid → iron(II) chloride + hydrogen

Even though it is quite reactive and heavy, iron is used for cooking pots because it is a cheap and hard metal. It can be made into a corrosion-resistant alloy (stainless steel) by adding small amounts of less reactive metals and carbon.

To achieve this (practice) assessment

For a minimum of three metals:

- Properties of the selected metals have been gathered and recorded by carrying out the relevant practical work summarised in Task 1.
- Relevant physical and chemical properties of these metals are described.
- Word equations are provided for any reactions, but note that errors in the equations will not, on their own, prevent the student from being awarded the standard.
- An account is given, for each metal, of its suitability or otherwise for use in cooking pots and pans. Note that for merit, the response will include statements that clearly explain the link between the properties and the uses of the metal.

Practice assessment 2: Corrosion of metals

Task 1: Chemical properties of metals

1.

Metal	Symbol	Reaction with cold water	Reaction with oxygen	Reaction with dilute acid
Zinc	Zn	No reaction	Becomes dull	Bubbles steadily
Copper	Cu	No reaction	Becomes dull; black coating when heated strongly	No reaction
Iron	Fe	No reaction	Becomes dull, red-orange coating forms	Bubbles slowly
Magnesium	Mg	Bubbles slowly	Becomes dull; burns rapidly with a bright flame to produce a white powder	Bubbles rapidly

2. For example, magnesium:

metal + water	**i.** magnesium + water → magnesium hydroxide + hydrogen **ii.** $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$
metal + oxygen	**i.** magnesium + oxygen → magnesium oxide **ii.** $2Mg + O_2 \rightarrow 2MgO$
metal + hydrochloric acid	**i.** magnesium + hydrochloric acid → magnesium chloride + hydrogen **ii.** $Mg + 2HCl \rightarrow MgCl_2 + H_2$

3.

(1) copper	(2) iron	(3) zinc	(4) magnesium
Copper is the least reactive because it reacts very slowly with oxygen, and does not react with water or acid. Iron has a slow reaction with oxygen and acid, but does not react with cold water. Zinc reacts more quickly with oxygen, reacts with acid, but does not react with cold water. Magnesium is most reactive because it reacts vigorously with oxygen and acid, and has a moderate reaction with water.			

Task 2: Methods of preventing corrosion of metals

1. 'Corrosion' describes the reaction of a metal with substances in its surroundings, such as air, water and/or acids. When a metal corrodes, a new substance is formed, which no longer has the useful properties of the metal.

2.

Metal	Reaction with air
Copper	Little or no reaction with air
Zinc	Reacts fairly rapidly to form a zinc oxide coating, which prevents further corrosion
Iron	Reacts at a moderate speed to form red-brown iron(III) oxide; this oxide layer flakes off and leaves a fresh layer of iron available for reaction with air
Magnesium	Reacts rapidly with air, forming a dull coating of magnesium oxide; this oxide layer prevents further corrosion

3. a. iron + oxygen → iron(III) oxide

b. rust

4. (*Two out of three*)

Method 1 Prevent contact with air	Metals are coated with an unreactive substance such as paint, grease or oil, or another, unreactive, metal. This prevents corrosion because the oxygen, water vapour or acid cannot come into contact with the metal, so no reaction takes place.

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Method 2 Sacrificial protection	A metal (usually iron) is coated with a *more reactive* metal. This metal reacts with oxygen in preference to the iron reacting with the oxygen, and prevents any reaction between iron and oxygen.
Method 3 Alloying	Metals are mixed with other *less reactive* metals to form an alloy, which is more resistant to corrosion than the pure metal.

Task 3: Chemical properties and corrosion

Chemical properties

The reactivity of each metal determines how quickly the metal reacts with substances in the air. The reactions with water, oxygen and dilute acid show that magnesium is most reactive, zinc is next most reactive, iron is moderately reactive and copper is not very reactive at all.

(*See Task 1, answers 1. and 2. for reactions and word equations*.)

Corrosion of metals and its prevention

Magnesium and **zinc**, which are the more reactive metals, rapidly form a layer of metal oxide in air, which prevents any further contact between the air and the metal. Once this happens, no further reaction can take place between the metal and oxygen.

magnesium + oxygen → magnesium oxide

zinc + oxygen → zinc oxide

However, these metals react with water and acids, so corrosion by these substances is prevented by forming metal 'alloys' – mixtures of metals.

Magnesium may be mixed with aluminium to form a less reactive alloy.

Zinc may be mixed with copper (a less reactive metal) to form an alloy called 'brass' which is corrosion resistant.

Iron forms a coating of red-orange iron(III) oxide (commonly called 'rust').

iron + oxygen → iron(III) oxide

The rust flakes off and exposes a fresh layer of metal to the air, so iron continues to corrode until it has all been 'eaten away'.

More reactive metals, such as magnesium and zinc, can be used for 'galvanising' or 'sacrificial protection' of iron. The more reactive zinc (or magnesium) metal reacts with oxygen and prevents the reaction of iron with oxygen.

zinc + oxygen → zinc oxide

Galvanising is commonly used on iron roofs. Blocks of magnesium or zinc (both more reactive than iron) may be attached to the iron hulls of ships to prevent corrosion by seawater. Eventually the zinc or magnesium is used up, once it has all reacted.

Plating with a less reactive metal such as copper, tin, silver or gold prevents air coming into contact with iron, so no reaction can take place. This is commonly used on tin cans (tin on iron). If the protective coating is broken, the iron rusts faster than usual because the presence of tin speeds up the reaction of iron with oxygen in air.

In the same way, other coatings can also be used to prevent corrosion: for example, paint on car bodies, and oil or grease on tools.

Corrosion of iron can also be prevented by making a mixture of iron, carbon and a less reactive metal, such as chromium, to form a 'stainless steel' alloy. Only a small percentage of chromium is needed. This method provides permanent protection from corrosion but is more expensive than galvanising, plating or coating.

Copper is so unreactive that prevention of corrosion is not usually necessary. This means it can be used as spouting or in pipes because it will not react with the water. Similarly copper can be used as a base in cooking pots as it will not react with the food and liquid in the pot.

To achieve this (practice) assessment

For a minimum of three metals:

- Properties of the selected metals have been gathered and recorded by carrying out the relevant practical work summarised in Task 1.
- Relevant chemical properties of these metals are described.
- Word equations are provided for reactions occurring.
- A description is given of what corrosion is, and an explanation is provided of why corrosion prevention is necessary.
- An account is given, for each metal, of the methods used to prevent corrosion.

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