Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E___

TOPIC: METALS REVIEW

Multiple-Choice Questions

1 Which statement is **not** true for all metals?

A They are malleable. **B** They conduct electricity.
C They conduct heat. **D** They form coloured compounds. (**D**)

2 Which metal carbonate melts on heating but does **not** decompose?

A calcium carbonate **B** magnesium carbonate
C sodium carbonate **D** zinc carbonate (**C**)

3 Which compound does **not** give off a gas when heated?

A hydrated copper(II) sulfate **B** hydrated sodium carbonate
C magnesium carbonate **D** sodium carbonate (**D**)

4 When heated, solid X gives off a gas. When the gas is bubbled into limewater, a white precipitate is formed. The residue after heating solid X reacts with dilute acid and also with aqueous alkali. What is X?

A copper(II) carbonate **B** magnesium carbonate
C sodium carbonate **D** zinc carbonate (**D**)

5 The thermal stability of metal nitrates is related to the position of the metal in the reactivity series in the same way as carbonates.

Which metal nitrate, on heating, will decompose to form the metal?

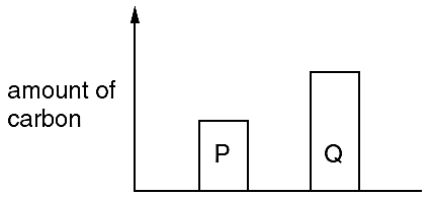
A iron(III) nitrate **B** potassium nitrate
C silver nitrate **D** sodium nitrate (**C**)

6 The carbonates of metals X and Y were heated in air. The carbonate of metal X changed colour from green to black when heated and carbon dioxide was given off. The carbonate of metal Y did not decompose. Which statements are correct?

1 Metal X is more reactive than metal Y.
2 Both metal carbonates would react with dilute nitric acid to form carbon dioxide.
3 Metal X could be a transition element.

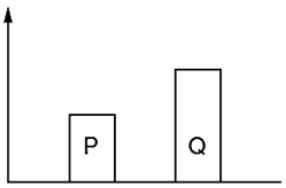
A 1, 2 and 3 **B** 1 and 2 only
C 1 and 3 only **D** 2 and 3 only (**D**)

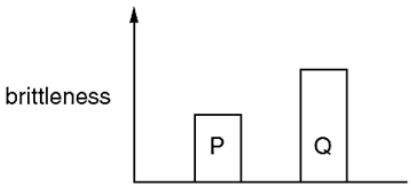
7 The diagram compares the amount of carbon in two steels, P and Q.



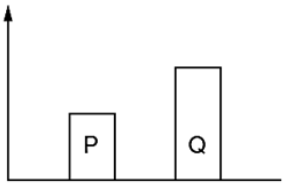
Which two diagrams correctly compare the strength and brittleness of P and Q?

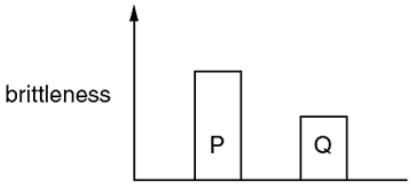
A



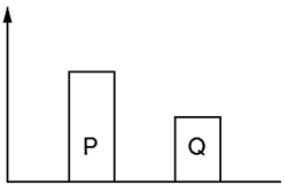


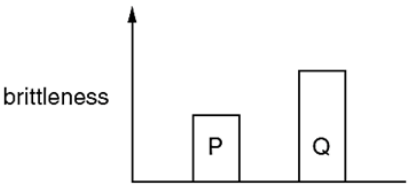
B



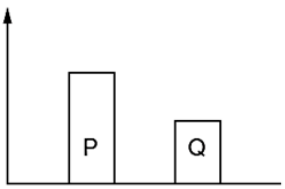


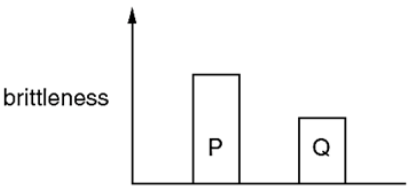
C





D





(**A**)

8 Metals W, X, Y and Z are placed in salt solutions as shown in the table.

metal	result of placing metal in solution of			
	salt of W	salt of X	salt of Y	salt of Z
W	no reaction	X displaced	Y displaced	no reaction
X	no reaction	no reaction	no reaction	no reaction
Y	no reaction	X displaced	no reaction	no reaction
Z	W displaced	X displaced	Y displaced	no reaction

What is the order of reactivity of the metals from most reactive to least reactive?

A Y → X → W → Z
B Y → W → Z → X
C Z → W → Y → X
D Z → Y → X → W

(**C**)

9 Metal X is more reactive than metal Y which is more reactive than metal Z. The sulfates of X and Z are colourless; the sulfate of Y is blue. Which observation is correct?

	metal added to solution of sulfate	solution of sulfate	colour change
A	X	Y	blue → colourless
B	Y	X	colourless → blue
C	Y	Z	blue → colourless
D	Z	Y	blue → colourless

(**A**)

10 How does the mass of a sample of copper(II) oxide change when it is heated in hydrogen and in oxygen?

	mass after heating in hydrogen	mass after heating in oxygen
A	decreases	decreases
B	decreases	unchanged
C	unchanged	decreases
D	unchanged	unchanged

(**B**)

11 The ionic equations below represent the reactions between the metals copper, iron, zinc and X with solutions of the salts of the same metals.

$$\begin{aligned} Cu + X^{2+} &\rightarrow \text{no reaction} \\ Fe + Cu^{2+} &\rightarrow Fe^{2+} + Cu \\ X + Zn^{2+} &\rightarrow X^{2+} + Zn \\ Zn + Cu^{2+} &\rightarrow Zn^{2+} + Cu \\ Zn + Fe^{2+} &\rightarrow Zn^{2+} + Fe \\ Zn + X^{2+} &\rightarrow \text{no reaction} \end{aligned}$$

What is the correct order of reactivity of the metals?

	most reactive → least reactive			
A	Cu	Fe	Zn	X
B	X	Fe	Zn	Cu
C	X	Zn	Fe	Cu
D	Zn	X	Cu	Fe

(**C**)

12 The table shows the results of adding weighed pieces of iron to solutions M and S.

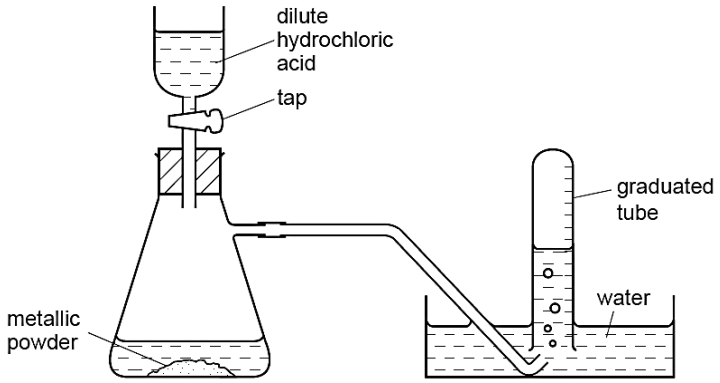
solution	initial mass of iron / g	mass of iron after 15 minutes / g
M	5	4
S	5	4

What could the aqueous solutions M and S have been?

	M	S
A	copper(II) sulfate	silver nitrate
B	dilute hydrochloric acid	sodium chloride
C	iron(II) chloride	calcium chloride
D	magnesium chloride	dilute sulfuric acid

(**A**)

13 The diagram shows apparatus for measuring the volume of hydrogen given off when an excess of dilute hydrochloric acid is added to powdered metal. The volume of gas is measured at room temperature and pressure.



The experiment is carried out three times, using the same mass of powder each time but with different powders:

- pure magnesium
- pure zinc
- a mixture of magnesium and zinc

Which powder gives the greatest volume of hydrogen and which the least volume?

	greatest volume of H_2	least volume of H_2
A	magnesium	zinc
B	magnesium	the mixture
C	zinc	magnesium
D	zinc	the mixture

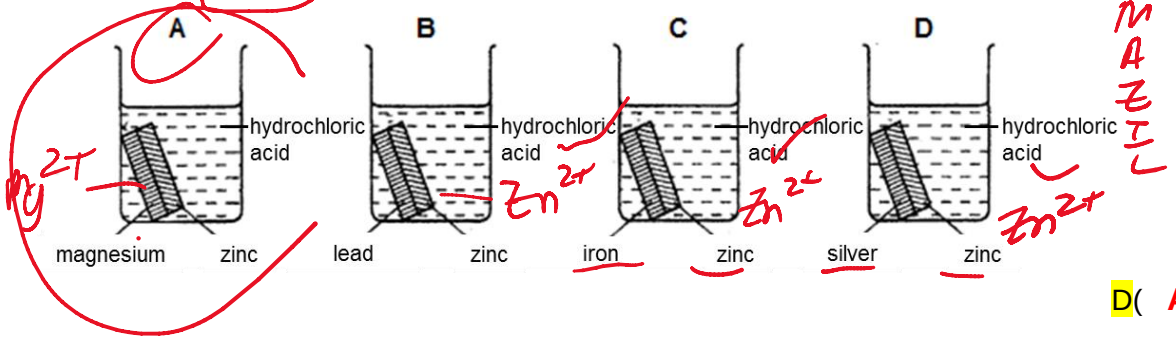
(**A**)

14 Molten iron from the blast furnace contains impurities. The process of turning the impure iron into steel involves blowing oxygen into the molten iron and adding calcium oxide. Which row correctly explains the reason for blowing oxygen and adding calcium oxide?

	blowing in oxygen	adding calcium oxide
A	carbon is removed by reacting oxygen	reacts with acidic impurities making slag
B	carbon is removed by reacting oxygen	reacts with slag and so removes it
C	iron reacts with the oxygen	reacts with acidic impurities making slag
D	iron reacts with the oxygen	reacts with slag and so removes it

(**A**)

15 Each beaker contains two strips of metal fastened together and immersed in hydrochloric acid. All the strips are of the same size. After five minutes, which beaker contains the **least** amount of zinc ions?



D(**A**)

16 Experiments are carried out to arrange metals X, Y and Z in order of decreasing reactivity. The table shows the results.

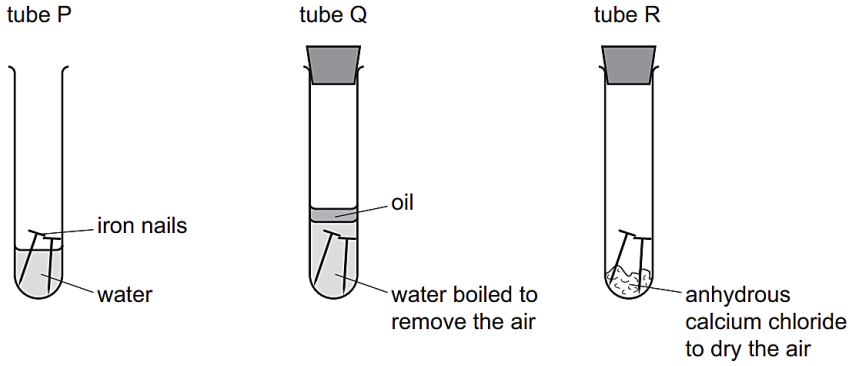
experiment	X	Y	Z
Does the metal liberate hydrogen from dilute hydrochloric acid?	yes	no	yes
Is the metal oxide reduced by heating with carbon?	yes	yes	no

What is the correct order of reactivity of the metals?

	most reactive ⟶		least reactive
A	X	Z	Y
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

(**C**)

17 The diagrams show experiments involving the rusting of iron.



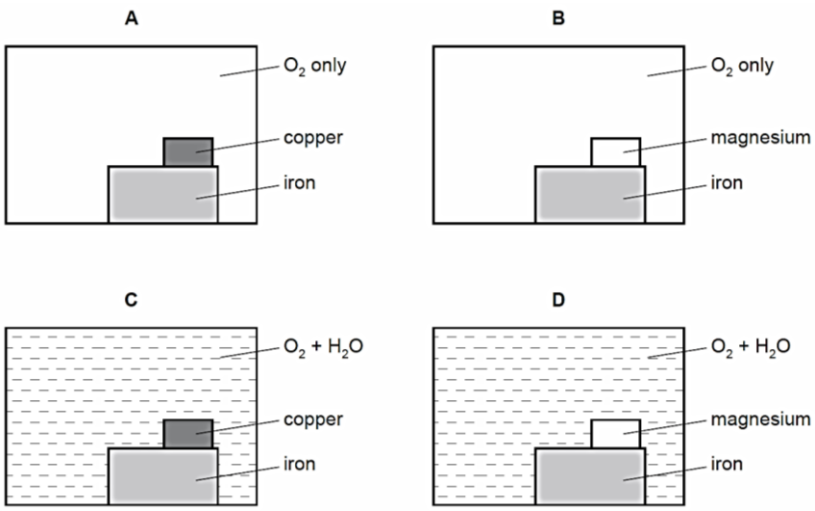
Four statements are made with respect to tubes P, Q and R.

1 The iron nails in tube P will not rust when a rubber stopper is placed over the tube.
2 The iron nails in tube P will rust faster with the addition of mineral salts to water.
3 The iron nails in tube Q will rust due to the dissolved oxygen trapped in the oil.
4 The iron nails in tube R will not rust due to the absence of water.

Which statements are correct?

A 1 and 2 **B** 1 and 3
C 2 and 3 **D** 2 and 4 (**D**)

18 Which diagram correctly illustrates the conditions necessary for the rusting of iron and the metal that can be used to prevent rusting by sacrificial protection?



(**D**)

Structured questions

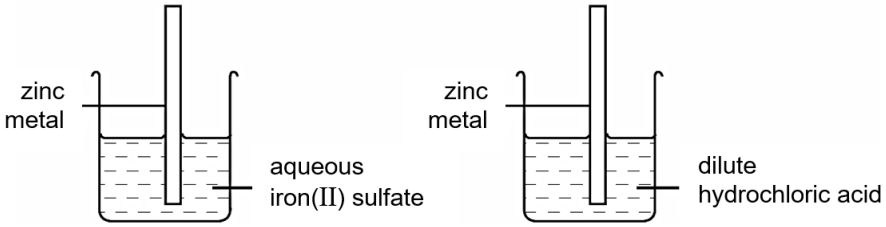
19 Zinc can be extracted from calamine, $ZnCO_3$, in a two-stage process.

$$\text{Stage 1: } ZnCO_3 \rightarrow ZnO + CO_2$$
$$\text{Stage 2: } ZnO + C \rightarrow Zn + CO$$

(a) Explain why the same two-stage process cannot be used to extract sodium from sodium carbonate, Na_2CO_3.

Sodium is a very reactive metal and forms Na^+ ions readily. Na^+ ions bind strongly to CO_3^{2-} ions. Hence, a large amount of energy is required to overcome the strong electrostatic forces of attraction between the oppositely charged ions to obtain sodium. Hence, electrolysis is used.

(b) In the laboratory, two experiments were set up using zinc metal.



For each experiment, describe what you would observe and how you would test any gases evolved. Write an equation for the reaction in each beaker.

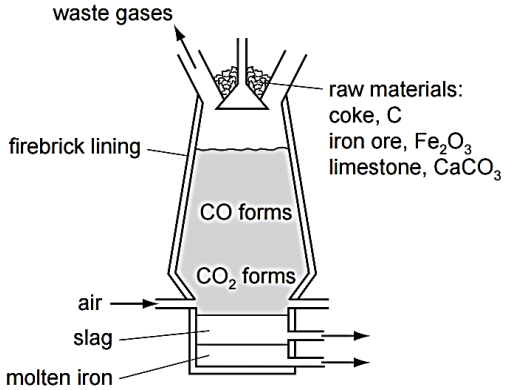
$Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$

In the first experiment, zinc dissolves, with the green solution turning colourless and a grey solid is formed. This is because zinc is more reactive than iron, hence zinc displaces iron from iron(II) sulfate to form zinc sulfate.

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

In the second experiment, effervescence is observed due to the production of hydrogen gas. Place a lighted splint at the mouth of the test tube of gas. If gas produced extinguishes a lighted splint with a 'pop' sound, hydrogen is produced. Zinc metal dissolves and solution remains colourless.

20 Iron is extracted from the ore haematite in the Blast Furnace.



(a) The coke reacts with the oxygen in the air to form carbon dioxide.

(i) Explain why carbon monoxide is formed higher in the Blast Furnace.

As carbon dioxide is formed, it rises to the top of the furnace to react with coke, C added from the top to form carbon monoxide / carbon monoxide formed has a lower relative molecular mass than carbon dioxide / carbon monoxide has a lower density than carbon dioxide.

(ii) Write an equation for the reduction of haematite, Fe_2O_3, by carbon monoxide.

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(b) **(i)** Limestone decomposes to form two products, one of which is calcium oxide. Name the other product.

carbon dioxide

(ii) Calcium oxide reacts with silicon(IV) oxide, an acidic impurity in the iron ore, to form slag. Write an equation for this reaction.

$CaO + SiO_2 \rightarrow CaSiO_3$

(iii) Explain why the molten iron and the molten slag form two layers and why molten iron is the lower layer.

Molten iron and molten slag are immiscible liquids. Molten slag is less dense than molten iron and floats on top of molten iron.

(iv) Suggest why the molten iron does not react with the air.

Slag floats on top of molten iron, forming a protective layer to prevent air from reacting with iron.

(c) Iron and steel rust. Iron is oxidised to hydrated iron(III) oxide, $Fe_2O_3.2H_2O$, which is rust.

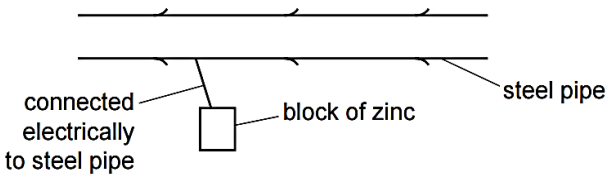
(i) Name the two substances which cause iron to rust.

oxygen and water

(ii) Explain why an aluminium article coated with aluminium oxide is protected from further corrosion but a steel article coated with rust continues to corrode.

Aluminium oxide is a non-porous / impermeable layer which acts as a protective barrier to prevent oxygen and water from corroding the metal. On the other hand, iron(III) oxide is a porous layer which allow oxygen and moisture to enter, causing the steel article to continue to corrode.

(d) There are two electrochemical methods of rust prevention. One method is sacrificial protection. Explain why the steel article does not rust.



Zinc is more reactive than iron in steel. Hence, zinc serves as a sacrificial metal to protect iron and corrodes in place of iron in steel. Zinc is then oxidised by losing 2 electrons to form Zn^{2+} ions in the reaction.

21 An important ore of zinc is zinc blende, ZnS.

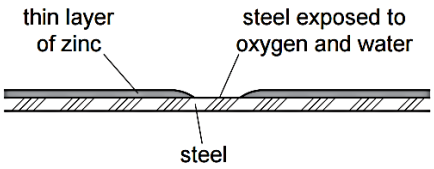
(a) Suggest how zinc blende is changed into zinc oxide.

Heating zinc blende in air / Combustion of zinc blende

(b) Zinc oxide can be further reduced to zinc by the reduction of carbon. Write a balanced equation for this reaction.

$2ZnO + C \rightarrow 2Zn + CO_2$ / $ZnO + C \rightarrow Zn + CO$

(c) A major use of zinc is galvanizing; steel objects are coated with a thin layer of zinc. This protects the steel from rusting even when the layer of zinc is broken.



Explain, by mentioning ions and electrons, why the exposed steel does **not** rust.

Zinc is more reactive than iron, hence zinc acts as a sacrificial metal to prevent iron in steel from rusting. Zinc being a more reactive metal, loses 2 valence electrons more readily to form Zn^{2+} ions to react with oxygen and moisture in the air.

22 The order of reactivity of four metals, starting with the most reactive metal, **W**, **Z**, **Y**, **X**.

(a) An unknown metal **M** is discovered by a student and he carried out further experiments to place **M** in the list. He used dilute hydrochloric acid and samples of the metals above. He found that the metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out. Your answer should include:

- the experiments that he carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that he made,
- how the results showed that metal M is the fourth most reactive metal.

To a fixed mass (1.00 g) of metal M, add a fixed volume (25.0 cm^3) and concentration (0.100 mol/dm^3) of dilute hydrochloric acid into the conical flask.

Start the stopwatch immediately when hydrochloric acid is added to metal M. Collect and measure the volume of hydrogen gas evolved using a gas syringe.

Record the volume of hydrogen gas produced after 1 minute. A similar procedure is carried out with metals W, X, Y and Z.

The metal that produces the most hydrogen gas after 1 minute has the fastest rate of reaction. The volume of gas collected after 1 minute using metal M falls between Y and X, making M the fourth most reactive metal.

(b) The five metals, **W**, **X**, **Y**, **Z** and **M** are extracted from their ores in three different ways. Two of the metals are extracted from their ores by electrolysis. Metal **M** and one other metal are extracted by heating their ores with carbon. One of the metals occur uncombined.

(i) Suggest which other metal, **W**, **X**, **Y** or **Z** is extracted by heating its ores with carbon. Explain your reasoning.

position

Metal Y. The two most reactive metals, W and Z are extracted by electrolysis, while the least reactive metal X occurs uncombined.

Since the reactivity of metal M falls between metals Y and X and metal M is extracted by heating its ores with carbon, metal Y must be extracted in the same manner too.

(ii) Suggest the name of metal **M**.

iron / zinc

23 A student decides to investigate the thermal stability of the carbonates of the four metals. He heats each metal carbonate in a test-tube and bubbles the gas given off through limewater.

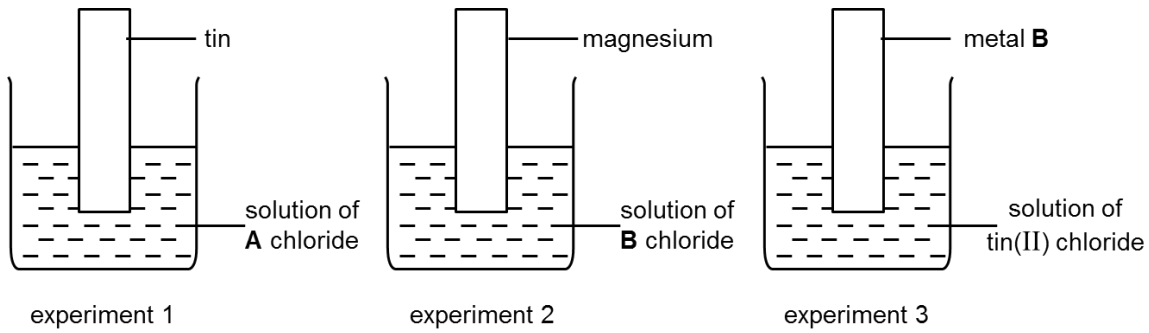
(a) Describe what results he should record.

Time taken for the limewater to form a white precipitate / Time taken to collect a fixed volume of gas should be recorded.

(b) Describe how he can use his results to place the metal carbonates in order of thermal stability.

The longer the time taken for limewater to form a white precipitate / The longer the time taken to collect a fixed volume of gas, the higher the thermal stability of the metal carbonate.

24 A student investigated the reactivity of four metals, **A**, **B**, magnesium and tin. He set up three experiments shown.



In all the three experiments, changes were observed to the rods and the solution.

(a) Place the four metals in order of reactivity, starting with the most reactive metal.

Magnesium, B, tin, A

(b) Explain why changes were observed to the rod and the solution in experiment 1.

Tin is more reactive than A. Hence, tin displaces A from the solution of A chloride.

(c) Given that the solution of **B** chloride is pale green, describe what you would observe in experiment 2.

Magnesium rod dissolves and the solution turns from pale green to colourless. A grey solid / deposit is formed at the bottom of the beaker.

(d) **(i)** In another experiment, experiment 4, magnesium metal is placed into a solution of iron(II) chloride. Write an ionic equation, with state symbols, for the reaction that happens in experiment 4.

$Mg(s) + Fe^{2+}(aq) \rightarrow Fe(s) + Mg^{2+}(aq)$

(ii) Explain, in terms of oxidation state, why the reaction in experiment 4 is said to be a redox reaction.

Oxidation state of iron decreases from +2 in Fe^{2+} to 0 in Fe. Oxidation state of magnesium increases from 0 in Mg to +2 in Mg^{2+}.
Since Fe^{2+} is reduced to Fe and Mg is oxidised to Mg^{2+} simultaneously / at the same time, hence it is considered a redox reaction.

(iii) Experiment 4 is also an alternative method to prepare magnesium chloride as compared to the addition of excess magnesium metal to dilute hydrochloric acid.

However this method of preparation is **not** practised in the industry. Suggest a reason why.

Displacement reactions are not used for preparation of salts because the reaction takes a long time to complete / reaction is very slow.

25 Molten iron from the blast furnace contains carbon. The carbon is removed from the iron. Carefully controlled amounts of carbon are then added to make steel.

Explain why carbon is added to iron and why the amounts added must be carefully controlled.

Carbon is added to iron for alloying to make steel, which is harder and stronger than pure iron.

Careful amounts of carbon are added to iron as low amounts of carbon (low carbon steel) are softer, more easily shaped / malleable while high amounts of carbon (high carbon steel) are stronger and harder but more brittle.

26 **(a)** What are the conditions that cause iron to rust?

Oxygen and water

(b) Explain why rusting is an example of oxidation.

Iron gains oxygen atoms to form iron(III) oxide / Iron loses 3 electrons to form Fe^{3+} in iron(III) oxide / Oxidation state of iron increases from 0 to +3 in iron(III) oxide

(c) **(i)** Car bodies can be protected from rusting by painting and sacrificial protection. Explain how the two methods work.

The layer of paint in car bodies acts as a protective barrier which prevents oxygen and water in the air from coming into contact with iron. This prevents iron from reacting with oxygen and water to form rust.

Sacrificial protection like the galvanising of zinc onto the car bodies prevent rusting as the more reactive metal (zinc) acts as a sacrificial metal to react with oxygen and water and corrodes in place of iron.

(ii) Explain what happens to the car body if the paint on a galvanised car body is being scratched off.

The car body will not rust. This is because zinc is more reactive than iron, hence zinc will corrode in place of iron.

27 The following list shows some elements in order of reactivity, starting from the most reactive element.

potassium, magnesium, carbon, iron, tin, gold

(a) Some reactions of the metals are summarised in the table below.

metal	reaction with water or steam	reaction with dilute acids
potassium	violent reaction with cold water	explosive
magnesium	violent reaction with steam	fast
iron	slow reaction with steam	slow
tin	slow reaction with steam	slow
gold	no reaction with water or steam	no visible reaction

(i) From the table, deduce the position of hydrogen in the reactivity series.

In between tin and gold

(ii) Based on your answer in **(a)(i)**, deduce a general rule for the reactivity of metals with water and dilute acids.

Only metals that are more reactive than hydrogen will react with water and dilute acids.

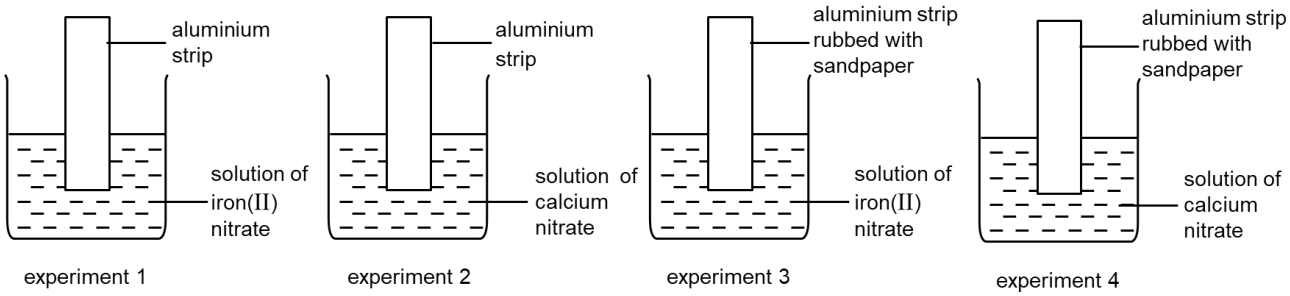
(b) Hence, state the method of extraction of the metals from their compounds.

(i) magnesium from magnesium chloride **electrolysis**

(ii) tin from tin(IV) oxide **reduction by carbon**

28 Aluminium is the most abundant metal in the Earth's crust. It has a low density and is corrosion resistant.

In a laboratory, some experiments involving aluminium were set up.



Changes were only observed in experiment 3.

(a) Describe the observations you would see in experiment 3. Include a chemical equation in your answer.

$$2Al + 3Fe(NO_3)_2 \rightarrow 2Al(NO_3)_3 + 3Fe$$

Aluminium strip will dissolve and become smaller. The colour of the solution changes from green to colourless. A grey deposit is formed.

(b) Suggest why a reaction occurred in experiment 3 but **not** in experiments 1 and 4.

When exposed to air, aluminium reacts with oxygen to form a non-porous aluminium oxide layer. This oxide layer prevents aluminium from reacting with the other solutions. Hence, aluminium was unable to displace iron from iron(II) nitrate in experiment 1.

On the other hand, the sandpaper in experiment 3 removed the aluminium oxide layer, allowing a more reactive aluminium metal to displace iron from iron(II) nitrate.

In experiment 4, despite the removal of the aluminium oxide layer, aluminium is less reactive than calcium, hence aluminium cannot displace calcium from calcium nitrate solution.

(c) Hence, arrange the three metals in increasing order of reactivity.

iron, aluminium, calcium

(d) The carbonates of calcium and iron decompose on heating. Based on your answer in **(c)**, deduce the thermal stability of aluminium carbonate. Explain your answer.

Aluminium is positioned in between calcium and iron in the reactivity series. Since both calcium carbonate and iron(II) carbonate decompose on heating, the thermal stability of aluminium carbonate will be similar to calcium and iron(II) carbonate where aluminium carbonate decomposes on heating to form aluminium oxide and carbon dioxide.