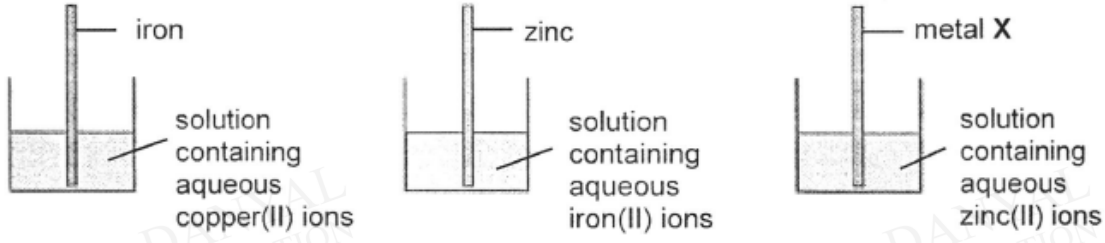
O Level Pure Chemistry Structured

Metals Test 2.0

Q1

A student investigate the reactivity of four metals, iron, copper, zinc and metal **X**.



experiment 1 **experiment 2** **experiment 3**

(a) In **experiment 1**, the student sees changes happen to both the iron and the solution. Describe the changes that the student sees and explain why these changes occur.

[3]

(b) Write an ionic equation, including state symbols, for the reaction that happens in **experiment 2**.

[1]

(c) The student observes that a reaction happens in all three experiments.

(i) Arrange the four metals in order of **increasing** reactivity. Explain your answer.

[2]

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

[1]

(d) At the end of **experiment 3**, the student wanted to check if there are any zinc ions left in the solution. What can the student do to confirm this?

[2]

Q2

Titanium (melting point of 1688 °C) can be extracted from its ore, rutile. Fig. 3.1 shows how titanium metal is extracted from rutile.

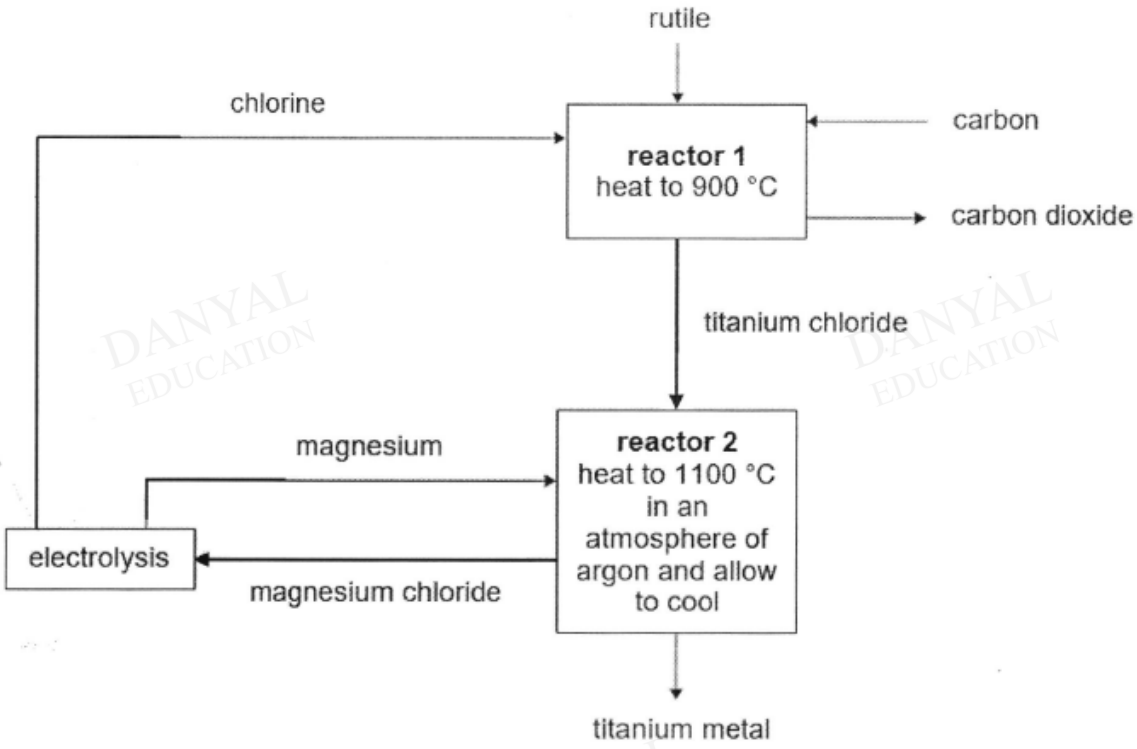


Fig. 3.1

(a) Using the information provided, arrange carbon, magnesium and titanium in increasing order of reactivity.

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.....[1]

(b) Describe an example of recycling in the extraction of titanium.

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.....[1]

(c) Explain why an atmosphere of argon must be used in reactor 2.

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.....[2]

(d) Fig. 3.2 shows how the mass of titanium metal produced changes with different mass of pure and impure rutile.

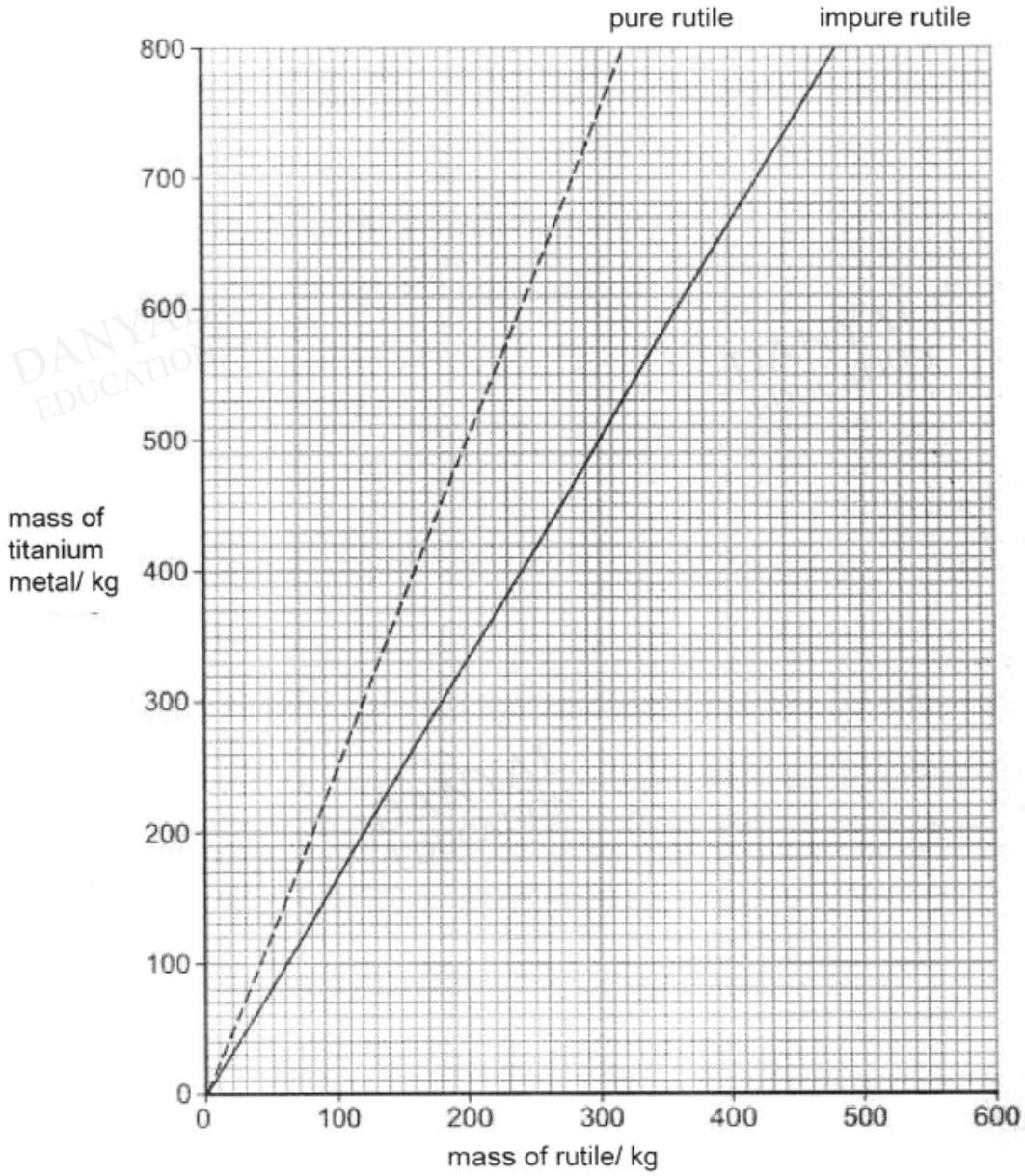

Fig. 3.2

(i) State the mass of titanium that can be obtained from 200 kg of pure rutile.

.....[1]

(d) (ii) Calculate the percentage purity of rutile in the impure ore for the same mass of titanium obtained.

[1]

(e) Describe how the titanium produced in reactor 2 can be separated from magnesium chloride.

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.....[2]

[Total: 8]

Q3

Some metal carbonates, when heated, decompose to produce carbon dioxide. Fig. 5.1 shows the results from an investigation on the rate of decomposition of four metal carbonates. In each experiment, 1.00 g of metal carbonate was heated to the same temperature using flame of the same intensity. The volume of carbon dioxide produced was measured at every minute interval.

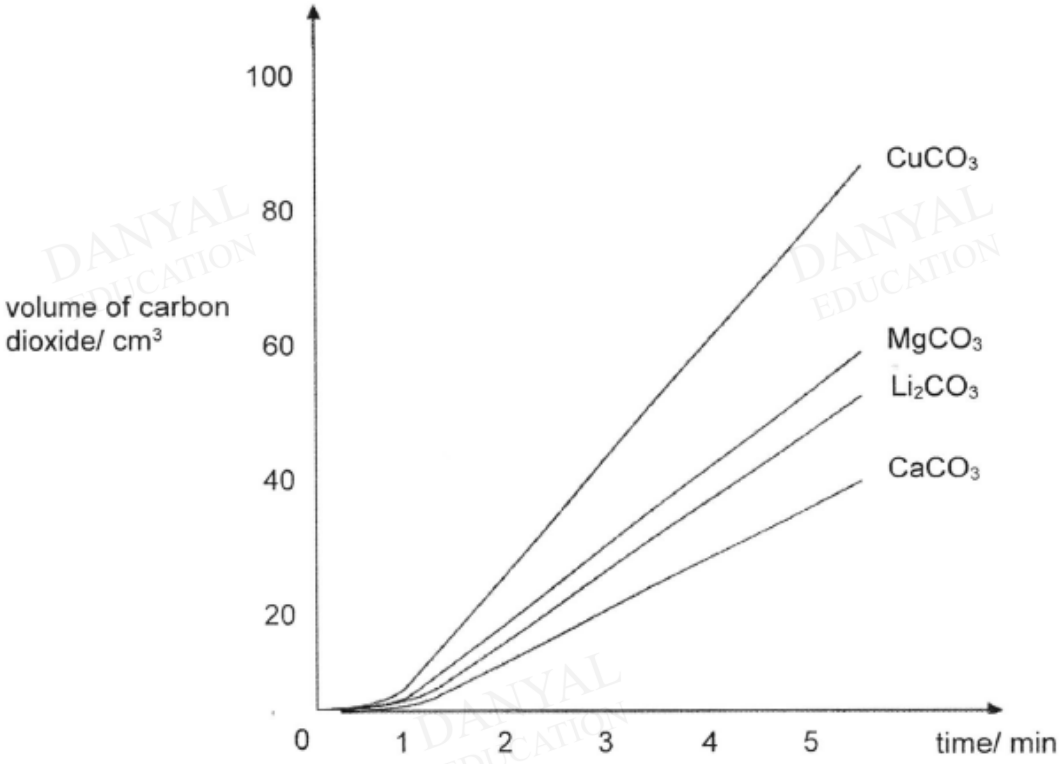

Fig. 5.1

(a) Explain why very little carbon dioxide was collected at the start of each experiment.

.....

.....[1]

(b) Using Fig. 5.1, explain why the decomposition of metal carbonates was not complete at the end of the investigation.

……

……[1]

(c) Using only information from Fig. 5.1, state and explain which metal carbonate decomposed at the fastest rate.

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……[2]

(d) Describe and explain how the volume of carbon dioxide will change with time if sodium carbonate was used for the experiment.

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……[2]

[Total: 6]

Q4

The relative positions of the elements rubidium(Rb), beryllium(Be) and bismuth(Bi) in the reactivity series are shown in Table 3.1.

Table 3.1

Position in the reactivity series
Rubidium
Sodium
Magnesium
Beryllium
Zinc
Iron
Hydrogen
Bismuth
Copper

(a) An unknown photo showing specks of silvery deposits with the following caption was posted on social media and has gone viral.

"Pure rubidium found on a tiny island in the Pacific Ocean"

Use your chemistry knowledge to discuss the validity of this post.

.....

..... [1]

(b) Predict with reasons, the reactions of beryllium with cold water and with steam.

.....

.....

..... [3]

(c) Suggest a suitable method to extract bismuth from its ore.

..... [1]

(d) Underground iron pipelines are used in transporting substances such as natural gas from place to place. When underground, these iron pipes will rust relatively rapidly.

(i) Pieces of magnesium are often attached to underground iron pipes. Explain how this helps prevent iron from rusting.

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..... [2]

(ii) A sample of a compound of iron is analysed. The sample contains 0.547 g of potassium, 0.195 g of iron, 0.252 g of carbon and 0.294 g of nitrogen. Determine the empirical formula of this compound.

[2]

[Total: 9 marks]

Q5

A4 An investigation was carried out into the energy changes that occur when different metals were added to copper(II) sulfate solution. 3 cm^3 of copper(II) sulfate solution was added to each of six test tubes and the temperature of each solution was taken. An equal mass of metal was added to each test tube, the contents stirred and the temperature of the mixtures noted after one minute.

metal added	initial temperature of copper(II) sulfate solution / °C	temperature of mixture after 1 min / °C	temperature rise / °C
magnesium ribbon	20.0	29.0	
magnesium powder	20.5	56.0	
zinc granules	19.0	25.0	
zinc powder	21.0	41.0	
iron granules	18.5	20.0	
iron powder	19.5	34.5	

(a) Complete the table by writing down the temperature rise for each metal added. [1]

(b) What common observation, apart from temperature changes, would be made when each metal is added to copper(II) sulfate solution?

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.....[1]

(c) State three conclusions that you can draw from all the results to these experiments. Explain how you arrived at each conclusion.

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.....[6]

Answers

Metals Test 2.0

Q1

(a)		Pink copper metal formed on iron rod; as it is displaced out of the solution by iron. Blue solution turns pale green; as the Cu^{2+} ions are being replaced by Fe^{2+} ions. Iron is more reactive than copper, iron displaces copper out from its salt solution to form copper and Fe^{2+}.	1 1 1
(b)		$Zn(s) + Fe^{2+}(aq) \rightarrow Zn^{2+}(aq) + Fe(s)$	1
(c)	**(i)**	Copper, iron, zinc, **X**. Metal X is more reactive than zinc as there is a reaction in experiment 3. The rest of the arrangement follows the reactivity series.	1 1
	(ii)	Magnesium or aluminium or calcium	1
(d)		Add aqueous ammonia / ammonium hydroxide solution till excess; (Reject: addition of sodium hydroxide) If zinc(II) ions are left in the solution, a white precipitate will be formed which will dissolve in excess of aqueous ammonia to form a colourless solution.	1 1

Q2

(a)	Titanium, carbon, magnesium;	[1]
(b)	The magnesium chloride produced in reactor 2 is collected and electrolysed to produce magnesium metal which is then used to react with titanium chloride again; OR Chlorine produced by electrolysis is used to react with rutile to produce titanium chloride in reactor 1;	[1]
(c)	Argon is used to provide an unreactive/ inert atmosphere; To prevent the oxidation of/ reaction of oxygen with magnesium/ titanium/ titanium chloride; A: ensure that titanium chloride only reacts with magnesium in reactor 2	[1] [1]
(d)(i)	500 kg;	[1]
(d)(i)	% purity = 200/300 x 100%; = 66.7% (3 sf)	[1]
(e)	Wash the mixture with water to dissolve the soluble magnesium chloride; Filter the mixture to obtain titanium as the residue and aqueous magnesium chloride as the filtrate; R: filtration	[1] [1]

Q3

(a)	Energy was still being absorbed to overcome the activation energy/ most reactant particles have insufficient activation energy to undergo decomposition; A: little or not enough energy for decomposition	[1]
(b)	Volume of carbon dioxide has not reached a constant/ is still increasing at the end of 5 minutes; A: CO_2 was still being produced	[1]
(c)	Copper(II) carbonate/ $CuCO_3$; Highest volume of carbon dioxide produced per unit time; A: copper carbonate A: most carbon dioxide produced throughout the experiment	[1] [1]
(d)	No carbon dioxide will be collected as time pass; Sodium carbonate is stable to heat/ does not decompose upon heating; R: less/little carbon dioxide, no change in volume of carbon dioxide, volume of carbon dioxide collected will be a horizontal/straight line R: very hard/hard to decompose sodium carbonate, sodium is heat stable	[1] [1]

Q4

A3(a)	The photograph is unlikely to show deposits of pure rubidium / hoax. Rubidium is a highly reactive metal which will react violently when exposed to air / water	**1**
(b)	Beryllium is less reactive than magnesium. It has no reaction with cold water / reacts very much slower than magnesium with water. It will react with steam to form beryllium oxide and hydrogen gas.	**1** **1** **1**
(c)	Reduction by carbon / carbon monoxide	**1**
(d)(i)	Magnesium is more reactive than iron. It will undergo sacrificial protection/ corrode in its place/ lose electrons to iron.	**1** **1**
(ii)	Simplest mole ratio of Fe, K, C, N $= \frac{0.195}{56} : \frac{0.547}{39} : \frac{0.252}{12} : \frac{0.294}{14}$ $= 0.003482 : 0.01403 : 0.021 : 0.021$ $= \frac{0.003482}{0.003482} : \frac{0.01403}{0.003482} : \frac{0.021}{0.003482} : \frac{0.021}{0.003482}$ $= 1 : 4 : 6 : 6$ Empirical formula is $FeK_4C_6N_6$. [1] for working, [1] for giving empirical formula.	**2**

Q5

a	9.0, 35.5, 6.0, 20.0, 1.5, 15.0 [1] [All answers must be to 1 d.p.]	1
b	A pinkish brown solid would be seen / would form on each metal. [Reject: Blue solution turns colourless as iron(II) sulfate solution is pale green]	1
c	Any three of the following: (i) All the three metals are more reactive than copper, [1]. They all displace copper from copper(II) sulfate solution as shown by the temperature rise in each reaction. [1] (ii) The reactions are exothermic [1] as there is an increase in temperature for each reaction. [1] (iii) Powdering the metals produces a faster reaction. [1] The temperature increases during the first minute is greater for each powdered metal. [1] (iv) The reactivity of the metals in order of increasing reactivity is : iron < zinc < magnesium. [1] The temperature rise is greatest for magnesium and least for iron. [1]	6